Chapter 18
Discourse Comprehension

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1. INTRODUCTION

Consider the following children's riddle[1] (and please do not read ahead until coming up with an answer):

- How do you get an elephant into a refrigerator?

The answer to the riddle, quite simply, is you open the fridge, put the elephant inside, and close the door. This solved, consider another riddle:

- How do you get a giraffe into a refrigerator?

Readers might be tempted to reuse the previous answer for this second riddle, but this turns out to be too simple. The correct answer is you open the fridge, take out the elephant, put the giraffe inside, and close the door. Now, a third riddle:

- All of the animals are going to a meeting held by the king of the jungle. Only one animal does not come. Which one is it?

This answer to this riddle, of course, is the giraffe. After all, it is still in the fridge. A final riddle:

- How do you get across a river where dozens of crocodiles live?

By this time, the astute reader realizes that a solution is going to require thinking about answers from the previous riddles. With that in mind, the answer, of course, is just swim. After all, the crocodiles are at that important meeting with the king of the jungle and all of the other animals.

[1]We thank Isabel Zwaan for bringing this riddle to our attention.

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These four children's riddles make up a single set, which derives its effect from the reader's (or listener's) inclination to treat each riddle as referring to a separate situation. To answer them as they were intended, the riddles must be treated as connected discourse that describes a single situation with a single set of animals in a single environment. Each subsequent riddle requires the reader to consider the described events with respect to what they already know (and have updated in memory) as a function of the previous riddle. People often fail to provide correct answers to these riddles for a variety of reasons, and these incorrect responses can provide insights into some of the cognitive processes at work as we attempt to comprehend discourse. Most notably, comprehension necessitates the application of prior knowledge in combination with the encoding of information currently in discourse focus.

The example above serves to highlight some of the critical features and processes of discourse comprehension that we will discuss in this chapter. Underlying this example is the basic notion that comprehension involves the construction and application of an *integrated mental representation of the described events*. Those events can be read, heard, seen through some presentation, or even experienced firsthand. Comprehension requires building connections between those events and existing representations in memory. For example, the situations described in the first two riddles take place in *chronological order* and are *temporally contiguous*. The elephant was put in the refrigerator first; unless the elephant is removed, the giraffe cannot be stored in the fridge. To answer the riddle, the reader must connect these two situations. Comprehenders routinely assume that consecutively described events take place in the order in which they are described, and that no unmentioned event will have occurred between them (otherwise such an event would have been described or the omission of events would have been indicated by a time shift such as "an hour later"). Thus, the two events should be connected with each other and, given expectations about chronological order, those events should be assigned a predictable temporal association. In fact, a growing body of evidence suggests that comprehenders routinely and/or strategically keep track of protagonists, objects, locations, and events to build useful associations.

Linguistic cues also provide critical information that can either facilitate or hinder comprehension. The second riddle in the above example makes clever use of one type of linguistic cue to wrongfoot the listener. The indefinite article "an" normally functions as a cue to introduce a new entity into the developing situation, whereas the direct article "the" is interpreted as a cue to search memory for an appropriate referent. Thus, the indefinite article suggests that the refrigerator mentioned in the second riddle is not the same as that mentioned in the first. This promotes the assumption that the described situations are separate, whereas the solution actually requires listeners to think of these riddles as referring to a single situation. Consider also the use of these cues for the fourth riddle: by way of a categorical inference, crocodiles, being animals, should be included under "all animals" and therefore inherit the feature of attending the meeting. Linguistic cues such as definite and indefinite articles can either create or reduce ambiguity, and thereby influence comprehension.

In this chapter, our focus is primarily on text processing; this is based on our overarching goal of examining how processes of memory and language influence general comprehension. We begin at the macro-level by discussing the broad impact of different types of discourse genres. Genres can differ greatly, not just in the types of information they describe, but also as a function of the expectations a comprehender has for that type of genre. We discuss this issue in more detail in Section 2. In Section 3, we consider similar issues at the linguistic level, by discussing the influence of linguistic cues on comprehension.

The example also demonstrates that neither genre-specific knowledge nor more specific linguistic cues are sufficient for describing comprehension processes. Comprehenders invoke various types of background knowledge to understand described situations. In fact, the use of background knowledge is necessary for discourse comprehension. For instance, the answer to the fourth riddle only makes sense if we activate our knowledge that crocodiles should be included in the real-world category of animals. The example also shows that comprehenders must, at times, ignore and revise their prior knowledge to make sense of discourse. Refrigerators are normally not big enough to house elephants and giraffes, and animals as a rule do not convene to attend jungle conferences. To answer these questions, we must ignore our real-world expectations about these facts. Skilled comprehension of various types of discourse, for instance fairy tales and science fiction, involves discounting our expectations about the reality of the described situations and anticipating specific violations of our normal expectations (but see Prentice, Gerrig, & Bailis, 1997, for another view of suspended disbelief). For example, in fairy tales, we might expect characters to possess magical powers or animals to speak, but not expect to read about spaceships or other futuristic technologies. Conversely, in science fiction stories, we might expect such futuristic technologies but perhaps no talking animals or wizardly wands. Riddles derive most of their effects from the fact that the listener does not know beforehand which violations to expect, and what to update in memory. Thus, the acquisition and application of background knowledge is an important issue in discourse comprehension.

For the past three decades or so, the consensus view in the literature on discourse processing has been that comprehension arises out of both information provided by language experience (e.g., linguistic cues in text or speech) and information brought to the experience by the reader (e.g., background knowledge). However, more important than these separable components is the interplay between them, which yields a mental representation of the described situation, termed as mental model or situation model (Johnson-Laird, 1983; van Dijk & Kintsch, 1983). Considerable work has outlined the contents, structure, and construction of situation models. We discuss these issues in Section 5.

In Section 6, we further discuss the nature of the mental representations that may be invoked during discourse comprehension. Until recently, most views of discourse comprehension have suggested that memory is largely abstract, consisting of propositional, amodal representations. Current work has started to question this view, by examining whether these representations should be thought of as grounded in perceptual and motor

processes and representations. This topic provides a stepping stone for considering future developments in the field. Finally, we close with a return to our original riddle set, intended as an example of how the processes and issues we describe are critical to everyday discourse comprehension.

2. DISCOURSE GENRES

At a general level, discourse comprehension is shaped by discourse genre. Discourse genres can be categorized as a function of discourse topic, formality, delivery system, and author or speaker goals and intentions. Three of the most well-studied genres include narrative, expository, and procedural discourse. Other categorizations have been proposed as well for texts and genre subsets (e.g., Meyer & Freedle, 1984).

Narratives have often been associated with fiction, although they can include nonfictional accounts (e.g., historical narratives such as *John Adams* by David McCollough). What differentiates narratives from other genres is that they typically describe a series of events involving a protagonist attempting to overcome obstacles and accomplish a goal (e.g., Mandler & Johnson, 1977; Propp, 1968; Stein & Glenn, 1979; Trabasso & Sperry, 1985; van den Broek, 1988). Narratives are often defined by the causal structure of their events (e.g., Trabasso & van den Broek, 1985; van den Broek, 1990); they contain sequences of events that lead, by necessity and sufficiency, to later events and can be traced back, causally, to early sequences in the plot. Causal structures in narratives are, in many cases, so familiar that readers may have expectations for how the narrative will unfold. These expectations can influence comprehension. For example, readers know that Greek tragedies are likely to end with the death of a main character, mysteries contain bits of information that may be useful for guessing the identity and intent of criminals, and biographies will describe some of the major events in a subject's life, likely in chronological order. Thus, readers can rely on their knowledge about narrative subgenres to build strategies that may facilitate comprehension.

Expository texts are usually produced with the goal of explanation or persuasion. Examples are textbooks, encyclopedias, and other materials that describe facts or principles (Britton & Black, 1985; Goldman & Bisanz, 2002). Examples also include articles in newspapers and magazines (although many of these articles have narrative elements) and the chapters in this *Handbook*. As with narratives, knowledge of the expository genre can provide readers with strategies for encoding the material. For instance, knowing that you are going to read an article in an experimental psychology journal leads you to expect an abstract, followed by an introduction, followed by a method section, followed by a results section, followed by a discussion section. On the other hand, if you read an article in *Science* or *Nature*, you might expect to find the method section at the end of the article. Specifically because expository texts are often implemented in learning settings or situations, readers can use strategies to decide which information may be critical for adequate comprehension, and hence focus their attention on that material (for example, ignoring or focusing on method sections in articles).

Procedural discourse is also associated with explanations, but unlike expository materials, procedural materials are usually structured as sets of directions for completing certain activities. Examples of procedural discourse include the online manual for Microsoft Word and your car maintenance guide. These situations involve the description of a sequence of acceptable or expected actions to be executed in order to successfully perform (and complete) a task. Unlike in narratives, the causal sequence is often explicitly detailed and is a function of particular actions to be completed by the comprehender. For example, in do-it-yourself furniture guides, assembling a desk is a matter of putting together the components one piece or step at a time. Procedural discourse not only includes directions for things to do, but often also includes descriptions of what not to do (e.g., do not put metal objects in the microwave).

These three genres have received attention in experimental research on discourse comprehension, with narratives obtaining the lion's share. Knowledge or expectations with respect to genre can guide the cognitive activities that underlie comprehension processes as well as the ways in which readers represent discourse information in memory. These expectations can be set by prior experiences, or the tasks and goals associated with a particular text (Horiba, 2000; Narvaez, van den Broek, & Ruiz, 1999; Schmalhofer & Glavanov, 1986; van den Broek, Lorch, Linderholm, & Gustafson, 2001; Zwaan, 1991,1993, 1994). For example, when assigned a particular reading purpose (e.g., to study or for enjoyment), readers may focus on different statements as well as the processes they engage in (e.g., evaluation, rereading, inference production) or deem necessary for comprehension (Linderholm & van den Broek, 2002). Similarly, the genre of a text can modify readers' propensities for generating inferences, connecting statements across a text, and building strong memory for what has been read.

One influential view with respect to genre, the material-appropriate processing framework, suggests that particular text types can lead readers to process texts differently (Einstein, McDaniel, Owen, & Coté, 1990; McDaniel, Einstein, Dunay, & Cobb, 1986). This view has focused on how narrative and expository texts lead readers to focus on either the relations among concepts, or on individual facts, respectively. It was later expanded to include reader-initiated processes (e.g., those not directly invoked during or after reading experiences) by examining how expectations for text genre, along with explicit textual genre cues, influence the processes and products of comprehension. There is evidence that expectations about genre influence how readers process and remember texts (Zwaan, 1991, 1993, 1994). Importantly, these findings are not simply a function of deeper processing; readers approached these texts in qualitatively different ways that influenced the types of representations that they formed during reading (e.g., Wolfe, 2005). Knowledge about the goals of the author, the purported purpose of the text, and the topic to be covered, are all potentially meshed into the notion of text genre. Readers often rely on such information to help them comprehend texts.

Genre information is sometimes explicitly provided, as in the case of bookstores and libraries organizing books into sections. However, it can also be cued by other, more implicit information, such as title, potential readership, availability, price, and use of terminology.

Beyond these macro-level cues, there are also micro-level cues *within* a text that directly influence the processes and products that develop during reading experiences.

3. LINGUISTIC CUES

Linguistic cues directly influence the ways that readers process and comprehend discourse. For example, they guide the comprehender with respect to the activation of concepts. Some of the cues that guide such activation patterns are quite explicit (e.g., "Now I am going to describe what you should know for the test."), but others are more subtle (e.g., Bangerter & Clark, 2003). For example, in the sentence "I saw a student enter the lab," the indefinite article "a" is a cue to the comprehender to activate a mental representation of a new protagonist. On the other hand, in "I saw the student enter the lab," the comprehender is prompted to reactivate or keep activated a mental representation of a protagonist that was introduced before. Finally, in "I saw this student enter the lab," the use of the pronoun "this" suggests that the student in question will be the focus of the narrative (Gernsbacher & Shroyer, 1989).

As these examples show, linguistic cues often function to help comprehenders integrate incoming information. This is thought to promote the generation of a coherent mental representation. In this sense, language can be thought of as a set of processing instructions (Gernsbacher & Givón, 1995; Givón, 1992), indicating to comprehenders what information should be activated, what information may no longer be important (and therefore should be deactivated), and where to focus attentional resources in the immediate discourse. We discuss two types of linguistic cues – lexical cues and structural cues.

Connectives such as "therefore," "and then," "but," and "however" are lexical cues that provide information as to how particular associations should be built between linguistic units (e.g., Halliday & Hasan, 1976). They serve as cues for maintaining particular concepts in various states of activation over the course of the comprehension process and are therefore critical for coherence (Britton, Glynn, Meyer, & Penland, 1982; Sanders & Noordman, 2000). Causality, for example, is often marked with terms such as "because," because such terms detail how a sequence of events leads to a particular outcome or state. Connectives facilitate memory for textual information, particularly in cases involving causal descriptions (Caron, Micko, & Thuring, 1988; Millis & Just, 1994; Myers, Shinjo, & Duffy, 1987; also see Millis, Graesser, & Haberlandt, 1993, for a discussion of lack of facilitation in cases involving expository texts). Current work has also assessed how connectives influence reading times, with evidence suggesting that appropriately structured connectives facilitate moment-by-moment comprehension (Deaton & Gernsbacher, in press).

Pronoun referents, synonyms, and direct/indirect markers are also cues that modulate the activation of concepts during comprehension. Anaphora provide information on how incoming information should be integrated with the active memory representation. For example, in the statement, "Jay wanted to work but he kept making phone calls," "he" might be intended to refer to Jay. Anaphor resolution is the process by which a particular referent

in the memory representation is selected for a current concept. To understand discourse, comprehenders must *resolve anaphors*, i.e., determine which referent is targeted by a specific anaphor.

In addition to lexical cues, there are syntactic and macro-structural cues. For example, the position of a sentence in a paragraph or a phrase in a sentence often serves as an integration cue. With roots in linguistics (e.g., Chafe, 1976; Halliday, 1967), this issue has been addressed by examining the pragmatic functions of first mentions. As examples of the importance of first mention, the first sentence of a paragraph traditionally conveys the main idea; introductory lectures often begin with a preparatory statement on the information to be described (e.g., Mayer, 1984). Work on discourse comprehension has assessed the ways in which first mentions are processed, and their resulting effects in memory. First mentions can attract reader attention, convey information about the topic and why it is important, and provide comprehenders with introductory material with which to consider what they might already know and how it potentially relates to the discourse (Clark & Clark, 1977; Gernsbacher, 1990; Givón, 1986). Thus, first-mentioned material receives privileged status during comprehension, and sets the stage for the encoding and retrieval of subsequent information (e.g., Lorch & Lorch, 1996).

Comprehenders rely on this knowledge in developing strategies for comprehension. One such strategy, the given–new strategy (Clark & Haviland, 1977; Haviland & Clark, 1974), suggests that listeners and readers divide linguistic units into given and new segments. The given information refers to what is already known. This can help comprehenders activate existing representations with the goal of understanding the new set of information. New information is comprehended in light of associations and relations with old, given information. Originating from the study of conversation (e.g., Grice, 1975), the view is that language producers and comprehenders set up implicit contracts that align with this given–new strategy. That is, a speaker or writer will refrain from introducing new information prior to establishing its relation to old information, unless such an introduction serves a specific purpose (e.g., emphasizing a new issue or explicitly changing the topic). Cues for indicating given–new material can range from explicit reminders to, in some cases, changes in intonation (e.g., Bock & Mazzella, 1983; Terken & Nooteboom, 1987). Thus, coherence is a direct function of the degree to which comprehenders can connect information they are currently processing, with prior information either in the linguistic stimulus or in memory. The given/new strategy, then, works directly in line with notions of effective coherence.

Lexical and syntactic cues often work in conjunction with each other and in conjunction with background knowledge. For example, in the sentences “Paul and Markus are going swimming today. I hope he has his water wings,” “he” will likely be associated with “Paul” given the lack of prior context. The first–mentioned concept, in this case Paul, is most likely to fill the anaphor slot (Gernsbacher, 1989; Gernsbacher & Hargreaves, 1988). Of course, background knowledge can also influence this process. If, for example, the reader knew that Markus was a 2-year child going to a pool with his father Paul, the reader might be more likely to link “he” with “Markus.” Thus, the activation of concepts across linguistic inputs is

a function of lexical and grammatical cues grammar, contextual constraints, and background knowledge (Järvikivi, van Gompel, Hyönä, & Bertram, 2005).

4. BACKGROUND KNOWLEDGE

Consider the following passage:

> The procedure is actually quite simple. First you arrange items into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to a lack of facilities that is the next step; otherwise you are pretty well set. It is important not to overdo things. That is, it is better to do a few things at once than too many. In the short run it may not seem important but complications can easily arise. A mistake can be expensive as well. At first, the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for this task in the immediate future, but then, one never can tell. After the procedure is completed one arranges the materials into different groups again. Then they can be put in their appropriate places. Eventually, they will be used once more and the whole cycle will have to be repeated. However, that is part of life.

In a classic study, Bransford and Johnson (1972, 1973) read this passage to three groups of participants. Each group rated the passage on comprehensibility and also recalled it. The *No Topic* group performed these tasks without additional information. These participants rated the passage as incomprehensible and exhibited poor recall. The *Topic Before* group was first given the topic "Washing Clothes" before being read the passage. These participants rated the passage as much more comprehensible than the *No Topic* group and recalled more than twice as much of the presentation. Finally, the *Topic After* group was given the topic following presentation of the passage. This did little to help their understanding; their performance was similar to that of the *No Topic* group. This study makes two important points. First, background knowledge facilitates understanding. Second, for background knowledge to facilitate understanding, it must be activated. As we discussed in the previous section, linguistic cues are important with respect to activating the relevant background knowledge. In the washing clothes example, the passage title is such a cue. The importance of background knowledge has been demonstrated in a study on German school children (Schneider & Körkel, 1989; Schneider, Körkel, & Weinert, 1989). Third graders with background knowledge about soccer outperformed seventh graders without this background knowledge in recall of a text about soccer. Given that we may assume that the seventh graders had superior reading skills, this result suggests that relevant background knowledge can compensate for potential differences in reading ability (Recht & Leslie, 1988).

Knowing *that* background knowledge affects comprehension is one thing, but knowing *how* is another. In order to address this issue, we need to consider how background knowledge is organized in long-term memory (LTM). Researchers in the field of

artificial intelligence (AI) have occupied themselves with this question in their quest to build intelligent computer systems that can perform human tasks such as problem solving and language comprehension. One popular format of knowledge organization is the semantic network (Collins & Quillian, 1969; see also the chapter in this volume by Ober and Shenaut), which captures facts in the form of nodes in a network and the links between them. For example, the fact that a giraffe is a mammal is captured by the nodes for giraffe and mammal and an ISA link (literally meaning "is a") that connects these nodes. The fact, or proposition, that a giraffe has a long neck would be captured by the nodes giraffe and long neck and a link between them labeled for property. In propositional notation, this fact can be represented as [HAS[GIRAFFE, LONG-NECK]]. If a node in the network is activated, for example, because the corresponding word is read, it will send activation to its nearest neighbors, which in turn will send activation to their nearest neighbors, and so on. During each cycle, less activation will be transmitted, such that activation gradually dissipates. Thus, LTM is not completely activated all of the time. Through this process of spreading activation, the network (whether computer or human) is able to provide an affirmative response assessing the validity of statements such as "A giraffe is a mammal."

In order to understand discourse, more structured knowledge defined by higher-order organizations may be required. For example, stories are often set in stereotypical locations (e.g., a living room, an office) and involve stereotypical event sequences. To represent this knowledge, AI researchers have developed knowledge–representation structures such as frames (Minsky, 1975) and scripts (Schank & Abelson, 1977). A restaurant script allows us to understand a story like

> Donald and his third wife entered Mario's. When they were seated, Donald declared himself unhappy with his table, which, located near the door, was not conducive to a romantic conversation. He requested a table in the back of the restaurant. He studied the menu and ordered ossobucco for two. The food was great. Instead of a dessert, they ordered cappuccino. Donald left a big tip.

This story leaves out quite a bit of detail. For example, it does not specify who seated Donald and his wife, who took his order, who prepared the food, who delivered it to his table, and who received the tip. However, this presents little difficulty to a reader equipped with a restaurant script. Among other things, the script contains slots for roles of participants. Because of this, the comprehender already knows that people visit restaurants to enjoy a meal and drinks, that greeters lead patrons to their table, waiters take orders, waiters deliver food and drinks, waiters are the recipients of tips, and that cooks prepare the food. By invoking this script, the storyteller can rely on the comprehender to supply the missing information. Schank (1982) noted that scripts might be overly rigid, given that stories are rarely if ever told if they completely follow the script. After all, in describing scripted information, we are not telling the listener anything they did not already know. In fact, we usually feel compelled to tell a story if the events somehow violate a script; for example, if our food was not served by a waiter, but by a chimpanzee on a unicycle. Schank (1982) also proposed more flexible knowledge–organization structures, such as memory-organization packages.

However, symbolic knowledge structures, even those proposed by Schank (1982), are still not flexible enough to explain human cognition. Therefore, cognitive scientists have turned their attention to neural networks – computer models that are roughly based on our understanding of the human nervous system. In these neural network models (see also the chapter in this volume by Seidenberg and MacDonald), knowledge is not programmed by the experimenter, but is acquired by the system as it processes input and receives feedback on its performance (Rumelhart, McClelland, & The PDP Research Group, 1986). In supervised learning paradigms, the output produced by the system (for example, an affirmative response to a verification statement) is judged by the experimenter to be correct or incorrect. The system incorporates this feedback by adjusting the weights on links between the nodes in its hidden layer. This adjustment may lead to a different categorization of the same input on a subsequent trial. The system has now "learned." Connectionist models are much more flexible knowledge–representation systems than symbolic systems, which is exemplified by their ability to handle incomplete or noisy input.

Although connectionist models acquire knowledge structures themselves, they require a programmer to provide a stimulus, with the model passively receiving it. The model itself has no direct way of interacting with the world. A relatively recent development in cognitive science is to embed neural networks in robots that have sensors and effectors and are thus able to interact with their environment and learn from these interactions (Brooks, 1992; Pfeifer & Scheier, 1999). For example, a system has been developed that learns words via sensorimotor processes (Roy & Pentland, 2002). As we will discuss in Section 7, perceptual and motor knowledge may play an important role in language comprehension.

Symbolic and neural network architectures have influenced theories of discourse comprehension. As one case, text comprehension researchers have studied the role of scripts in language comprehension, focusing on the retention of scripted versus nonscripted information in stories (e.g., Graesser, Woll, Kowalski, & Smith, 1980). A very influential model is Kintsch's construction–integration (CI) model (Kintsch, 1988, 1998), which combines knowledge structures such as propositions with the connectionist mechanism of constraint satisfaction (see chapter by Seidenberg and MacDonald). According to the CI model, comprehension involves two phases. During the construction phase, the verbal input activates knowledge in an unconstrained fashion. For example, in the sentence "During the earthquake, the mint collapsed," the word "mint" activates both its *candy* and its *building* meaning, even though only the latter is relevant in the context of the sentence. During the integration phase, the model settles on an interpretation of the sentence via a constraint-satisfaction mechanism. In this case, for example, the *building* meaning will receive stronger support from the context of the sentence than the *candy* meaning; after all, earthquakes do not usually cause pieces of candy to collapse. Thus, nodes representing *earthquake* and *collapse* will send more activation to the node coding for the *building* meaning than to the competing node coding for the *candy* meaning. As a result, the *building* node will remain activated, whereas the *mint* node will gradually become deactivated. The model is updated in cycles. Once the amount of change between cycles is below a certain predefined threshold, the network is deemed to have settled, and it is

considered to have "understood" the sentence. The CI model has been used to simulate the online comprehension of text, text recall, and the recognition of textual materials (see Kintsch, 1998, for an overview). In more recent work, the CI model has been interfaced with a latent-semantic analysis (LSA) system, which provides information about the associations between words based on the similarities of the contexts in which they occur in large corpora of texts (Landauer & Dumais, 1997). Kintsch (2000) has applied this combination in the context of metaphor comprehension.

How knowledge is *organized* is only part of the question. An equally important issue is how knowledge is *retrieved* during comprehension. One proposal is that knowledge is retrieved via an inferencing process. Articles on discourse comprehension often refer to inference generation when they discuss how information from the text is supplemented with background knowledge. This term is somewhat misleading in that it suggests a deliberate and slow process, akin to reasoning. However, as our review of knowledge representation shows, information is usually thought of as being activated automatically, or at least passively (O'Brien, Rizzella, Albrecht, & Halleran, 1998). In this sense, it is more appropriate to view inference generation as knowledge activation or integration (Cook, Limber, & O'Brien, 2001; Kintsch, 1993).

There are several types of inferences (van den Broek, 1994). For example, there are connective (or bridging) and elaborative inferences. Connective inferences provide a way of connecting two successive text statements. For example, consider the following two sentences: "Murray poured water on the bonfire. The fire went out." The two statements can be integrated by activating the knowledge that water extinguishes fire (Singer, 1993; Singer & Halldorson, 1996). Thus, "water extinguishes fire" functions as a connective inference here. An elaborative inference is the activation of knowledge that augments the mental representation of the described situation, but which is not needed to integrate statements. Instrument inferences are a type of elaborative inference. For example, in "John let the tomato soup cool off for a while. Then he ate it," the most plausible instrument inference would be that John used a spoon to eat the soup. This information is not necessary to integrate the two sentences, but it is a plausible inference to make, given that spoons are normally used when eating soup. Another example of an elaborative inference is a predictive inference. For example, in "The tired speaker finished his talk and walked over to a chair," it is possible, based on what we know about giving lectures, about being tired, and about the function of chairs, to infer that the speaker is going to sit. There is strong evidence that comprehenders generate connective inferences (e.g., Graesser, Singer, & Trabasso. 1994). The evidence for more elaborative inferences, though, tends to be mixed. For example, whether or not predictive inferences are generated appears to depend on several factors including contextual constraints, individual differences, processing strategies, task instructions, and reader expectations (e.g., Allbritton, 2004; Calvo, 2000; Calvo & Castillo, 1996; Cook et al., 2001; Fincher-Kiefer, 1996; Klin, Guzmán, & Levine, 1999; Linderholm, 2002; McKoon & Ratcliff, 1986, 1992; Murray, Klin, & Myers, 1993; Rapp & Gerrig, 2006; van den Broek, 1990, 1994; Weingartner, Guzmán, Levine, & Klin, 2003). Even reader preferences, the wishes and desires readers build for story characters and events, influence the construction and application of inferences (Allbritton

& Gerrig, 1991; Gerrig & Rapp, 2004; Rapp & Gerrig, 2002, 2006). At least partially as a function of this large number of potential influences, there is still considerable debate about the particular circumstances that lead to automatic activation of predictive inferences. Not surprisingly then, evidence suggests that such activation occurs under a limited set of circumstances, rather than across all discourse conditions.

This debate over predictive inferences is directly related to a more general issue; the extent to which comprehension involves the active construction of a mental representation or a more passive form of knowledge activation. One extreme view would be that comprehension is a very active process, akin to reasoning, in which the comprehender makes a conscious effort to generate bridging and elaborative inferences in order to arrive at a detailed "high resolution" mental representation of the described situation. At the other extreme is the view that background knowledge is retrieved automatically as a function of the processing of incoming stimuli; in this the comprehender passively activates background knowledge, with integration being a function of such passive activation. Neither view is completely supported by the data, which is why most theories fall somewhere in the middle; some state that comprehenders do not indiscriminately generate inferences, but only those that are relevant to their "effort after meaning" (Graesser et al. 1994), whereas others focus on the activation of information that is "easily available" through passive memory processes (McKoon & Ratcliff, 1992; Myers & O'Brien, 1998). A comprehensive model of discourse comprehension likely invokes both sets of processes (see Gerrig & O'Brien, 2005; Guéraud & O'Brien, 2005; van den Broek, Rapp, & Kendeou, 2005, for a discussion).

Additionally, these processes capture two important general intuitions about discourse comprehension. The first intuition is that comprehension often seems incomplete, regardless of whether it involves automatic activation or strategic processing. For example, we often fail to notice inconsistencies in texts (e.g., Barton & Sanford, 1993), or between text and background knowledge (e.g., Kendeou & van den Broek, 2005; Otero & Kintsch, 1992). This suggests that comprehension is a "sloppy" process. The second intuition is that language comprehension, especially narrative comprehension, often produces a sense of experiential richness. Again, whether information is activated as a function of dynamic spreading activation processes driven by either (or both) a 'dumb' passive process or an active search for meaning, it is clear that comprehenders can become engaged in their discourse experiences. It is difficult to see how theories that view comprehension as involving a small number of abstract representations, whether automatically activated or strategically generated, can explain why children and adults become engrossed in popular stories such as the *Harry Potter* books and *One Hundred Years of Solitude* by Gabriel Garcia Marquez.

The role of background knowledge in the comprehension process cannot be overstated (Kendeou, Rapp, & van den Broek, 2004). Comprehenders rely on this knowledge, even in cases for which it is incorrect and may create problems. For example, students often hold misconceptions, and these misconceptions are resistant to change, even in the face of refuting evidence (e.g., Diakidoy & Kendeou, 2001; Diakidoy, Kendeou, & Ioannides,

2003; Guzzetti, Snyder, Glass, & Gamas, 1993; Kendeou & van den Broek, 2005). Students attempt to understand material in line with these faulty beliefs, rather than spontaneously engaging in processes of conceptual change to revise their beliefs and mental models (DiSessa, 2002; Posner, Strike, Hewson, & Gertzog, 1982; Vosniadou, 2002; Vosniadou & Brewer, 1994). Thus, background knowledge from LTM serves as the scaffold for newly encountered information, regardless of the validity of that knowledge.

5. SITUATION MODELS

The most basic purpose of discourse is to convey information about a state of affairs in the real or a fictional world. Accordingly, the comprehender's usual goal is to achieve an understanding of the described situations. As we have suggested, the comprehender relies on linguistic cues in the discourse and his/her prior knowledge to achieve understanding (McNamara & Kintsch, 1996). Integration of information from the discourse and the comprehender's knowledge and cognitive activities is necessary for successful comprehension (as well as for forming a representation of the experience that could be applied at a later time point).

Because people apply their discourse comprehension skills for many different goals (e.g., browsing a magazine; listening for key facts in a lecture; evaluating the views of a political candidate), it is likely that they can build a variety of types of mental representations in the process. One influential theory has proposed that discourse comprehension involves at least three levels or types of mental representations (Schmalhofer & Glavanov, 1986; van Dijk & Kintsch, 1983).[2] The most basic level is the surface structure, a mental representation of the exact text read. Surface representations decay rapidly from memory (e.g., Anderson & Bower, 1973; Kintsch, Welsch, Schmalhofer, & Zimny, 1990; Sachs, 1967, 1974), although they tend to be more resistant to decay when pragmatically relevant (e.g., Keenan, MacWhinney, & Mayhew, 1977; Murphy & Shapiro, 1994). The second level, the textbase or propositional representation, contains idea units explicitly stated in the text, along with some bridging inferences. The textbase representation is also described as gist-like memory (Kintsch & van Dijk, 1978). At this level, readers represent the ideas described in the text, but not every single word or concept contained therein. The highest level of representation, often viewed as essential to comprehension, is the situation model (e.g., Hess, Foss, & Carroll, 1995; van Dijk & Kintsch, 1983; Zwaan, 1999b; Zwaan & Radvansky, 1998). At this level, readers represent information described by the text, activating knowledge that goes beyond what was explicitly stated. Readers often rely on their prior knowledge to fill in gaps in the text, as well as to run "mental simulations" of the information (Kahneman & Tversky, 1982; also see Barsalou, 1999, for a recent discussion of mental simulation), and these processes constitute activity at the level of the situation model.

[2]Other theories have suggested two levels as sufficient, although these levels likely combine elements of the three-level view we will describe, e.g., Johnson-Laird (1983)

An example of representation at each of these levels will help clarify this taxonomy. Consider the following sentence: "Sid searched for a new apartment on the North side of Chicago." A surface representation would contain every word in that sentence; essentially it would be a verbatim replication of the sentence. A textbase representation would contain the major idea units described in the sentence. This would include Sid (as agent) searching for an apartment, Sid searching Chicago, and so on. Thus, readers at this level would remember the concepts conveyed in the sentence (as a sample recall, "Sid was looking for a place to live in Northern Chicago") but not necessarily every word. At the situation level, the reader might build expectations about the type of apartment Sid is looking for as a function of prior knowledge about Chicago, inferences about the potential neighborhoods Sid might be exploring, and perhaps even elaborations with respect to why Sid is moving. Thus, it is readily apparent that readers can build a variety of representations for what they read as a function of the text proper, the concepts conveyed by the text, and relevant information from prior knowledge (and likely, some integration across these levels).

The situation model is considered central to comprehension. The role of situation models has been considered in written discourse as well as in spoken discourse, such as dialogue (e.g., Pickering & Garrod, 2004). However, most of the research has focused on (narrative) text comprehension. A large body of work has delineated some of the elements or dimensions that readers may encode into situation models. Five such dimensions of situation models have been distinguished based on the event-indexing model; space, time, entity (protagonists and objects), motivation, and causation (Zwaan & Radvansky, 1998). Evidence for these dimensions is consistent with several general assumptions (Zwaan, Langston, & Graesser, 1995a; Zwaan, Magliano, & Graesser, 1995b). Readers attempt to integrate each incoming event with the current mental representation in working memory on each of the five dimensions. In doing so, readers assume that the incoming event shares an index with the active mental representation. A shift on a dimension should lead to an increase in processing time, because a change in the described situation has taken place. Furthermore, the resulting memory representation should reflect this change by showing weaker links between events that are separated by a change than events that are not. These assumptions are entirely consistent with more general theories of language processing, such as the CI model (Kintsch, 1988,1998) and the structure-building framework (Gernsbacher, 1990). In fact, recent work suggests the utility of integrating event-indexing and structure-building frameworks into a cohesive theory, by appealing to the former as a description of the contents of situation models, and the latter as a process model of cognitive activity during reading experiences (e.g., Rapp & Taylor, 2004). Regardless of the nature of that cognitive activity, the event-indexing model serves as a guide for determining factors that influence both the structure and content of memory for discourse.

An example from Zwaan (1996) illustrates these ideas. This study examined how readers' tracking of the passage of time, one of the five dimensions in the event-indexing model, can affect online comprehension and LTM of text. Time shifts are common events in narratives, for example,"Later that day…" or "A few weeks later… ." When they occur, the speaker or writer can use the shift to omit events that are deemed irrelevant to the situation. For example, we usually do not need to know that the main character in a novel has

brushed his teeth or tied his shoes. In fact, when such mundane events are actually reported in a story, it is usually a clue that they will be relevant later (e.g., in a murder mystery). The omission of these types of events in a story can be signaled by a time shift such as *an hour later*. Zwaan created stories that came in three versions. In the *moment* version, the temporal adverbial *a moment later* was used. The assumption was that a moment does not constitute a time shift of any temporal magnitude, and thus maintains the current time frame. In the *hour* and *day* versions, the critical phrases were *an hour later* and *a day later*, respectively. In these cases, there should be a shift to a new time frame, and indeed, more activities can take place within these longer shifts than the shorter *moment* shift. Following one of these shifts, participants were asked to identify whether a probe word had appeared in the story. Probe words were selected from descriptions preceding the temporal adverbial. The findings were consistent with the previously described assumptions of the event-indexing model. Responses to probe words were significantly longer in the hour and day versions than in the moment versions, suggesting that the time shift made the previous event less accessible. A primed-recognition task performed after all of the stories were read showed that when events occurred within the same time frame, they showed more priming than when these same events were separated by a time shift (both in the hour and day cases). This suggests that events from the same time frame are more strongly connected in LTM than events from different time frames.

Considerable research has demonstrated similar results across the dimensions described in the event-indexing model, specifically with narrative texts.

Space. Much of the early work on situation models focused on how the spatial features of descriptions influence memory for texts. Nearly every text has a setting or set of locations in which the described events take place. For instance, texts often detail information about locations, objects in those locations, movement of characters through locations, and other spatial relationships between elements in the text. Classic work on situation models has assessed readers' tracking of spatial information by examining how shifts in space impact the accessibility of information from memory (Bower & Morrow, 1990). For example, participants were asked to memorize a map illustrating a series of rooms and their linear pathways, along with objects contained in each of the rooms (e.g., Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987). After memorizing the map, participants read a story that described a character moving through the rooms. At particular points in the text, participants were presented with pairs of objects and their task was to determine whether those objects were located in the same or in different rooms. Across multiple studies, evidence supports the spatial distance effect; participants take longer to identify objects that are further away from the currently described situation or events in the text. This result suggests that information in the same spatial frame (e.g., a particular room from the map) is strongly activated in memory, and shifts from that spatial frame lead to decrements in response accuracy and speed. This finding is robust across a variety of methodologies and testing conditions (e.g., Bower & Rinck, 2001; Rinck & Bower, 1995, 2000; Rinck, Bower, & Wolf, 1998; Rinck, Hähnel, & Becker, 2001; Rinck, Hähnel, Bower, & Glowalla, 1997; Rinck, Williams, Bower, & Becker, 1996). The prevailing view is that reader focus, guided by the activities and descriptions in currently read text, directly influences the accessibility of

information from memory. This suggests that the spatial concomitants of text descriptions are likely to be tracked and updated as texts unfold. Even in cases without explicit map memorization (e.g., de Vega, 1995; Glenberg, Meyer, & Lindem, 1987), readers monitor the locations of objects and environments.

An important question involves the degree to which spatial models are spontaneously encoded into memory. Evidence suggests that elaborate spatial representations are not formed unless (a) the spatial features of a text are particularly salient or (b) readers are specifically instructed to focus on the spatial descriptions in a story (e.g., de Vega, 1995; Hakala, 1999; Levine & Klin, 2001; O'Brien & Albrecht, 1992; Rich & Taylor, 2000; Taylor, Naylor, & Chechile, 1999; Zwaan, Radvansky, Hilliard, & Curiel, 1998; Zwaan & van Oostendorp, 1993). Thus, the spatial dimension is more or less likely to be tracked as a function of its importance in the situation, especially when it may facilitate comprehension of a particular discourse.

Time. Research on the temporal components of texts has grown considerably in the last 10 years. One reason for this increased interest has been the utility of assessing readers' tracking of temporal dimensions without the map-memorization tasks traditionally employed in spatial experiments (e.g., Morrow et al., 1987). Additionally, time is implicitly (if not explicitly) provided in descriptions, mainly through verb tense or aspect. This ubiquitous quality of time provides an interesting opportunity for assessing the ways in which individuals track, remember, and comprehend event-based information.

In comprehending event sequences described in text, people have been found to entertain the *iconicity assumption*; they assume that events are described in chronological order. For example, when reading Julius Caesar's famous dictum "Veni, vidi, vici," we assume that the Roman Consul first came, then saw, and then conquered, in that sequence (Jakobson, 1971). There are various techniques to describe events in ways that deviate from chronological order and temporal expectations. Not only can we omit events from descriptions as mentioned previously, but we can also describe events later (flashbacks) or earlier (flash forwards) than they have actually occurred in a plot. Events can often overlap with each other and even occur simultaneously. Despite these various potential sequences for events, speakers and writers are constrained by the linear nature of language, which forces them to describe events one at a time. In other words, a discourse producer has to map nonlinear events onto a linear structure, whereas the comprehender has to recover the nonlinear temporal relations among these events from that linear structure. This process of recovering the appropriate order from sparse linguistic input has received an extensive amount of work in narrative comprehension.

Linguistic cues help guide readers' mapping of such events into their appropriate described sequences. These cues include lexical information such as time adverbials and grammatical cues such as verb tense and verb aspect. Recent work has examined the role of verb aspect in comprehension (Bestgen & Vonk, 2000; Carreiras, Carriedo, Fernandez, & Alonso, 1997; Madden & Zwaan, 2003; Magliano & Schleich, 2000; Rinck & Bower, 2001; Zwaan, 1996; Zwaan, Madden, & Whitten, 2000). This work shows that

the temporal nature of a verb or verb clause influences the accessibility of the described events from memory. For example, completed events, as compared to ongoing activities, are deactivated in memory.

Expectations regarding the amount of time necessary for initiating and completing activities also influence the comprehension process (Rapp & Gerrig, 2002). The processes involved in generating and applying expectations about temporal activities help outline how event-based constraints influence the structure and contents of temporal situation models (de Vega, Robertson, Glenberg, Kaschak, & Rinck, 2004; Gennari, 2004; Kelter, Kaup, & Claus, 2004; Radvansky, Zwaan, Federico, & Franklin, 1998; Rapp & Taylor, 2004; Speer & Zacks, 2005).

Entity. Story characters are integral to unfolding plot. Often plots revolve directly around the interactions among characters and objects in the text. Pronouns are one type of linguistic cue speakers and writers use to help comprehenders track such entities in the described situation. By investigating how people resolve pronouns, researchers have gained insight into how comprehenders track characters and objects in discourse (e.g., Gernsbacher & Hargreaves, 1988; Gordon, Grosz, & Gilliom, 1993; Sanford & Garrod, 1981; Sanford, Moar, & Garrod, 1988). For example, when provided with an ambiguous pronoun, readers tend to resolve the pronoun using the main character of a story; thus, important characters in narratives often receive privileged status (and are tracked accordingly), and thus are readily available during comprehension (McDonald & Shaibe, 2002; Sanford, Clegg, & Majid, 1998).

Comprehenders also encode the attributes and characteristics of characters as they read. In everyday situations, we often generate inferences and accompanying expectations about others' emotional states and personality traits (Fiske & Talyor, 1991; Newman & Uleman, 1990; Uleman, Hon, Roman, & Moskowitz, 1996; Winter & Uleman, 1984). Similar processes occur in text comprehension. For example, participants take longer to read outcomes that are inconsistent, as compared to consistent, with emotions, behaviors, and traits suggested by preceding story contexts (e.g., de Vega, Leon, & Diaz, 1996; Gernsbacher, Goldsmith, & Robertson, 1992; Gernsbacher, Hallada, & Robertson, 1998; Gernsbacher & Robertson, 1992). In one study examining readers' propensities for tracking the traits of characters (Rapp, Gerrig, & Prentice, 2001), participants were asked to read character-driven narratives that contained behavioral evidence for a particular trait (e.g., "[Albert's clothes] were buried under old candy wrappers, crumpled magazines, and some dirty laundry," suggesting the trait *sloppy*). In a second story, the same character behaved in a manner either consistent or inconsistent with the trait. Participants tended to agree with outcomes consistent with implied traits, and also took longer to read outcomes inconsistent with those traits. Importantly, these effects did not obtain when stories failed to provide behavioral evidence for that trait (e.g., instead of the above trait sentence, participants read "Albert's friends had suggested meeting outside the pizzeria adjacent to the movie theater"). Readers, then, use character profiles to generate predictive expectations about future narrative events (e.g., Albrecht & O'Brien, 1993; Peracchi & O'Brien, 2004). Additionally, and in line with the event-indexing model, this suggests

that readers track information about characters in a manner similar to that for time and space.

At what level of detail do readers represent information about characters? Current evidence suggests that representations of characters, particularly their emotions, are relatively superficial (Gygax, Oakhill, & Garnham, 2003; Gygax, Garnham, & Oakhill, 2004). This is consistent with views contending that implicit inferences in general may not be specified at levels akin to that for explicit information (McKoon & Ratcliff, 1986; Singer & Remillard, 2004). The situations under which character-based inferences become more specific remain to be outlined, although they are likely influenced by readers' goals and strategies.

To date, there has been much more work on character-based models than object models. This makes sense, given that narratives are typically centered around characters rather than objects. Nonetheless, a common assumption is that the tracking processes involved in encoding and applying such information would be similar regardless of entity type (and, of course, influenced by their perceived importance in the text).

Motivation. Sometimes labeled as intentionality, the dimension of motivation has been assessed with respect to the goals of characters in discourse. In most narratives, goals set the stage for plot; characters attempt to achieve or satisfy some goal, and along the way must accomplish subgoals to complete their activity (e.g., Trabasso & Wiley, 2005). Sometimes, goals may be satisfied (e.g., the hero saves the world), while at other times they may remain unsatisfied (e.g., the villain manages to escape). Indeed, suspense is often set up by creating hurdles that reduce the likelihood of a particular goal being satisfied (e.g., Gerrig, 1989, 1993). Character goals provide justification for character behaviors and guide story plot. Thus, the extent to which readers track goals in texts is critical to theories that assess narrative comprehension.

Comprehenders appear to actively track goals (e.g., Albrecht & Myers, 1995, 1998; Fletcher & Bloom, 1988; Foss & Bower, 1986; Goldman & Varnhagen, 1986; Richards & Singer, 2001; Singer & Halldorson, 1996). Goal information is readily available during reading (e.g., Suh & Trabasso, 1993; Trabasso, van den Broek, & Suh, 1989). Thus, the goals a character has for a particular situation are actively maintained in memory over the course of a reading experience. Indeed, maintaining such goals provides coherence over the course of a text (e.g., Huitema, Dopkins, Klin, & Myers, 1993; van den Broek, Lynch, Naslund, Ievers-Landis, & Verduin, 2003).

Authors often set up circumstances for which multiple goals occur sequentially or simultaneously over the course of some text. Readers can track such multiple goals, even when those goals are hierarchically organized (Suh & Trabasso, 1993). However, in some cases subsequently mentioned goals can reduce the availability of earlier mentioned goals, although the reverse does not seem to occur (Magliano & Radvansky, 2001). Readers appear to show quite sophisticated and dynamic goal-tracking processes. For example, they deactivate goals that have been completed, as measured by accessibility of

the goal from memory, in comparison to newly presented or failed goals (Lutz & Radvansky, 1997; Radvansky & Curiel, 1998). The degree to which goals fluctuate in accessibility may be a function of suppression-based processes, as new goals can reduce the availability of previous goals (Linderholm et al., 2004). Importantly for these cases, neutral information is still generally less accessible than even completed goals, which suggests a hierarchical organization for ongoing goals, completed goals, and nongoals. These studies demonstrate that goals hold an important role in moment-by-moment comprehension, and that they are dynamically updated in memory as plots develop.

Causation. The situations described in texts often lead readers to expect other events, or to attribute causes to particular events as a function of background knowledge. Linguistic cues such as causal connectives (e.g., "because" and "so") have an impact on the unfolding comprehension process and the resulting memory representation (e.g., Caron et al., 1988; Millis & Just, 1994; Traxler, Bybee, & Pickering, 1997). In addition to linguistic cues, the comprehender's background knowledge is instrumental to forming causal representations. For example, the sentence pair "Murray poured water on the bonfire. The bonfire went out" is not simply a temporal sequence of unrelated events, but conveys the idea that the water actually caused the bonfire to go out. To understand this bridging concept, we need to activate our knowledge that *water extinguishes fire*. This is exactly what comprehenders have been shown to do (Singer, 1993; Singer & Halldorson, 1996). Thus, readers appear to track the underlying causal structure of event sequences.

This example, though, also indicates the degree to which causality is likely to be integrated with other dimensions. Causality is often instantiated through conceptual associations with space, goals, time, and so on. In the above case, causality is associated with the entities "Murray," "bonfire," and "water." Also, Murray's goal seems to involve extinguishing the fire. Embedded in larger text, we could imagine cases for which this bridging inference might be a function of space (e.g., Murray does not want to set the nearby woods ablaze) or even time (e.g., it was almost midnight and Murray wanted to go to sleep). This suggests that the dimension of causality is often complementary with other dimensions. In fact, one could take this further to make the claim that, although it may be useful for analytic purposes to consider them separately, in practice situational dimensions rarely appear separately; the five dimensions outlined in the event-indexing model are often directly connected or integrated during discourse presentations. We turn to this issue next.

Interactive dimensions. It is clear that situational dimensions are not completely independent. For example, if the sequence in the previous example had been "The bonfire went out. Murray poured water on the bonfire," then a causal interpretation would not have been possible (or easily activated). Accordingly, research has begun to consider the interactivity among dimensions, for example, between causality and space, and between causality and time (Rapp & Taylor, 2004; Zwaan & Radvansky, 1998; Zwaan & van Oostendorp, 1994). For instance, comprehenders are more likely to track and remember spatial information when it is causally relevant or relevant to a character's goals than when it is not (Jahn, 2004; Sundermeier, van den Broek, & Zwaan, 2005).

Most novels describe multiple characters visiting multiple locations, with characters having diverse goals and characteristics, and all of this occurring within a single plot. Preliminary work on the interactions between dimensions has examined the degree to which readers are more or less likely to track particular dimensions during text experiences. Some evidence points to the dimensions of causality (e.g., Keefe & McDaniel, 1993; Singer & Halldorson, 1996) and character (Rich & Taylor, 2000) as privileged during narrative comprehension. Additional research has suggested that dimensional privilege may be a function of reader goals or text cues for particular reading activities (Taylor & Tversky, 1997). One approach to examining the relative importance of situational dimensions is to investigate the extent to which specific dimensions are impervious to reading instructions. Recent evidence suggests that time and protagonist (and to a lesser extent location) are tracked, even when subjects are instructed to focus on a different dimension (Therriault, Rinck, & Zwaan, 2006). For example, participants remain sensitive to time shifts even when asked to focus on the locations described in texts.

An additional question concerning the interaction between dimensions arises when we consider that particular event dimensions may be correlated (Zwaan et al., 1995a). For instance, space and time are often conceptualized using similar metaphors (e.g., Boroditsky, 2000; McGlone & Harding, 1998). This might suggest that these dimensions can provide complementary information. Although dimensions have traditionally been studied by considering their *supplementary* activity (e.g., what either space or time contribute to comprehension), dimensions may actually have more *complementary* relationships. Information from a particular dimension may not only occur alongside another dimension, but in some cases dimensions may actually inform each other. Thus, investigations of the ways in which dimensions interact, and perhaps become integrated into a cohesive situation model, are of great interest. This has led to a burgeoning area of study examining how multiple dimensions are integrated in situation model construction and application (e.g., Jahn, 2004; Rinck & Weber, 2004; Sundermeier et al., 2005; Zwaan et al., 1998).

As suggested earlier, two dimensions that appear to hold such complementary relationships are space and time. This relationship appears to be interactive and informs the construction of situational representations for texts. In one study investigating this issue, participants read stories describing characters as moving from one spatial location to the next (Rapp & Taylor, 2004). During this movement, characters engaged in activities that could take either a short or long time to complete. This temporal information influenced how readers structured their spatial situation models: participants took longer to recognize start location probes following long activities compared to short activities. Similar work focusing on how readers structure situation models with respect to time (e.g., Zwaan, 1996) shows that readers can also structure their situation models with respect to the interplay of time *and* space. This interplay closely aligns with what we might expect given the degree to which multiple dimensions guide unfolding plot in the diverse texts we commonly read.

Perspective effects. The work reviewed thus far is entirely consistent with the idea that the comprehender takes a perspective with respect to the situation conveyed by the

discourse (Zwaan, 1999b). Perspective effects have a long history in research on memory for discourse. Classic work by Bartlett (1932) demonstrated that individuals tended to distort memory toward information in line with their own experiences. After listening to a story entitled "The War of The Ghosts," British participants tended to recall descriptions including "hunting seals" and "canoes" as "fishing" and "boats." Thus, the perspective that participants brought to the experimental situation influenced their memory for texts. Similar to this classic study, recent work on perspective effects has examined how readers' viewpoints may change their interpretation, comprehension, and memory for texts.

Some studies have explicitly asked readers to assume a perspective within the narrative world, for example, that of a burglar or a homebuyer in a story about a home. Readers recall more information that is relevant to their adopted perspective (Anderson & Pichert, 1978) and spend more time reading perspective-relevant than perspective-irrelevant information (Kaakinen, Hyönä, & Keenan, 2002). However, perspective effects can also be brought about by subtle lexical cues, such as the verbs *come* and *go*. For example, when we read or hear "He came into the room," we are taking the point of view of someone who is already in the room. On the other hand, when we read or hear "He went into the room," we take the point of view of someone who is outside of the room (Black, Turner, & Bower, 1979).

Recent evidence provides support that readers may actually take the visual perspective provided in a narrative. In one such study (Horton & Rapp, 2003), participants read stories describing characters observing the environment. In the experimental condition, a critical object was blocked from the protagonist's view by an occluding object (e.g., a curtain). In control cases, the critical object remained visible to the protagonist. Target questions asked participants about the existence of the critical object. Participants took longer to answer questions for blocked objects than unblocked objects. These results suggest that to some degree, readers assumed the visual perspective of characters in the stories. Further support for this conclusion comes from a different study in which participants were presented with a sentence and then were to make speeded responses to nouns denoting parts of the object mentioned by the last word in the sentence (Borghi, Glenberg, & Kaschak, 2004). Crucially, the sentence was used to manipulate perspective; for example, "You are fueling a car" versus "You are driving a car." The verification of perspective-relevant words (e.g., trunk or horn) was facilitated relative to that of perspective-irrelevant words. These findings align with other, less-visually based studies that demonstrate similar perspective-biased effects. For example, just as distant objects are less accessible in the real world than close objects, words denoting objects far from the protagonist are less accessible than words denoting objects that are close to the protagonist (Glenberg et al., 1987). In this case, reader perspective is based on the location of the protagonist with respect to the rest of the narrative situation, and objects are organized around (or away from) that protagonist.

For the described perspective effects, readers may be constructing representations as if they themselves are involved in the narrative situation (Gerrig, 1993). We discuss this issue further with specific interest in the nature of underlying representations following discourse experiences.

6. THE IMMERSED EXPERIENCER

The research on situation models in narrative comprehension is generally consistent with the notion of the comprehender as an immersed experiencer (Zwaan, 1999b, 2004) in the narrative world (Gerrig, 1993). Traditionally, such views have been espoused in areas including literary theory and linguistics (Genette, 1983; Duchan, Bruder, & Hewitt, 1995). The strong form of this view suggests that readers actually experience information in a narrative as if they were participating in the activity. Evidence for this view comes from an unexpected source: cognitive neuroscience research on humans (and monkeys) suggests that we understand the actions of others by covertly simulating these actions using the motor programs we ourselves would use to perform the action (e.g., Rizzolatti & Arbib, 1998; Rizzolatti & Craighero, 2004). The brain system involved in this process has been dubbed the "mirror system." Given that the mirror system includes Broca's area in humans, it stands to reason that language understanding, like action understanding, might involve the simulation of described actions (Rizzolatti & Arbib, 1998; Gallese & Lakoff, 2005).

The main prediction from the mirror-system theory with regard to language comprehension is that we understand action-related language by covertly activating the motor processes we use to produce these actions. Initial evidence for this prediction has been obtained (Tucker & Ellis, 2004): participants were presented with pictures or words denoting objects and then asked to judge whether the objects were natural or manmade. They made their judgments by manipulating an input device that required either a power grip or a precision grip. Power grip responses were faster to pictures and words denoting objects requiring power grips compared to pictures and words denoting objects requiring precision grips. The reverse was true for precision grip responses. The compatibility effect for words was comparable to that of pictures. This finding suggests that words make available the affordances (Gibson, 1986) of their referent objects. Additional evidence comes from tasks with specific action descriptions (Glenberg & Kaschak, 2002). Participants listened to sentences such as "He opened the drawer," and were asked to make sensibility judgments. These judgments necessitated button press activities requiring either movement toward or movement away from the responder's body. An action-compatibility effect was obtained such that responses were faster when the physical response was in the same direction as the movement implied by the sentence. For instance, responses made toward the body were faster after "He opened the drawer" than after "He closed the drawer" and the reverse was true for responses away from the body. Similar findings have been extensively reported prior to these studies in situations involving positive and negative lexical stimuli (e.g., Chen & Bargh, 1999; Wentura, Rothermund, & Bak, 2000).

There is additional evidence for the relationship between language and action. We note that the affordances of referent objects have an immediate influence on sentence processing (Chambers, Magnuson, & Tanenhaus, 2004). Hand shapes, for example, prime the comprehension of sentences describing the manipulation of objects (Klatzky, Pellegrino, McCloskey, & Doherty, 1989). Recent neuroimaging studies have also

produced converging findings. Motor regions of the brain are active during the comprehension of action words (Hauk, Johnsrude, & Pulvermüller, 2004) and sentences (Tettamanti et al., 2005). More specifically, both of these imaging studies found that the areas of activation in the premotor cortex were somatotopically organized, such that sentences about mouth actions, hand actions, and leg actions each activated different areas, which in other studies have been associated with movement in these effectors.

These findings imply a close coupling between language comprehension and motor programs, which is consistent with the notion of comprehension as simulation. This research is also consistent with other views of "embodied cognition," according to which cognition is grounded in perception and action and relies on the use of perceptual and motor representations, rather than of abstract, amodal, and arbitrary mental representations such as propositional networks or feature lists (e.g., Barsalou, 1999; Glenberg, 1997). A great deal of empirical evidence has been amassed recently showing that visual (and sometimes spatial) representations are routinely activated during language comprehension. This includes visual representations of object shape (Zwaan, Stanfield, & Yaxley, 2002; Zwaan & Yaxley, 2004), orientation (Stanfield & Zwaan, 2001), and motion direction (Kaschak et al., 2005; Zwaan, Madden, Yaxley, & Aveyard, 2004); for more extensive reviews, see Spivey, Richardson, and Gonzalez-Marquez (2005), Zwaan (2004), and Zwaan and Madden (2005). Tanenhaus and Trueswell (this volume) discuss the close link between language and visual representations in the context of the visual-world paradigm.

In order to function as parsimonious theories of mental representations, embodied views of cognition should not only provide an account of the use and understanding of concrete concepts, but also for that of abstract ones. Accordingly, perceptual and motor representations are thought to underlie not only the comprehension of sentences about concrete objects and actions, but also the comprehension of abstract concepts such as *justice* and *love* (Barsalou & Wiemer-Hastings, 2005; Gallese & Lakoff, 2005; Prinz, 2005).

The studies discussed in this section have mostly focused on the comprehension of words or sentences. However, their relevance to the study of discourse – narrative, expository, and procedural – should be clear. It stands to reason that perceptual or motor representations activated during sentence or word comprehension play a role in discourse comprehension. Earlier, in Section 4, we stated that theories of discourse comprehension need to come to terms with two important facts. The first fact is that language comprehension involves incomplete representations. This is a function of limited attentional and memory resources, although these can be expanded in skilled comprehension (Ericsson & Kintsch, 1995). As such, it is unrealistic to assume that comprehenders build elaborate propositional networks by promiscuously activating large numbers of inferences (Graesser et al., 1994; McKoon & Ratcliff, 1992). At the same time, the sales figures for the *Harry Potter* saga, *The Lord of the Rings* trilogy, and *The Da Vinci Code* attest to the phenomenological experience of narrative comprehension as a highly engrossing and immersive activity (see Nell, 1988, for empirical evidence). It is difficult to see how this can be explained by sparse networks of abstract, amodal, and arbitrary propositions.

A view that assumes perceptual and motor representations underlie cognition provides a way to address the dilemma. Consider the following sentences (from Sanford & Garrod,1998):

He put the wallpaper on the table. Then he put his mug of coffee on the wallpaper.

These sentences are quite easy to understand. A (somewhat simplified) propositional representation of these sentences would be [[PUT[HE, WALLPAPER]][ON[TABLE, WALLPAPER]]] and [[PUT[HE, MUG]][ON[MUG, WALLPAPER]]]. But now consider the following sentence pair (also from Sanford & Garrod, 1998):

He put the wallpaper on the wall. Then he put his mug of coffee on the wallpaper.

Most people notice right away that the second sentence does not make sense, or at least would result in a broken mug and coffee spilled all over the floor. However, it is not clear how they could come to this conclusion based on a propositional representation like: [[PUT[HE,WALLPAPER]] [ON[WALL,WALLPAPER]]] and [[PUT[HE, MUG]][ON [MUG, WALLPAPER]]]. A large number of additional propositions would have to be activated, such as that (1) walls are typically vertical, (2) wallpaper can be made to adhere to walls, (3) when wallpaper is attached to a wall, it is also vertical, (4) wallpaper when attached to a wall does not support objects, (5) unless some way to attach the object, e.g., glue is used, or (6) the object is a small insect, arachnid, reptile, or amphibian. As our discussion of inferences shows, most researchers assume that elaborative inferences are made only under a narrow set of circumstances; the complex sets of inferences necessary for the above explanation, then, seem even less tenable.

How, then, are we to account for comprehender's almost instantaneous balking at the validity of the second set of sentences in Garrod and Sanford's example? The problem seems less daunting if we abandon the idea of abstract, amodal, and arbitrary representations, and instead view comprehension as the language-guided mental simulation of the described situation. The key idea is that comprehension engages perceptual and motor systems by activating previous experiences, or *experiential traces* (Zwaan, 1999a, 2004), stored in these areas. For example, our reading or hearing of "wall" may activate a visual representation, which necessarily involves its verticality; the phrase "put the wallpaper" activates the motor program that we would use to hold and move wallpaper (e.g., using both hands); the prepositional phrase "on the wall" would activate a motor representation in which the arms are extended above the head and perhaps a visual representation of wallpaper occluding our view of the wall; the phrase "put his mug" would activate a motor representation of holding a mug (presumably by its handle) and moving it; the phrase "on the wallpaper," which would activate a visual representation of a vertical surface, would quickly lead to the conclusion that the action cannot be carried out because wallpaper cannot support the mug. Thus, this might be a way in which we can describe how linguistic input facilitates the construction of rich mental representations without assuming too much in the way of processing and knowledge activation. Mental simulations involving experiential traces can allow

humans to use language in a vicarious manner to gain "lifelike" experiences without requiring too much in the way of inferential processing activity. Current work continues to address the nature of these embodied representations by contrasting them with traditional accounts that invoke propositional explanations. The accumulating evidence continues to favor an embodied view.

7. CONCLUSION

Discourse comprehension is an essential and complex human endeavor involving processes and mechanisms associated with general cognition (e.g., memory and attention). We opened this chapter with a set of riddles in order to demonstrate the role of some of those processes. We now close this chapter with a final, fifth riddle. Again, recall that adequate comprehension is a function of incorporating background knowledge and current text in the service of problem solving. Hopefully that serves as enough of a hint to suggest how the reader might come up with an answer for this final question.

- In a race between an elephant and a giraffe, who do you think might win?

  Well, if *our* giraffe is still in that fridge ….

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