# Two Decades of Structure Building

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During the past decade I have been developing a very simple framework for describing the cognitive processes and mechanisms involved in discourse comprehension. I call this framework the Structure Building Framework, and it is based on evidence provided during the first decade of discourse processing research. According to the Structure Building Framework, the goal of comprehension is to build coherent mental representations or *structures*. Comprehenders build each structure by first laying a foundation. Comprehenders develop mental structures by mapping on new information when that information coheres or relates to previous information. However, when the incoming information is less related, comprehenders shift and attach a new substructure. The building blocks of mental structures are memory nodes, which are activated by incoming stimuli and controlled by two cognitive mechanisms: suppression and enhancement. In this article, first I review the seminal work on which the Structure Building Framework is based (the first decade of structure building research); then I recount the research I have conducted to test the Structure Building Framework (the second decade of structure building research).

Two decades ago when the first issue of *Discourse Processes* was being prepared for publication I was more likely to be reading a Dallas, Texas high school sophomore's five-paragraph theme on why the legal drinking age should be maintained at age 18 than I was to be reading a scholarly article on how students produce the genre of discourse that we so lovingly call the five-paragraph theme. Two decades ago I was more likely to be collecting informal data on why ninth-graders prefer reading *Romeo and Juliet* to *Julius Caeser* than I was to be conducting laboratory experiments on the mental processes underlying their comprehension of either play. And two decades ago I was more likely to be reporting to

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my colleagues the latest conversation overheard in the teachers' lounge than I was to be reporting to my colleagues the results of a state-of-the-art reaction time experiment.

Alas, when the field of discourse processing launched its flagship journal, I was no where close to the dock. This is not to say that I wasn't producing discourse, comprehending discourse, or informally observing its production and comprehension; I just wasn't doing it for a living. I'd have to wait until 1980, when I began graduate school at the University of Texas at Austin with my mentor Don Foss before I could even pronounce the word anaphora, much less spell it. And then I would have to wait until 1983, when I assumed my first faculty position, as an assistant professor at the University of Oregon and was surrounded by gurus of cognitive psychology such as Mike Posner, Doug Hintzman, and Steve Keele, before I would realize that so much of discourse processing can be explained by general cognitive processes and mechanisms.

That is the simple history of the Structure Building Framework, a simple framework I have used the past decade to explain the processes and mechanisms involved in discourse comprehension (the lion's share of my research) and discourse production (the mouse's share of my research). However, the Structure Building Framework, in print only since the beginning of the second decade of discourse processing research, is based on solid evidence provided by the first decade of discourse processing research. In this article, first I review the seminal work on which the Structure Building Framework is based (the first decade of structure building research); then I review the research I have conducted to test the Structure Building Framework (the second decade of structure building research). I shall begin with a brief overview of the framework.

## The Structure Building Framework: A Brief Overview

Language can be viewed as a specialized skill involving language-specific processes and mechanisms. Another position views language as drawing on general, cognitive processes and mechanisms—processes and mechanisms that underlie nonlinguistic tasks as well. This commonality might arise because language comprehension evolved from nonlinguistic cognitive skills (Bates, 1979; Lieberman, 1984), or because the mind is based on a common architecture, such as a connectionist architecture (Rumelhart & McClelland, 1986). In my research, I have adopted the view that many of the processes and mechanisms involved in language comprehension are general cognitive processes and mechanisms. My Structure Building Framework identifies a few of those general cognitive processes and mechanisms. According to the Structure Building Framework, the goal of comprehension is to build coherent mental representations or *structures*. At least three component processes are involved. First, comprehenders lay foundations for their mental structures. Next, comprehenders develop mental structures by mapping on new information when that information coheres or relates to previous information. However, when the incoming information is less coherent, comprehenders employ a different process: They shift and build a new substructure. Thus, most representations comprise several branching substructures.



The building blocks of these mental structures are memory nodes. Memory nodes are activated by incoming stimuli. Initial activation forms the foundation of mental structures. Once a foundation is laid, subsequent information is often mapped on because the more coherent the incoming information is with the previous information, the more likely it is to activate the same or connected memory nodes. In contrast, the less coherent the incoming information is, the less likely it is to activate the same or connected memory nodes. In this case, the incoming information activates a different set of nodes, and the activation of these other nodes forms the foundation for a new substructure. In addition, once memory nodes are activated, they transmit processing signals to enhance (increase) or suppress (dampen or decrease) other nodes' activation. In other words, once memory nodes are activated, two mechanisms control their level of activation: suppression and enhancement. Memory nodes are enhanced when the information they represent is necessary for further structure building; they are suppressed when the information they represent is no longer as necessary.

I have empirically explored the three processes involved in structure building: laying a foundation, mapping information onto a foundation, and shifting to build new substructures. I have also empirically explored the two mechanisms that control these structure building processes: suppression and enhancement. I have found that these general cognitive processes and mechanisms underlie numerous comprehension phenomena. I have also found that differences in the efficiency of these processes and mechanisms underlie differences in adult comprehension skill. In the next section I briefly describe evidence supporting the Structure Building Framework. (A more complete description is available in *Language Comprehension as Structure Building*, with updates of that monograph available in Gernsbacher, 1991a, 1995.)

## Evidence for the Structure Building Framework: The First Decade

***Evidence for the Cognitive Process of Laying a Foundation: The First Decade.*** According to the Structure Building Framework, the initial stage of comprehension involves laying a foundation for each mental representation or structure. This proposal was based on a large body of converging data collected during the first decade of research on discourse processes. This large body of converging data demonstrated that comprehenders slow down when they are presumably laying mental foundations for their mental structures. For instance, sub-

jects in sentence-by-sentence reading time experiments spent more time reading the first sentence in a paragraph than sentences that occur later (Cirilo, 1981; Cirilo & Foss, 1980; Glanzer, Fischer & Dorfman, 1984; Graesser, 1975; Haberlandt, 1980, 1984; Haberlandt, Berian & Sandson, 1980; Haberlandt & Bingham, 1978; Haberlandt & Graesser, 1985; Olson, Duffy & Mack, 1984). In fact, subjects spent more time reading the first sentence regardless of whether it was the paragraph's topic sentence (Greeno & Noreen, 1974; Kieras; 1978, 1981). Subjects also spent more time reading the first sentence of each episode within a story than sentences that occurred later in that episode (Haberlandt, 1980, 1984; Haberlandt et al., 1980; Mandler & Goodman, 1982). Similarly, when subjects read independent sentences (sentences not embedded in a story), they spent more time reading the first word of each sentence than words that occurred later (Aaronson & Ferres, 1986; Aaronson & Scarborough, 1976; Chang, 1980). In fact, subjects read the same word more slowly when that word occurred at the beginning of a sentence or phrase than when it occurred later (Aaronson & Scarborough, 1976).

The same comprehension time effects were observed when subjects self paced their viewing of nonverbal, picture stories. Subjects spent more time viewing the first picture of a picture story or the first picture in each episode than later-occurring pictures (Gernsbacher, 1983). And when listening to spoken language, subjects required more time to identify a target word or phoneme when that target occurred during the beginning of its sentence or phrase than when it occured later (Cairns & Kamerman, 1975; Cutler & Foss, 1977; Foss, 1969, 1982; Hakes, 1971; Marslen-Wilson, Tyler & Seidenberg, 1978; Shields, McHugh & Martin, 1974). These phenomena suggested that comprehenders use initial segments (words, sentences, and pictures) to lay foundations for their mental representations of larger units (sentences, paragraphs, and story episodes). But, rather importantly, these phenomena were not observed when the information did not lend itself to coherent mental representations—for instance, when the sentences or paragraphs were self-embedded or extensively right-branching (Foss & Lynch, 1969; Greeno & Noreen, 1974; Hakes & Foss, 1970; Kieras, 1978, 1981).

Memory experiments conducted during the first decade of discourse processing research also suggested that a general cognitive process involved in comprehension is laying a foundation. Subjects recalled more of a story episode when they were cued by the first sentence of the episode than when they were cued by a later-occurring sentence (Mandler & Goodman, 1982), in the same way that subjects recalled more of a sentence when they were cued by the sentence's first content word or by a picture of that first content word than when they were cued by a later-occurring word (Bock & Irwin, 1980; Prentice, 1967; Turner & Rommetveit, 1968). Thus, initial stimuli seemed to serve as a foundation onto which subsequent information was added. Indeed, initial information played such a fundamental role in organizing mental structures in these early experiments that when subjects were asked to state the main idea of a paragraph, they were most likely to select the initial sentence—even when the actual theme was captured by a later-occurring sentence (Kieras, 1980). This phenomenon also suggested that the initial process of comprehension involves laying a foundation.



***Evidence for the Cognitive Process of Mapping: The First Decade.*** According to the Structure Building Framework, once a foundation is laid, incoming information that coheres with previous information is mapped onto the developing structure or substructure. I envision mapping as something like creating an object out of papier-mâché. Each strip of papier-mâché is attached to the developing object, augmenting it. Appendages can be built, layer by layer. Comprehenders build mental structures in a similar way: Each piece of incoming information can be mapped onto a developing structure to augment it, and new substructures (like appendages) are built in the same way.

Why does mapping occur? According to the Structure Building Framework, mental structures are built of memory nodes, and memory nodes are activated by incoming stimuli. The initial activation of memory nodes forms the foundations of mental structures. Incoming information is often mapped on to a developing structure because the more the incoming information overlaps with the previous information, the more likely it is to activate similar memory nodes. That is why coherent information is easier to map onto a developing structure, and why coherent information is likely to be represented in the same structure or substructure.

What do I mean by coherent information? I have suggested that coherence arises from at least four sources: referential, temporal, locational, and causal continuity. These four sources are not independent; coherent information is typically characterized by all four—and more. The first decade of discourse processing research provided multiple sources of data demonstrating that each of these sources encourages mapping. For instance, subjects read the second of a pair of sentences faster when that second sentence referred to a concept mentioned in the first sentence (i.e., the two sentences were referentially coherent). For example, *The beer was warm* was read faster when it followed, *We got some beer out of the trunk* than when it follows, *We checked the picnic supplies.* However, simply repeating a word does not ensure referential coherence; the word must refer to the same concept. *The beer was warm* was not read faster when it followed *Andrew was especially fond of beer*, presumably because the beer referred to in the second sentence was not the same as the beer introduced in the first sentence (Haviland & Clark, 1974).

Referential coherence is also signaled with pronouns. The pronoun *she* in the sentence *The aunt ate the pie, and she was senile* suggests that the person who ate the pie was also the person who was senile. In contrast, *The aunt ate the pie, and*

*Alice was senile* implies two different referents. Memory research in the 70s demonstrated that subjects were more likely to remember a sentence in its entirety when the second clause contained a pronoun than when the second clause introduced a new referent (Lesgold, 1972). This phenomenon suggests that referential coherence, signaled by pronouns, encourages comprehenders to map the second clause onto their substructure representing the first clause.

The first decade of discourse processing research also provided evidence that temporal coherence encourages mapping: Sentences that described events that occurred during the same time frame were read faster than sentences that described events that occur during two different time frames. For example, during a narrative about a restaurant meal, a sentence beginning with the phrase *Ten minutes later* was read faster than a sentence beginning with the phrase *Ten days later* (Anderson, Garrod & Sanford, 1983). The first decade of discourse processing research also provided evidence that locational coherence encourages mapping: Sentences that described events that occurred in the same location were read faster than sentences that described events that occured in two different locations. For example, if the narrator was located *inside the living room*, a sentence that maintained that point of view, *The door opened, and John came into the living room*, was read faster than a sentence that changed that point of view, *The door opened, and John went into the living room* (Black, Turner & Bower, 1979).

Finally, the first decade of discourse processing research also provided evidence that causal coherence encourages mapping: Sentences that described events that were likely consequences of previous events were read faster than sentences that described events that were less likely consequences. For example, *The next day, Joey's body was covered in bruises* was read faster following *Joey's big brother punched him again and again* than following *Joey went to a neighbor's house to play* (Keenan, Baillet & Brown, 1984; see also Bloom, Fletcher, van den Broek, Reitz & Shapiro, 1990; Duffy, Shinjo & Myers, 1990; Fletcher, Hummel & Marsolek, 1990; Haberlandt & Bingham, 1978; Myers, Shinjo & Duffy, 1987).

***Evidence for the Cognitive Process of Shifting: The First Decade.*** According to the Structure Building Framework, when incoming information is less coherent, comprehenders shift from building one substructure and develop another. Why does shifting occur? The building blocks of mental structures are memory nodes, which are activated by incoming stimuli. Initial activation forms the foundations of mental structures, and the continued activation of the same or related memory nodes enables mapping. But incoming information that indicates a change activates different memory nodes; activation of these different nodes forms the foundation of a new substructure. Shifting to build a new substructure requires processing, which should be manifested in increased comprehension time. This proposal was based on numerous reading-time experiments conducted



during the first decade of discourse processing research, which demonstrated that subjects slowed down after they encountered stimuli that indicated a change. For instance, subjects spent more time reading words and sentences that changed a previously established topic, point of view, location, or temporal setting than words and sentences that maintain the previous topic, point of view, location, or temporal setting (Anderson et al., 1983; Black et al., 1979; Daneman & Carpenter, 1983; Dee-Lucas, Just, Carpenter & Daneman, 1980; Haberlandt et al., 1980; Lesgold, Roth & Curtis, 1979; Mandler & Goodman, 1982; Olson et al., 1984). Subjects also had more difficulty accessing information that was presented before a change in topic, point of view, location, or temporal setting than they had accessing information that was presented after such a change (Anderson et al., 1983; Clements, 1979; Mandler & Goodman, 1982). According to the Structure Building Framework, these changes in topic, point of view, location, or temporal setting trigger comprehenders to shift. Therefore, the information that was presented before a change is represented in one substructure, whereas the information presented after a change is represented in another. According to the Structure Building Framework, comprehenders have greatest access to information represented in the substructure that they are currently developing.

***Evidence for the Cognitive Mechanisms of Suppression and Enhancement: The First Decade.*** According to the Structure Building Framework, when memory nodes are activated, they transmit processing signals that suppress or enhance the activation of other memory nodes. Thus, these two mechanisms modulate the activation of memory nodes. Suppression decreases or dampens the activation of memory nodes when the information they represent is no longer necessary for the structure being built. Enhancement increases the activation of memory nodes when the information they represent is relevant to the structure being built. By modulating the activation of memory nodes, suppression and enhancement contribute to structure building. Although the mechanisms of suppression and enhancement are not reserved for language, they are crucial to successful comprehension. Consider only the need for suppression: In many situations, irrelevant or inappropriate information is activated, unconsciously retrieved, or naturally perceived. For instance, reading the letter string *rows* can activate the phonological sequence */roz/*, which can activate the word *rose* (van Orden, 1987; van Orden, Johnston & Hale, 1988). But to correctly understand a homophone (*rows*), comprehenders must suppress the homophone's alternate forms (*rose*). Comprehenders must also suppress information from other media. We read in the presence of background noise, and we conduct conversations in the presence of visual stimuli. Comprehenders often experience interference across media. For instance, it is harder to read a word when it is written within a line-drawn object, and it is harder to name a line-drawn

object if a word is written within it (Smith & McGee, 1980). For successful comprehension, irrelevant information from other modalities must be suppressed (Tipper & Driver, 1988).

***Evidence for Individual Differences in Structure Building: The First Decade.*** The first decade of research on discourse processes demonstrated that individuals differed in their skill at comprehending language; however, this research also indicated that at an adult level of proficiency, individuals who were skilled at comprehending written language were shown to be similarly skilled at comprehending spoken language (Daneman & Carpenter, 1980; Jackson & McClelland, 1979; Palmer, MacLeod, Hunt & Davidson, 1985; Perfetti & Lesgold, 1977; Sticht, 1972, 1978; Sticht, Beck, Hauke, Kleiman & James, 1974; Sticht & James, 1984; Townsend, Carrithers & Bever, 1987). Therefore, some of the reasons why adults differ in comprehension skill might not be specific to modality.

According to the Structure Building Framework, many of the processes and mechanisms involved in language comprehension are general cognitive processes and mechanisms. Therefore, some of the reasons why adults differ in comprehension skill might not even be specific to language. Many comprehension phenomena, which occurred regardless of whether the media were linguistic or nonlinguistic, lead to this proposal. For instance, subjects perceived the same episode structure regardless of whether they viewed a narrative as a movie without dialogue or they heard the narrative as text (Baggett, 1979). Subjects drew the same inferences, regardless of whether they viewed textless cartoon sequences or they read verbal descriptions of those sequences (Baggett, 1975). Subjects judged the plausibility of a sentence just as quickly when a picture substituted for one of its words as when the sentence contained only words or they read or heard text-based stories; moreover, in all media, comprehending a new episode exacerbated this rapid forgetting (Gernsbacher, 1985). When recalling a story, subjects emphasized and elaborated the same information, regardless of whether they viewed the story as a movie without dialogue or heard it as text (Baggett, 1979). These phenomena suggested the following hypothesis: *Individuals differ in their skill at building coherent mental representations, regardless of modality.* In the next section I shall review the second decade of research on structure building, including research that directly tested this hypothesis.

## Research on the Structure Building Framework: The Second Decade

***Research on the Cognitive Process of Laying a Foundation: The Second Decade.*** According to the Structure Building Framework, the first process involved in building a mental structure for a clause, sentence, paragraph, or story episode is laying a foundation for the structure that represents that clause, sentence, paragraph, or story episode. In previous research, my students and I discovered one striking manifestation of the process of laying a foundation for a sentence-level representation: the Advantage of First Mention. The Advantage of First Mention has since been replicated numerous times in spoken (MacDonald & MacWhinney, 1990; McDonald & MacWhinney, 1995) and written English (Garnham, Traxler, Gernsbacher & Oakhill, 1996; Gernsbacher, 1989; Neath & Knoedler, 1994; Shaibe & McDonald, 1993) as well as Spanish (Carreiras, Gernsbacher & Villa, 1995), Korean (Lee, 1992), and American Sign Language (Emmorey, in press). The advantage is that the participant mentioned first in a sentence is more accessible than the participant mentioned second. For example, after reading the sentence, *Tina beat Lisa in the state tennis match*, if subjects are asked whether *Tina* occurred in the sentence, they respond considerably faster if *Tina* was the first participant mentioned in the sentence (as in *Tina beat Lisa in the state tennis match*) than if *Tina* was the second participant mentioned in the sentence (as in *Lisa beat Tina in the state tennis match*).



According to the Structure Building Framework, first-mentioned participants are more accessible because they form the foundations for their sentence-level representations, and because it is through them that subsequent information is mapped onto a developing representation. Thus, according to the Structure Building Framework, the Advantage of First Mention arises from general cognitive, not linguistic factors. Indeed, Gernsbacher and Hargreaves (1988) discovered that the Advantage of First Mention occurs regardless of whether the first-mentioned participants are semantic agents or patients, syntactic subjects, or literally the initial words of their sentences.

When we first discovered the Advantage of First Mention, we realized that it seemed to contradict another well-known advantage—the Advantage of Clause Recency, which occurs immediately after subjects hear or read a two-clause sentence. For example, subjects recognize the word *oil* more rapidly after they hear *Now that artists are working fewer hours, oil prints are rare* than after they hear *Now that artists are working in oil, prints are rare* (Caplan, 1972). So, like the Advantage of First Mention, the Advantage of Clause Recency is also an advantage based on order, but the Advantage of Clause Recency is for the most recently mentioned concept (Chang, 1980; von Eckardt & Potter, 1985).

Gernsbacher, Hargreaves and Beeman (1989) resolved this discrepancy by measuring the accessibility of sentence participants in two-clause sentences, such as *Tina gathered the kindling, and Lisa set up the tent.* We discovered that comprehenders represent each clause of a multi-clause sentence in its own substructure; comprehenders have greatest access to the information represented in the substructure that they are currently developing (hence, the Advantage of Clause Recency); however, after comprehenders have built substructures to represent both clauses, information from the first clause is more accessible because the first

clause serves as a foundation for the sentence-level representation (hence, the Advantage of First Mention). We also discovered that the Advantage of Clause Recency is a fairly quick-lived phenomenon, whereas the Advantage of First Mention is a relatively long-lived characteristic of the representation of a sentence. The Advantage of First Mention persists (and increases) for the longest duration that we have measured (i.e., 2000 ms after subjects finish reading a sentence).

Furthermore, we discovered that the Advantage of First Mention and the Advantage of Clause Recency are not mutually exclusive. We measured the accessibility of each of four participants (e.g., *Dave and Rick gathered the kindling, and John and Bill set up the tent*). At the point where we suspected subjects were completing their representations of the second clause, we observed both an Advantage of Clause Recency and an Advantage of First Mention: Both participants from the second clause were more accessible than both participants from the first clause; yet, within each clause, the first-mentioned participants were more accessible than the second-mentioned participants. When we delayed the test point, we no longer observed an Advantage of Clause Recency, only an Advantage of First Mention, both within each clause (first-mentioned participants were more accessible than second-mentioned participants) and between the two clauses (participants in the first clause were more accessible than participants in the second clause).

Gernsbacher and Hargreaves (1992) discovered the cross-linguistic generality of the Advantage of First Mention. If the Advantage of First Mention arises from the general, cognitive process of laying a foundation, then it should occur in languages other than English. We reviewed numerous languages in which speakers and writers have considerable flexibility in how they order the grammatical items within a sentence, as well as languages in which speakers and writers have relatively little flexibility in how they order the grammatical items within a sentence. From this extensive body of published cross-linguistic data we concluded that speakers and writers exploit different grammatical forms so that they place particular information first in a sentence. This primary placement occurs in languages whose word order is more rigid than English as well as languages whose word order is freer than English. Indeed, the evidence that we amassed strikingly supported Levelt's (1981) admonition that speakers and writers should carefully decide "what to say first."

Recently, Carreiras et al. (1995) discovered that the Advantage of First Mention occurs in Spanish. This discovery was important because our previous demonstrations of the Advantage of First Mention in English could be attributable to the fact that English speakers are particularly sensitive to the order in which words occur in sentences. That is, although our previous experiments, conducted in English, ruled out the possibility that the Advantage of First Mention in English



arises from English linguistic factors (e.g., the first-mentioned participants being syntactic subjects or semantic agents), English speakers might still show a language-specific preference for the first position of a sentence (because typically syntactic subjects and semantic agents occur in the "privileged" first position in English sentences, and order of mention is very informative for English speakers). In contrast, Spanish speakers rely considerably less on word order for sentence comprehension (Contreras, 1976; Kail, 1989; MacWhinney & Bates, 1989); thus, Spanish seemed an ideal language in which to test empirically the generality of the Advantage of First Mention. And indeed, we discovered that the Advantage of First Mention does occur in Spanish: Response times to the test name, *María*, were considerably faster after Spanish speaking subjects read, *María y Diana fueron al restaurante* (Maria and Diana went to the restaurant) than after they read, *Diana y María fueron al restaurante.*

Carreiras et al. (1995) also discovered that the Advantage of First Mention occurs even when first-mentioned participants are syntactic objects. We capitalized on a syntactic structure that is considerably more frequent in Spanish than in English: Object-Verb-Subject word order. We compared subjects' latencies to recognize first- versus second-mentioned participants in Spanish O-V-S active-voice sentences (e.g., *A Diana la invitó María a cenar en casa* [Diana, Maria invited to eat dinner at home]) with their latencies to recognize first- versus second-mentioned participants in Spanish S-V-O active-voice sentences (e.g., *María invitó a Diana a cenar en casa* [Maria invited Diana to eat dinner at home]). The Advantage of First Mention occurred in both types of constructions, and the Advantage was not compromised by syntactic position. We (Carreiras et al., 1995) also discovered that the Advantage of First Mention occurs for first-mentioned inanimate entities. Subjects responded considerably more rapidly to the test word *leche* [milk] after reading, *La leche y la fruta son alimentos básicos* [Milk and fruit are basic foods], than after reading, *La fruta y la leche son alimentos básicos.*

After the first half-decade after our first investigations of the Advantage of First Mention were first presented, the first naysayers came forth. Riesbeck and Fitzgerald articulated the following complaint in their 1994 *Psycoloquy* article:

> Consider your understanding of this example of Gernsbacher's: "Tina beat Lisa in the state tennis match." Who is Tina? Who is Lisa? What state? What tennis match? Who is telling you this and why? You have no answers for these questions. The sentence is an experimental test probe, not an act of communication. Its content goes in one ear and out the other. It is about nonexistent entities, and is not intended to connect to or affect your episodic memory.

Clark (this volume) has also accused me of designing utterances for my laboratory experiments that were ignorant of my audience.

In my defense, let me say that I assume that comprehenders can and do build mental structures to represent sentences, even if those sentences describe the actions of fictional participants. Moreover, I propose that comprehenders build their mental structures to represent fictional events by consulting their prior knowledge. Nonetheless, I thought it important to investigate whether the Advantage of First Mention occurs for well-known participants; therefore, in Gernsbacher, Robertson, Rootberg and Campana (1997) subjects heard sentences such as, *Michael Jordan and O.J. Simpson each appeared on the covers of six magazines* versus *O.J. Simpson and Michael Jordan each appeared on the covers of six magazines*, and we measured the accessibility of the first- versus second-mentioned participant. If the Advantage of First Mention reflects the general cognitive process of laying a foundation, and if comprehenders use first-mentioned participants as foundations for their mental structures regardless of whether those first-mentioned participants are culturally known or merely fictional, then we should have observed an Advantage of First Mention in this experiment. And we did.

Another concern about the Advantage of First Mention is that heretofore we have observed the advantage only while subjects were building mental structures to represent independent, single sentences. Indeed, subjects in these experiments were told explicitly to interpret each sentence in the series independently from the others. Therefore, in Gernsbacher et al.'s (1997) second experiment we asked whether the Advantage of First Mention that had heretofore been observed only when subjects were comprehending isolated sentences would occur when we embedded those sentences in a meaningful passage, for example:

> One weekend this summer my friends and I went camping in northern Wisconsin. We left on a Friday night and reached camp just as it was getting dark. I went off in search of the bathrooms since I had been drinking soda all the way up. The others stayed behind to prepare camp. Tina/Lisa set up the tent and Lisa/Tina gathered the kindling. Judy and Nora unpacked the sleeping bags so we could just hop into them when we got tired of sitting in front of the fire. The rest of the weekend was spent fishing and swimming. We enjoyed it so much we decided to do it again next summer.

We predicted that the Advantage of First Mention would occur for sentences within passages, because even when comprehenders are building mental structures of a longer passage, we propose that the initial information within each sentence serves as the foundation for that sentence-level structure. And that is exactly what we observed.

Previously, the Advantage of First Mention has been observed for animates, introduced by proper names, such as *Tina, Lisa, Michael Jordan*, and *O.J. Simpson*, for animates, introduced by common nouns, such as *the teacher* and *the banker*, and for inanimates, such as *milk* and *fruit*. But again we asked, how generalizable is the Advantage of First Mention? Does the advantage that we have observed with nominals extend to adverbials? If the process of laying a foundation is a general cognitive process, and if comprehenders use initial information to lay foundations for their sentence-level representations, then the Advantage of First Mention should extend to other first-mentioned concepts, for instance, adverbs of time, location, and manner.



To test this prediction, in Gernsbacher et al.'s (1997) third experiment we presented two-clause sentences, such as *In the evening Tina set up the tent and in the morning Tina gathered the kindling* as opposed to *In the morning Tina set up the tent and in the evening Tina gathered the kindling*. In our fourth experiment, the adverbials were locatives, such as *Near the stream Tina set up the tent and near the bluffs Tina gathered the kindling* as opposed to *Near the bluffs Tina set up the tent and near the stream Tina gathered the kindling*, and in a fifth experiment the adverbials were adverbs of manner, such as *Efficiently Tina set up the tent and methodically Tina gathered the kindling* as opposed to *Methodically Tina set up the tent and efficiently Tina gathered the kindling*. If the Advantage of First Mention extends to adverbials, then adverbials mentioned first should be more accessible than adverbials mentioned second. Once again, that is exactly what we observed.

***Research on the Cognitive Process of Mapping: The Second Decade.*** According to the Structure Building Framework, once comprehenders have laid a foundation for their mental structures, they develop those structures using the cognitive process of mapping. Incoming information that coheres with or relates to previously comprehended information is mapped onto the developing structure or substructure. What guides this mapping process? I have developed the theoretical assumption that comprehenders use various cues of coherence, coreference, and continuity; these cues are learned through experience with the world and experience with language (Gernsbacher, 1996; Gernsbacher & Givón, 1995). For example, comprehenders familiar with English pronouns have learned that *she* (typically) refers to a female; comprehenders familiar with English articles have learned that *the* typically precedes a definite concept (a concept that has been mentioned before, is in the deictic environment, e.g., *Just put the papers on the desk*, is part of a shared culture, e.g., *the sun, the President*, or is a component of a previously mentioned entity, e.g., *I'm reviewing a grant proposal. The ideas are terrific*). Comprehenders familiar with the meanings of the terms *scientist*, *man*, and *woman* have learned that the two expressions, *the man* and *the woman*, probably do not refer to the same entity, whereas the two expressions, *the scientist* and *the man*, can refer to the same entity, as can *the scientist* and *the woman* (although mapping the latter two expressions is a bit harder, an unfortunate circumstance

that we have investigated). Comprehenders familiar with the event described by the clause, *Susan's baby was sick*, have learned that the event described by the clause, *Susan phoned the doctor*, is a likely consequence. Thus, comprehenders' knowledge gained through their experience with events, entities, and relations in the world, as well as their knowledge of the language used to communicate about those events, entities, and relations, enables them to interpret cues that signal coherence.

Interpreting coherence cues can feel relatively unconscious or relatively deliberate. The Structure Building Framework allows for activation that occurs relatively "passively" and relatively "strategically." The crucial issue is that information—knowledge of various sorts—is activated during comprehension; indeed, comprehension is a quintessential act of using and acquiring knowledge. According to the Structure Building Framework, the building blocks of mental structures are memory nodes. Memory nodes represent previously stored information in a distributed fashion, such that a pattern of memory node activation can represent the meaning of a word, the meaning of a phrase, the meaning of a sentence, or the meaning of a passage (Hinton, McClelland & Rumelhart, 1986). When memory nodes are activated, the information they represent becomes available for comprehension. This information might be knowledge that was acquired years earlier when the comprehender mastered the English pronoun system, knowledge that was acquired moments earlier when the comprehender read that a particular *cat is on a* (particular) *mat*, or knowledge that was acquired, whenever, that allows the comprehender to interpret the expression *the cat is on the mat* as a situation in which the cat is lying (as opposed to other positions) on a mat. Although other models of language comprehension assume that previously acquired "real-world" knowledge is represented in a different "store" than is the knowledge used to comprehend language, the Structure Building Framework does not make this distinction. And although other models of language comprehension assume that knowledge gained from reading or listening to a particular sentence, discourse, or text (often referred to as a "text base") is represented separately from knowledge used to comprehend that sentence, discourse, or text, the Structure Building Framework does not make that distinction (just as many models of memory find the distinction between episodic and semantic memory to be unnecessary, Hintzman, 1984; McKoon, Ratcliff & Dell, 1986).

I have investigated several types of information that comprehenders might interpret as cues for mapping. For example, Gernsbacher and Robertson (1997a) investigated comprehenders' use of the English definite article *the* as a cue for referential coherence. Our investigation was motivated by a pioneering experiment by de Villiers (1974). In de Villiers' experiment, two groups of subjects heard the same set of 17 sentences. For one group, all 17 sentences were presented with only indefinite articles, for example, *A store contained a row of cages. A man bought a dog. A child wanted an animal.* For the other group of subjects, the same sentences were presented, but the definite article *the* replaced the indefinite articles (e.g., *The man bought the dog. The child wanted the animal. The father drove to his house*). When the sentences were presented with indefinite articles, subjects were more likely to interpret them as independent sentences that referred to multiple people and unconnected events; when the sentences were presented with definite articles, subjects were more likely to interpret them as a coherent story in which the same persons and events were referred to repeatedly. Gernsbacher and Robertson (1997a) discovered that this phenomenon generalized to more than one set of experimental sentences, and, more importantly, we discovered that the facilitative effect of the definite article *the* occurs while comprehenders are building their mental structures. We presented 10 different sets of sentences, each containing 14 to 17 sentences. For example, one group of subjects read: *Some siblings were happy to be together. A road was icy and slick. A family stopped to rest. A cafe was almost deserted. A waitress took an order. A driver left to get gas. A man slipped and fell in a parking lot. A sister watched through a window. A gas station was nearby. An attendant rushed out of a building. A stranger helped a brother. A man walked slowly. A group stayed for a night. A trip was postponed.* The other group of subjects read: *The siblings were happy to be together. The road was icy and slick. The family stopped to rest. The cafe was almost deserted*, and so forth. If the definite article *the* is interpreted as a cue for mapping, then subjects who read the sentences with the definite articles should have read those sentences more rapidly than subjects who read the sentences with indefinite articles, which is exactly what we observed (a 23% benefit in average reading time).

Furthermore, the subjects who read the sentences with the definite articles recalled those sentences in a more integrative way, often combining two or more sentences into one, and using pronouns. These results suggest that subjects who read the sentences with the definite articles were more likely to map the sentences of each set together. In our second experiment (Gernsbacher & Robertson, 1997a), we tested this hypothesis more directly. We again presented 10 sets of sentences to two groups of subjects; we again manipulated whether the sentences were presented with definite versus indefinite articles, and we again measured subjects' reading time for each sentence. However, in lieu of asking subjects to recall what they remembered after reading each set of sentences, we used McKoon and Ratcliff's (1980) priming-in-item-verification task. After subjects read two sets of sentences, they performed a timed recognition task. Thirty-two test sentences were presented; half were old and half were new. Unknown to the subjects, we arranged the test list in such a way that each old sentence was preceded by either an old sentence that was from the same set of sentences or an old sentence that was from a different set. For example, the sentence, *The sister watched through the window*, was preceded in the test list by *The man slipped and fell in*

*the parking lot.* These two sentences are from the same original set. Or the same test sentence was preceded in the list by a sentence from a different set. Subjects who read the sentences with the definite articles were faster to recognize old sentences when they were preceded by a sentence from the same versus different set.

Conceptual anaphora is another way that comprehenders' knowledge guides the process of mapping (Gernsbacher, 1991b). After reading *I need a plate*, subjects more rapidly read *Where do you keep them*? than *Where do you keep it*? In contrast, after reading *I need an iron*, subjects more rapidly read *Where do you keep it*? than *Where do you keep them*? Thus, comprehenders' knowledge that plates usually come in sets, whereas irons do not, and if a person has a plate, he is likely to have at least a few, whereas if a person has an iron, he is likely to have only one, guides comprehenders' interpretation of pronouns and their comprehension of what I dubbed conceptual anaphora.

In Gernsbacher (1991b), I identified three discourse situations in which such conceptual anaphora occur. In one situation, as just illustrated, a plural pronoun is used to refer to a singular item that comprehenders know is likely to be possessed in multiples, for example, *Would you get me a paper towel? They're in the kitchen.* Similarly, a plural pronoun is often used to refer to a singular event that comprehenders know is likely to be experienced repeatedly, for example, *Yesterday was my birthday. I used to really dread them, but yesterday I didn't care.* In these sentence pairs the literal referent is a sole item or event (*a paper towel, a birthday*); however, comprehenders' knowledge that paper towels are dispensed in a roll of many, and almost everyone has more than one birthday enables the correct interpretation of a technically illegal plural pronoun; in other words, comprehenders' knowledge guides the mapping of sentences that contain conceptual anaphors.

In a second discourse situation, such "illegal" but conceptual, plural pronouns are used to refer to generic types, for example, *My mother's always bugging me to wear a dress. She thinks I look good in them, but I don't; Carla's downstairs watching a soap opera. If she had her way, she'd watch them all afternoon; I enjoy having a pet. They are such good companions.* In this communicative situation, the literal referents are the concepts in general. For instance, soap operas in general, not the specific one that Carla is currently watching, are what the speaker believes Carla could watch all afternoon.

In a third discourse situation, conceptual anaphora are used to refer to the animate members of a collective set, for instance, the members of *a team, a group*, or *a musical band*, as in *The substitute teacher begged the class to stop misbehaving. But they didn't pay any attention to her.* Members of less traditional collective sets are also referred to by conceptual anaphora, for example, *After college, my sister went to work for IBM. They made her a very good offer; You wouldn't believe how bad it is to work for the city. They can never tell you whether your job will be covered in the next month's budget; I need to call Sears. They made a mistake on my last credit card bill.*



Thus, conceptual anaphora are used in at least three discourse situations: They are used to refer to (a) frequent or multiple items or events, (b) generic types, and (c) collective sets. Although the boundaries between these three situations might be sharper, what is common among them is that the conceptual anaphor (e.g., *them*) mismatches its literal antecedent in number (e.g., *a plate*) and it is comprehenders' knowledge that guides the mapping process, as demonstrated by subjects' faster reading times for sentences containing conceptual anaphora (e.g., after reading the sentence, *I need a plate*, subjects read the sentence *Where do you keep them*? more rapidly than they read the sentence, *Where do you keep it*?). Subjects' paraphrases also demonstrate the cognitive process of mapping (e.g., the sentence pair, *I need a plate. Where do you keep them*? is typically paraphrased as *Where do you keep your plates? I need one*). My European collaborators and I also discovered that conceptual anaphora are just as natural in British English and Spanish as they are in American English; indeed, the phenomenon commutes to the verb in pro-drop languages, such as Spanish (Carreiras & Gernsbacher, 1992; Oakhill, Garnham, Gernsbacher & Cain, 1992).

Foertsch and Gernsbacher (1997) demonstrated that comprehenders' knowledge about gender roles guides the process of mapping sentences that contain the singular *they*. The background to our investigation was the finding from the first decade of discourse processes research that comprehenders more easily map sentences that contain *she* and *he* onto sentences that contain nouns that are consistent with the gender-role expectations (Kerr & Underwood, 1984). For example, comprehenders map a sentence that contains *he* more easily onto a sentence that mentions *a surgeon*, and a sentence that contains *she* more easily onto a sentence that mentions *a nurse*. Foertsch and Gernsbacher (1997) investigated whether sentences that contain the singular *they* are easier to map onto sentences that contain gender-stereotypic nouns than sentences that contain gender-mismatched pronouns (e.g., is *a nurse ... they* easier than *a nurse ... he*?), and we investigated whether sentences that contain the singular *they* versus the generic *he* (or the generic *she*) are easier to map onto sentences that contain gender-neutral nouns.

Subjects read 72 three-clause sentences, such as *A mechanic will often replace a part that is only partially worn, even if she/he/they can tell that the repair is unnecessary, because auto shops always try to jack up their customers' bills.* The first clauses contained an indefinite nominal that 90% of a group of norming subjects considered more likely to refer to a male (*a mechanic*), more likely to refer to a female (*a receptionist*), or equally likely to refer to a male or a female (*a bicyclist*). The second clauses contained the pronoun *he, she*, or *they* and a verb not marked for number. The subjects' task was to read each clause, which was presented individually, and after reading all three clauses to respond whether they

agreed with the opinion reflected in the sentence (i.e., the last of 10 practice sentences was *A participant in this experiment should press the CONTINUE button to advance the screen, even if she/he/they would rather push the AGREE or DISAGREE buttons, because the AGREE and DISAGREE buttons won't work until the "Agree or Disagree" question appears*). Our motivation for presenting the three clauses individually was to isolate subjects' reading times for the clauses containing the critical pronouns from their reading times for the clauses containing the gender-stereotypic or gender-neutral nominals; our motivation for presenting the reading-time task as an opinion "survey" was to camouflage the pronoun manipulation. Sentences containing the six English indefinite pronouns (e.g., *someone, anyone*) in their first clauses, and the three definite pronouns (*he*, *she*, and *they*) in their second clauses were also tested; these sentences allowed us to test the hypothesis that sentences containing the generic *he* (and the generic *she*) are more difficult to map than sentences containing the singular *they*.

We (Foertsch & Gernsbacher, 1997) observed that clauses containing the singular *they* were read considerably more rapidly than clauses containing a gendered pronoun that went against the gender stereotype of the antecedent (e.g., *a nurse ... they* was easier to map than *a nurse ... he*). Indeed, clauses containing the singular *they* were read just as rapidly as clauses containing a gendered pronoun that matched the stereotype of the antecedent (e.g., *a nurse ... they* was as easy to map as *a nurse ... she*). For indefinite pronouns (e.g., *someone, anyone*), clauses containing the singular *they* were the easiest to map.

Givón (1984) classifies indefinite nominals into "nonreferential nominals [that] do not refer to a specific individual; sometimes they refer only to types of such individuals" and "referential nominals [that] refer to individuals assumed (by the speaker) to exist within the universe of discourse." Foertsch and Gernsbacher's (1997) first experiment, that was just described, explored the use of the singular *they* to refer to what Givón calls nonreferential nominals. Our second experiment investigated comprehenders' mapping of clauses containing the singular *they* when used to refer to what Givón calls indefinite-referential nominals. We modified the experimental sentences that we had used in our first experiment to convert the indefinite-nonreferentials into indefinite-referentials, for example, *I know a mechanic who will often replace a part that is only partially worn, even if she/he/they can tell that the repair is unnecessary, because auto shops always try to jack up their customers' bills*. We observed with such referential antecedents, which imply that the speaker knows the gender of the antecedent, that clauses containing the singular *they* were not read as quickly as clauses containing a gendered pronoun that matched the antecedent's stereotypic gender. This finding underscores my proposal that comprehenders' knowledge (in this case about gender stereotypes as well as narrators' knowledge of the gender of indefinite references) plays an important role in guiding the mapping process.



Haenggi, Gernsbacher and Bolliger (1993) discovered that comprehenders' knowledge about spatial, temporal, and locational relations guides mapping. In one experiment, subjects read passages that implied a protagonist's location, by explicitly stating only the time that the protagonist had been traveling, or the distance that he had traveled. For example, this passage implied location, by explicitly stating only distance:

> Carol enjoyed jogging to keep in shape, but lately she hadn't been able to jog very much because she'd been so busy. On Sunday, she decided to try to jog around her favorite five-mile loop. She hoped she'd be able to make it the whole five miles around the loop. After she had jogged one mile, she still felt okay. But after she had jogged two miles, she wished she was in better shape. After Carol finished the third mile, her legs really began to ache, and after she had jogged four and three-fourths miles she was truly exhausted.

Unknown to subjects, the last sentence of each passage was a target sentence. In each target sentence we explicitly stated the protagonist's location, and we manipulated whether that location matched or mismatched the location that had been implied, for example, *Although she was so close to* versus *Although she was so far away from where she wanted to finish, Carol had to walk the rest of the way.*

For counterbalancing purposes, we tested the same two target sentences after subjects read a comparison passage, for example:

> Julie loved to cycle and today she decided to bike along a nearby river. Along the river was a great 25-mile bike path. The entire 25-mile path was well-paved and conveniently marked off after every five miles. After Julie had ridden five miles, the path got steeper and she needed to pedal harder. After riding 10 miles, Julie felt the path flatten. She even passed a few other bikers. But after riding 15 miles, Julie heard the chain on her bike snap. She got off of her bike and inspected the chain.

For this passage the explicit location in the target sentence *so far away from* matches the protagonist's implied location, whereas the location *so close to* mismatches. In another experiment, subjects read passages that implied distance, by explicitly stating only time or location. In a third experiment, subjects read passages that implied time (duration), by explicitly stating only distance or location. For all three experiments, we observed the same result: Target sentences that matched the implied location, distance, or time were read 40% faster than target sentences that mismatched. These data suggest that comprehenders activate knowledge about spatial, temporal, and locational relations, and this knowledge enables the process of mapping.

I have also demonstrated that comprehenders' knowledge about the emotional consequences of events facilitates the cognitive process of mapping. Subjects read stories that explicitly stated only concrete actions but implied emotional consequences. For example, one story stated that the protagonist stole money from a store where his best friend worked and later learned that his friend had been fired. Following each story, subjects read a target sentence that contained an emotion word, which either matched the emotional state implied by the story (*guilt*) or mismatched that emotional state. Gernsbacher, Goldsmith, and Robertson (1992) manipulated the nature of the mismatch. Across three experiments, subjects read target sentences that contained matching emotion words at approximately the same rate; in contrast, and as predicted, the more disparate the mismatching emotion words were to the implied emotional states, the more slowly subjects read the target sentences containing those mismatching emotion words. When the mismatching emotion words were the same affective valence as the implied emotion (*guilt* vs. *shyness*), subjects read the target sentences slowly; when the mismatching emotion words were the opposite affective valence of the implied emotions (*guilt* vs. *hope*), subjects read the target sentences even more slowly; and when the mismatching emotion words were the converses of the implied emotions (*guilt* vs. *pride*), subjects read the target sentences most slowly (40% more slowly than they read target sentences containing matching emotion words). To demonstrate that the stories, without the target sentences, were indeed powerful sources of knowledge activation, subjects in Gernsbacher (1994) simply pronounced the matching versus mismatching emotion words immediately after reading the stories (and did not read the target sentences). Mismatching emotion words were pronounced more slowly. Gernsbacher and Robertson (1992) manipulated the number of emotional stories that our subjects read. We predicted that subjects' knowledge of emotional states would be more activated when they read more emotion stories, and indeed that is what we observed. All these experiments demonstrated that comprehenders activate knowledge about fictional characters' emotional states, and that sentences and words that match the comprehenders' activated knowledge are mapped more easily onto the comprehenders' mental structures.

Deaton and Gernsbacher (in press) discovered that comprehenders interpret the conjunction *because* as a cue to map two causally related clauses onto the same mental structure. In three experiments we discovered that two-clause sentences that described moderately causal events were read more rapidly when the two clauses were conjoined by *because (Susan called the doctor for help* because *the baby cried in his playpen*) than when they were conjoined by *and*, *then*, or *after*. When the two clauses were conjoined by *because*, subjects also recalled the second clauses more frequently when prompted with the first clauses. In two further experiments we discovered that the facilitative effect of *because* depends on the clauses' causal relatedness: Unrelated clauses were read least rapidly and recalled least frequently, regardless of their conjunctions; however, as the clauses' causal relatedness increased, the second clauses of sentences conjoined by *because* were read more rapidly and recalled more frequently. We concluded that comprehenders use the conjunction *because* and their knowledge about causality as cues for mapping.



Finally, Gernsbacher and Robertson (1997b) discovered that comprehenders use the syntactic and conceptual form of a preceding sentence as a cue for mapping. Writing specialists (e.g., Strunk & White, 1972) stress the importance of parallel form, and we empirically demonstrated the facilitative effect of parallel form in four experiments. Subjects read pairs of sentences, as illustrated in Table 1. In our first experiment, subjects made grammaticality judgments to both members of each pair; in our second, third, and fourth experiments, subjects simply read the first member of each pair and made a grammaticality judgment to only the second member of the pair (our second experiment replicated our first experiment with only this procedural change). The first sentence in each experimental sentence pair contained either an unambiguous gerundive nominal (*washing clothes*) or an unambiguous plural noun phrase (*whining students*). The second sentence contained a head noun phrase that, in isolation, would be ambiguous (*visiting relatives*, Tyler & Marslen-Wilson, 1977). In our first and second experiments, we found that subjects decided 16% more rapidly and 19% more accurately that the second sentence of each pair was grammatical when it matched the first sentence (as the first two example sentence pairs of Table 1 do). In our third experiment, we replicated this effect, despite the fact that the second sentence was less syntactically dependent on the first sentence (because the elliptical verb phrase was replaced by a full verb phrase). In our fourth experiment, we also replicated this benefit, despite the fact that the verb in the first sentence was a modal, not marked for number. This last experimental result suggests that the conceptual form of the first sentence, in addition to its syntactic form, facilitated subjects, ability to comprehend (and map) the second sentence.

***Research on the Cognitive Process of Shifting: The Second Decade.*** According to the Structure Building Framework, once comprehenders have laid a foundation for their mental structures they develop those structures by mapping incoming information onto a developing substructure when that information coheres with the previous information. However, if the incoming information is less coherent, comprehenders employ a different process: They shift, develop, and attach a new substructure. Gernsbacher (1985) discovered that the process of shifting from building one structure or substructure to building another accounts for a well-known language comprehension phenomenon: Shortly after hearing or reading a passage, comprehenders quickly forget recently comprehended infor-

**TABLE 1**

| Experiments 1 & 2 | Experiment 3 | Experiment 4 |
|---|---|---|
| Washing dishes is a drag.<br>Visiting relatives is, too. | Washing dishes is often a drag.<br>Visiting relatives is often a drag, too. | Washing dishes can be a drag.<br>Visiting relatives is often a drag, too. |
| Whining students are a drag.<br>Visiting relatives are, too. | Whining students are often a drag.<br>Visiting relatives are often a drag, too. | Whining students can be a drag.<br>Visiting relaitives are often a drag, too. |
| Washing dishes is a drag.<br>Visiting relatives are, too. | Washing dishes is often a drag.<br>Visiting relatives are often a drag, too. | Washing dishes can be a drag.<br>Visiting relatives are often a drag, too. |
| Whining students are a drag.<br>Visiting relatives is, too. | Whining students are often a drag.<br>Visiting relatives is often a drag, too. | Whining students can be a drag.<br>Visiting relatives is often a drag, too. |

mation. In particular, they quickly forget information typically considered "surface" information. Although some have attributed this phenomenon to language-specific processes, in my first two experiments, I discovered that this phenomenon also occurs during the comprehension of nonverbal picture stories. In two more experiments (Gernsbacher, 1985), I discovered that the phenomenon is not attributable to memory limitations. Neither the passage of time nor the comprehension of additional information predicts comprehenders' sudden forgetting, but, the structure of the information does. More specifically, comprehenders quickly forget previously comprehended information just after they cross a structural boundary, such as a clause, a phrase, a sentence, a paragraph, or an episode boundary (Bever & Townsend, 1979; Caplan, 1972; Chang, 1980; Flores d'Arcais, 1978; Jarvella, 1970; 1971; 1973; 1979; Jarvella & Herman, 1972; Jarvella, Snodgrass, & Adler, 1978; Marslen-Wilson, Tyler & Seidenberg, 1978; von Eckardt & Potter, 1985). In two final experiments, I discovered that the phenomenon is not attributable to a process of recoding superficial information into a more meaningful representation; rather, the cognitive process of shifting appears to be an adequate amodal explanation for why comprehenders often forget very recently comprehended information.

Presumably, comprehenders shift in response to signals, such as cues for new episodes in narratives. Gernsbacher (1984) empirically tested this hypothesis. In one experiment, I measured sentence reading time and found that new episode



cues, such as a change in setting, slowed comprehension. In a second experiment, I measured question answering latencies and found that comprehenders had more difficulty answering questions about information presented before a new episode cue than information presented afterward. These data suggest that new episode cues encourage comprehenders to shift and build new substructures, and that information that occurs after a new episode cue is represented in a different mental substructure. Beeman and Gernsbacher (1997) also discovered that comprehenders shift in response to new episode cues by capitalizing on comprehenders' tendency to draw coherence inferences. After first hearing that *Joan put a full can of white paint on the top step of the ladder*, and later hearing that *Joan looked down to the ground and saw the empty can and the tulips covered in paint*, comprehenders are likely to draw the coherence inference that *the paint can fell.* Coherence inferences, which differ from predictive or elaborative inferences (Duffy, 1986; O'Brien, Shank, Myers, & Rayner, 1988; Potts, Keenan, & Golding, 1988), are drawn to resolve a contradiction between a previous state (*the paint was on the ladder*) and a subsequent state (*the paint is on the ground*). In Beeman's and my experiments, subjects listened to stories that promoted coherence inferences; while listening to these stories, subjects made lexical decisions (in one experiment) or rapidly named (in a second experiment) visually presented words that were either related to the inferable events (*fell*) or were unrelated. We also manipulated whether the two sentences describing the discrepant states were separated by a sentence that cued a new episode (e.g., *Inside the house, Joan's husband was busy planning a surprise anniversary party for his parents*), or whether the intervening sentence maintained the ongoing episode. Lexical decisions and naming were faster when the test words were related to the inferable events, suggesting that subjects drew the coherence inferences. However, inferences that had to be drawn across episodes were considerably harder to draw: When the intervening sentence cued a new episode, latencies were only marginally faster to inference-related test words. These data suggest that comprehenders shift in response to episode cues. Each episode is represented in its own substructure, which is how comprehenders mentally capture the structure of narratives.

Haenggi, Kintsch, and Gernsbacher (1995) investigated another comprehension situation in which comprehenders' process of shifting renders recently comprehended information less accessible. Our experiments were inspired by Morrow, Greenspan, and Bower's (1987) experiments, in which subjects first memorize a floor plan of several rooms (in our case, a fictional castle), and each room contains certain objects (e.g., a magical sword). Later subjects read stories in which fictional characters move from room to room, and subjects' memory for the objects in each room is assessed before versus after a fictional character leaves a particular room. Replicating Morrow et al. (1987), we found that subjects were slower to verify the objects contained in a room immediately after they read that

a fictional character had left that room (*The King left the ballroom*) as opposed to remaining in that room. We also discovered that the result was not attributable to paired-associate learning (between the rooms and their object lists); indeed, the result persists when the passages simply stated that the character *walked to another room* or *left the room* (without mentioning which room). However, Foertsch and Gernsbacher (1994) discovered that comprehenders' tendency to shift and develop new substructures depends on their comprehension goals and motivation (Singer, Graesser, & Trabasso, 1994). When subjects are less motivated to read "for meaning," they show less evidence of shifting.

***Research on the Cognitive Mechanisms of Suppression and Enhancement: The Second Decade.*** According to the Structure Building Framework, suppression and enhancement are general cognitive mechanisms. They are not dedicated to language; they play vital roles in nonlinguistic processes, too. But language comprehension processes, particularly those involved in structure building, draw heavily on these two mechanisms. I have investigated the role of these two mechanisms in several comprehension phenomena. Gernsbacher and Faust (1991b) discovered that the mechanism of suppression underlies a phenomenon we called "fine tuning" the activation of lexical meanings. According to many models of word understanding, when comprehenders first hear or read a word, information provided by that word activates potential meanings. Constraints provided by lexical, semantic, syntactic, and other sources of information subsequently alter the activation of those meanings. Eventually, one meaning becomes most strongly activated; and is incorporated into comprehenders' developing mental structures (Becker, 1976; Kintsch, 1988; Marslen-Wilson & Welsh, 1978; McClelland & Rumelhart, 1981; Norris, 1986). We added to these ideas the proposal that suppression modulates the activation of the different meanings. Consider the case of homonyms. Immediately after comprehenders hear or read a homonym such as *bug* or *watch*, multiple meanings are often activated, even when a particular meaning is specified by the preceding semantic context (*spiders, roaches, and other bugs*), or the preceding syntactic context (*I like the watch* versus *I like to watch*). However, as introspection suggests, very shortly after multiple meanings are activated, only contextually appropriate meanings remain activated (Lucas, 1987; Seidenberg, Tanenhaus, Leiman & Bienkowski, 1982; Simpson, 1984; Swinney, 1979; Tanenhaus, Leiman & Seidenberg, 1979).

Gernsbacher and Faust (1991b) empirically explored what happens to the inappropriate meanings. Some theorists had suggested that inappropriate meanings become less accessible through a mechanism that we dubbed compensatory inhibition: The appropriate meanings' growth in activation causes the inappropriate meanings' decline in activation, like a seesaw (McClelland & Kawamoto, 1986; Waltz & Pollack, 1985). However, in one of our experiments we discovered that



as inappropriate meanings decrease in activation, appropriate meanings do not increase; therefore, compensatory inhibition seems an unlikely explanation. Other theorists had suggested that inappropriate meanings simply decay (Anderson, 1983). However, in another experiment we discovered that contextually unsupported meanings do not merely decay. In one condition of this experiment, we observed typical multiple activation: Immediately after subjects read homonyms in a biasing context (e.g., *Pam was diagnosed by a quack*), both meanings were activated, but within 350 ms the inappropriate meanings were no longer activated. In a second condition, the homonyms were not supported by context (e.g., *Pam was annoyed by the quack*). In this condition, both meanings remained activated at 350 ms; in fact, both remained activated at 850 ms (see also Hudson & Tanenhaus, 1984). If an inappropriate meaning's decreased activation is due to decay, then surely one or both of the meanings should have decayed in the condition in which they were not supported by context. Instead, we suggested that both meanings remained activated because neither was suppressed.

Gernsbacher and Faust (1995) also discovered that the suppression of homonyms is susceptible to some forms of strategic control. We created a laboratory condition in which it behooved subjects to suppress the inappropriate meanings. We discovered that subjects employed suppression more rapidly in this condition than they did in a condition in which the need for suppression occurred only rarely. Using a split-visual field presentation, Faust and Gernsbacher (1996) explored the cerebral laterality of the suppression of inappropriate meanings. When we presented the homonym to the left-visual field (thereby hypothetically stimulating the right-hemisphere prior to the left-hemisphere) resolution of the homonym meanings was slightly delayed. Faust, Balota, Duchek, Gernsbacher, and Smith (1997) discovered that patients with senile dementia of the Alzheimer's type were poorer than age-matched controls at suppressing the inappropriate meanings of homonyms. Thus, the cognitive mechanism of suppression plays a crucial role in lexical access.

Gernsbacher (1989) discovered the role that both the mechanisms of suppression and enhancement play in anaphoric reference. Anaphoric reference is the convention of referring to antecedents, such as *John*, by using anaphors, such as repeated names (*John*), synonymous noun phrases (*the guy*), or pronouns (*he*). In my first two experiments, I discovered that very explicit repeated name anaphors (but not less explicit pronouns) immediately improve their antecedents' accessibility through both enhancement and suppression. Repeated name anaphors enhance the activation of their antecedents, thereby improving the accessibility of those antecedents. Repeated name anaphors also make their antecedents more accessible by suppressing the activation of other concepts. In a third experiment, I discovered that less explicit pronoun anaphors also improve their antecedents' accessibility by suppressing the activation of other concepts; however, they do

this less powerfully and more slowly than more explicit repeated name anaphors. In my fourth experiment, I discovered that pronouns biased by a preceding semantic context (e.g., *John lost a tennis match to Bill. Accepting the defeat, he* versus *Enjoying the victory, he*) also suppress the activation of other concepts. In a fourth experiment, I discovered that pronouns that match the gender of only one participant trigger suppression even more rapidly than pronouns that match the gender of both participants. Thus, the cognitive mechanisms of suppression and enhancement play a crucial role in anaphoric reference.

Robertson, Gernsbacher, and Robertson (1997) discovered that enhancement and suppression also operate for repeated verb phrases. This demonstration was important because verbs differ from nouns, in both psychological and linguistic ways. For example, nouns are acquired earlier than verbs, and (to both children and adults) nouns are more memorable than verbs (Gentner, 1982). In all languages, nouns form a more clearly defined category than verbs. Indeed, Maratsos and Chalkley (1980) suggest that cross-linguistic evidence demonstrates only a distinction between nouns and everything else. Because verbs do not form a discernible category, it was unclear whether verbs would trigger the suppression and enhancement of other verbs. Nevertheless, we discovered that rementioning one action enhances the activation of that action. Subjects read sentence pairs such as *John ate dinner and watched television. Later he * ate * some dessert.* At the two points indicated by asterisks, a test word like *ate* appeared, and the subjects' task was to verify whether that word occurred in the sentence pair they were reading. If rementioning one action enhances that action, then responses to *ate* should have been faster after the verb had been rementioned than before, which is what we observed. We also discovered that rementioning one action suppresses the activation of another previously mentioned action. For example, rementioning *watched* in the sentence pair *John ate dinner and watched television. Later he * watched * a movie*, decreased the activation of John's other action (*ate*). In a third experiment we discovered that introducing a new action suppresses the activation of a previously introduced action. For example, introducing *cleaned* in the sentence pair *John ate dinner and watched television. Later he * cleaned * his room*, decreased the activation of John's previous action (*ate*). Thus, the cognitive mechanisms of suppression and enhancement play a crucial role in what we dubbed "action tracking."

Just as there are anaphoric devices that improve the accessibility of previously mentioned concepts, I have proposed that there are cataphoric devices that improve the accessibility of *subsequently* mentioned concepts. So, anaphoric devices improve access to concepts that have been mentioned before, and cataphoric devices improve access to concepts that are likely to be mentioned again. Gernsbacher and Shroyer (1989) discovered that the unstressed, indefinite article *this* operates as a cataphoric device. Subjects heard narratives that introduced new



concepts with either the indefinite *this (I have this friend)* or the indefinite *a/an (I have a friend)*. The subjects' task was to continue telling each narrative. When concepts were introduced with the indefinite *this*, subjects mentioned those concepts more frequently, often within the first clauses that they produced, and typically via less explicit pronoun anaphors. In contrast, when concepts were introduced with the indefinite *a/an*, subjects mentioned those concepts less frequently, and typically via more explicit repeated noun phrase anaphors. Thus, the indefinite *this* operates as a cataphoric device. However, I propose that cataphoric devices (such as the indefinite *this*) do more than signal that certain concepts are likely to be mentioned again. (In the same way, anaphoric devices do more than signal that certain concepts have been mentioned before.) I suggest that cataphoric devices improve their concepts' status in listeners' mental representations.

Gernsbacher and Jescheniak (1995) discovered how cataphoric devices improve the mental accessibility of the concepts that they mark. We investigated two cataphoric devices: spoken stress and the indefinite *this*. We tested three hypotheses: first, that cataphoric devices enhance the activation of the concepts that they mark; second, that cataphoric devices suppress the activation of previously mentioned concepts; and third, that cataphoric devices protect the concepts that they mark from being suppressed by subsequently mentioned concepts. To test these hypotheses we constructed 48 experimental narratives, such as,

> I swear, my friend Vicky, every time we go to a garage sale, she just, uh, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an ashtray, 'n y'know, ...

As this example illustrates, each narrative introduced several concepts, for example, *Vicky*, a *garage sale*, an *ashtray*. In each narrative, one of these concepts was our experimental concept; it was the concept we manipulated. We manipulated whether the word that referred to our experimental concept was marked with a cataphoric device (e.g., whether *ashtray* in the above narrative was spoken with stress or introduced with the indefinite *this*). We (Gernsbacher & Jescheniak, 1995) measured the accessibility of these experimental concepts by presenting the name of our experimental concept visually, and measuring how rapidly and accurately subjects verified that the concept had occurred in the narrative. In our first experiment, we discovered that the cataphoric device, namely spoken stress, enhances the activation of the concepts it marks. In our first experiment, we also discovered that the cataphoric device (spoken stress) suppresses the activation of other, previously mentioned concepts. In our second experiment, we discovered that the spoken stress protects the concepts that it marks from being suppressed by subsequently mentioned concepts. In a third experiment, we discovered the same results with another cataphoric device, the unstressed indefinite article *this*.

In our final experiment, we discovered that a compensatory inhibition mechanism could not account for the results we observed in our other experiments. Thus, we concluded that the mechanisms of suppression and enhancement improve the accessibility of concepts marked by cataphoric devices.

The role of suppression and enhancement in comprehension is articulated more completely in Gernsbacher (in press). Furthermore, Gernsbacher (1997) presented four principles that govern the mechanisms of suppression and enhancement: (1) suppression is an active dampening of activation; (2) suppression and enhancement signals are transmitted as a function of the strength of the activated memory nodes that transmit them; (3) suppression and enhancement are general cognitive mechanisms; and (4) suppression and enhancement are dissociable. Gernsbacher and St. John (in press) presented a parallel-distributed processing network of suppression and enhancement based on St. John's sentence-gestalt (St. John & McClelland, 1990) and story-gestalt model (St. John, 1992). Our network used gestalt-level representations to suppress inappropriate/irrelevant information and enhance relevant/necessary information.

***Research on Individual Differences in Structure Building: The Second Decade.*** According to the Structure Building Framework, many of the processes and mechanisms involved in language comprehension are general cognitive processes and mechanisms. Gernsbacher, Varner, and Faust (1990) tested this hypothesis by creating a "multi-media" comprehension battery (Gernsbacher & Varner, 1988), which comprises two written, two auditory, and two nonverbal picture stories. When we administered the battery to 270 college-students, we found the correlations between reading, listening, and picture viewing to be very high. In addition, a factor analysis revealed only one factor: most likely "general" comprehension skill. To explain differences in General Comprehension Skill, one must look for general cognitive processes and mechanisms.

In our second experiment (Gernsbacher et al., 1990), we discovered that a marker of less proficient reading and listening skill also marks less proficient General Comprehension Skill. The marker is less-skilled comprehenders' poorer memory for recently comprehended information, regardless of whether they are reading, listening, or viewing picture stories. In our third experiment (Gernsbacher et al., 1990), we discovered that this marker could be traced to less-skilled comprehenders' tendency to shift too often; instead of continuing to map incoming information onto a developing structure or substructure, less-skilled comprehenders shift and build too many new substructures. Why might less-skilled comprehenders shift too often? Consider the consequence of a less efficient suppression mechanism. Information that is less relevant or even inappropriate to the structure being developed would remain activated. Because this irrelevant information cannot be mapped onto a developing structure, its activation lays the foundation for a new substructure. So, one consequence of an inefficient suppression mechanism is the tendency to develop too many substructures.



In our fourth experiment (Gernsbacher et al., 1990), we tested the hypothesis that less-skilled comprehenders are less efficient at suppressing irrelevant information. Subjects read a sentence, and then they read a test word. Their task was to verify whether the test word fit the context of the sentence they just read. On some trials, the last word of the sentence was a homonym, for example, *The man dug with the spade*, and the test word was related to the contextually inappropriate meaning of the homonym, for example, *ACE* . We compared how rapidly subjects rejected a test word like *ACE* with how rapidly they rejected the same test word after reading the sentence with the last word replaced by an unambiguous word, for example, *The man dug with the shovel*. We discovered that immediately after reading each sentence, both less- and more-skilled comprehenders experienced interference to test words related to inappropriate meanings of homonyms. But after a 750 ms delay, more-skilled comprehenders no longer experienced any interference. We concluded that less-skilled comprehenders were less able to quickly suppress the inappropriate meanings.

Gernsbacher and Faust (1991a) discovered three additional types of information that less-skilled comprehenders are less able to quickly suppress. We discovered that less-skilled comprehenders are less able to suppress (1) the incorrect forms of homophones (e.g., reject *CALM* after reading *He had lots of patients* versus *He had lots of students);* (2) the activation of typical-but-absent objects in scenes (e.g., reject *TRACTOR* after viewing a scene comprised of *farm* versus *kitchen* objects); and (3) information across modalities (ignore pictures superimposed on pictures or words surrounded by pictures).

Thus, in several experiments, we discovered that less-skilled comprehenders are less efficient at suppressing irrelevant or inappropriate information. However, less-skilled comprehenders are not less efficient at enhancing contextually appropriate information. Indeed, just the opposite is the case: They often benefit more from a contextually predictable context. In our fourth experiment, we discovered that less-skilled comprehenders are just as able as more-skilled comprehenders to enhance the contextually-appropriate meanings of homonyms (e.g., accept *GARDEN* after reading the contextually biased sentence *He dug with the spade* versus the contextually neutral sentence *He picked up the spade*). In our fifth experiment, we discovered that less-skilled comprehenders are just as able as more-skilled comprehenders to enhance typical-and-present objects in scenes (e.g., accept *TRACTOR* after viewing a scene comprised of *farm* versus *kitchen* objects). Thus, we discovered that less-skilled comprehenders suffer only from less efficient suppression mechanisms, not from less efficient enhancement mechanisms. This result demonstrates an important dissociation between the mechanisms of suppression and enhancement (see also Gernsbacher, 1993).

Gernsbacher and Robertson (1995) investigated a ramification of Gernsbacher and Faust's previous work: If less-skilled comprehenders are less able to suppress the contextually inappropriate meanings of homonyms, perhaps less-skilled comprehenders might be better than more-skilled comprehenders at comprehending puns. However, intuition and previous research suggested against this hypothesis, as did the results of our empirical investigation. On a task that required accepting, rather than rejecting, a meaning of a homonym that was not implied by a sentence context, (e.g., correctly accepting that *ACE* is a meaning of *spade* but not the meaning implied in the sentence, *He dug with the spade*) less-skilled comprehenders responded less rapidly than more-skilled comprehenders. However, on a task that required accepting a meaning of a homonym that was implied by the sentence context (e.g., correctly accepting that *ACE* is the meaning of *spade* implied in the sentence, *He dealt the spade*), more- and less-skilled comprehenders performed equally well, as Gernsbacher and Faust (1991a) demonstrated previously. We concluded that less-skilled comprehenders are less able to rapidly accept *inappropriate* meanings of homonyms because they are less skilled at suppression (which in the case of puns involves suppressing the appropriate meanings, e.g., to comprehend the pun, "Two men walk into a bar, and a third man ducks," we must suppress the more typical meaning of a *bar* that men are likely to walk into).

***Research on Structure Building during Discourse Production: The Second Decade.*** Although the vast majority of my research has tested the Structure Building Framework in discourse *comprehension*, Matthew Traxler and I used the Structure Building Framework to explore the cognitive processes and representations involved in one form of discourse *production*: written composition (Traxler & Gernsbacher, 1995). We hypothesized that written communication is often difficult because writers need to build, maintain, and evaluate three mental structures while they are composing their texts. They need to build a mental structure of what they want to communicate. They need to build a mental structure of what they have communicated (i.e., what their texts communicate, which of course is often different from what they intend to communicate). They need to build a mental structure of how their readers will interpret their texts. We proposed that building this third mental structure is often the most difficult. Therefore, in two series of laboratory experiments we provided two treatments that were intended to help writers form a better mental structure of how their readers would interpret their texts. In one series of experiments, we gave writers feedback on how well their readers had interpreted their texts (Traxler & Gernsbacher, 1992). This feedback not only helped writers improve their original texts (in a revision), but the writers who received feedback (in a treatment/no-treatment design) also produced more comprehensible novel texts. In a second series of experiments, we gave writers



experience "being in their readers' shoes" (Traxler & Gernsbacher, 1993). By reading other subjects' texts, our writers gained their readers' perspective, and our perspective-taking treatment again improved writers' ability to write more comprehensible texts.

## The Structure Building Framework: The Next Decade

So, there we have it. The first decade of discourse processing research served as the basis from which the Structure Building Framework was derived; the second decade allowed me to begin testing its implications and ramifications. What do I envision for the third decade? My best hunch is that I shall continue to sharpen the Structure Building Framework by providing empirical tests of its boundaries and attempting to falsify the hypotheses it encourages me to generate. For instance, are there other manifestations of the cognitive process of laying a foundation, beyond the Advantage of First Mention? But regarding the Advantage of First Mention, what are its boundary conditions? Do any other discourse devices interact or negate it? Can I sketch more completely the underpinnings of the cognitive process of mapping? Is the cognitive process of shifting just the 'flip side of the coin,' or are those two processes, mapping and shifting, dissociable in the same way that the two general cognitive mechanisms of enhancement and suppression have been found to be dissociable? Furthermore, what is the relation between the cognitive processes of mapping and shifting and the cognitive mechanisms of enhancement and suppression? My naivetè (and optimism) lead me to suggest that the latter enable the former. Empirically testing that prediction will be one of my goals within the next ten years of my research on structure building.

I also hope to broaden my investigative arsenal in the next decade. Already I am flirting with the use of neural imaging techniques to further illuminate the cognitive processes and mechanisms involved in discourse comprehension, perhaps in the same way that the 1970s discourse processes researchers had crushes on our (nowadays) staple methodology, reaction time. And given that my home "laboratory" is now delightfully filled by a young fellow who, on the day that I am penning these last words, is celebrating not his first ten years but only ten months of life, I suspect that I shall soon be curious about the development of discourse processes. No doubt I shall use the Structure Building Framework for that pursuit.

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