COGNITIVE PROCESSES AND MECHANISMS IN LANGUAGE COMPREHENSION: THE STRUCTURE BUILDING FRAMEWORK

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I. The Structure Building Framework

Language can be viewed as a specialized skill involving language-specific processes and language-specific mechanisms. Another position views the processing of language—be it comprehension or production—as drawing on many general cognitive processes and mechanisms. Such processes and mechanisms might also underlie nonlinguistic tasks as well. This commonality might arise because, as Bates (1979), Lieberman (1984), and others have suggested, language comprehension evolved from other nonlinguistic cognitive skills. Or the commonality might arise simply because the mind is best understood by reference to a common architecture, e.g., a connectionist architecture.

In recent work, I have adopted the view that many of the processes and mechanisms involved in language comprehension are general cognitive processes and mechanisms. This article describes a few of those cognitive processes and mechanisms, using a simple framework, the structure building framework, as a guide. According to the structure building framework, the goal of comprehension is to build a coherent, mental representation, or *structure*, of the information being comprehended. Several component processes are involved. First, comprehenders lay foundations for their mental structures. Next, comprehenders develop their mental structure by

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mapping on information when that incoming information is coherent or related to previous information. However, if the incoming information is less coherent or related, comprehenders employ a different process: They shift and initiate 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 onto a developing structure 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 might activate a different set of nodes, and the activation of this other set of nodes might form the foundation for a new substructure.

In addition, once memory nodes are activated, they transmit processing signals to either enhance other nodes' activation (they boost or increase those nodes' activation) 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. Presumably memory nodes are enhanced because the information they represent is necessary for further structure building. They are suppressed when the information they represent is no longer as necessary.

This article discusses the three subprocesses involved in the structure building process: laying a foundation, mapping coherent or relevant information onto that foundation, and shifting to initiate a new substructure. This article also discusses the two mechanisms that control the structure building processes: enhancement, which increases activation, and suppression, which dampens it.

When discussing these processes and mechanisms I begin by describing the empirical evidence to support them. Then, I describe some exemplary phenomena for which these processes and mechanisms account. Let me stress that I assume that these processes and mechanisms are general, i.e., the same processes and mechanisms should be involved in nonlinguistic phenomena.

This orientation suggests that some of the reasons that individuals differ in comprehension skill might not be specific to language. Toward the end of this article, I describe research investigating this suggestion. But first, I describe the processes and mechanisms involved in structure building, beginning with the process I refer to as *laying a foundation*.

II. The Process of Laying a Foundation

According to the structure building framework, the initial stage of comprehension involves laying a foundation for the mental representation or structure. Laying this foundation should require additional processing. What manifestations might we see of this additional processing? One possibility is increased comprehension time, and indeed, a large body of converging data suggest that comprehension slows down when comprehenders are laying their mental foundations for these mental structures.

For instance, experiments measuring the reading time for each sentence in a paragraph show that initial sentences take longer to read than subsequent sentences (see citations in Gernsbacher, 1990). In fact, this is the case regardless of where the paragraph's topic sentence occurs (Greeno & Noreen, 1974; Kieras, 1978, 1981). In addition, the first sentence of each miniepisode in a story takes longer to read than other sentences in that miniepisode (Haberlandt, 1980, 1984; Haberlandt, Berian, & Sandson, 1980; Mandler & Goodman, 1982).[1]

Similarly, experiments measuring the reading time for each word within a sentence show that initial words take longer to read than subsequent words (Aaronson & Ferres, 1983; Chang, 1980). In fact, the same word is read more slowly when it occurs at the beginning of a sentence or phrase than when it occurs later (Aaronson & Scarborough, 1976).[2] The same comprehension time effects are observed when comprehenders self-pace their viewing of nonverbal picture stories. Comprehenders spend more time viewing the initial picture of each story and the initial picture of each subepisode (Gernsbacher, 1983).

When comprehending spoken language, subjects are slower to identify a target phoneme or a target word when that target occurs during the beginning of its sentence or phrase than when it occurs later (see citations in Gernsbacher, 1990). So both the comprehension time and the target identi-

[1] Some regression analyses of sentence-by-sentence reading times do not show a simple "serial position" effect (e.g., Graesser, Hoffman, & Clark, 1980). Perhaps this is because the stimulus sentences vary in length, and length is also a substantial predictor of reading time. Indeed, when the same sentences are read word by word, and the regression analyzes average word-by-word reading times per sentence (and therefore equates sentence length), these analyses also show that initial sentences take longer to read (Haberlandt & Graesser, 1985).

[2] This effect is not manifested when subjects are required to memorize (as opposed to comprehend) the stimulus sentences. Neither is the effect manifested when subjects are required to perform a second task (e.g., answer a question or press a key to signal an anomaly) immediately after they finish reading each sentence. In preparation of this second task, subjects often delay their reading of the last words of the sentences.

fication data display the pattern one expects if comprehenders use initial words and sentences to lay foundations for their mental representations of larger units, such as phrases, sentences, story episodes, and paragraphs. But, rather importantly, this pattern is not displayed when stimuli do not lend themselves to coherent mental representations, e.g., when the sentences or paragraphs are self-embedded or extensively right branching, as in (1), which is a self-embedded version of (2) (Foss & Lynch, 1969; Greeno & Noreen, 1974; Hakes & Foss, 1970; Kieras, 1978, 1981).

(1) *Grants, manuscripts, graduate students, committees, articles, data, experiments, classes, the professor taught, conducted, collected, published, served on, trained, reviewed, and submitted.*

(2) *The professor taught classes, conducted experiments, collected data, published articles, served on committees, trained graduate students, reviewed manuscripts, and submitted grants.*

Memory data also support the proposal that a general cognitive process involved in comprehension is first laying a foundation. For instance, sentences are recalled better when they are cued by their first content words or by pictures of those first content words than when they are cued by later occurring words (Bock & Irwin, 1980; Prentice, 1967; Turner & Rommetveit, 1968). Similarly, story episodes are recalled better when they are cued by their first sentences than when they are cued by later occurring sentences (Mandler & Goodman, 1982). These data suggest that initial stimuli serve as a foundation onto which subsequent information is added.

Indeed, initial information plays such a fundamtneal role in organizing mental structures that when comprehenders are asked to recall the main idea of a paragraph, they are most likely to select the initial sentence—even when the actual theme is captured by a later occurring sentence (Kieras, 1980). This phenomenon also suggests that the initial process of comprehension involves laying a foundation.

A. The Advantage of First Mention

Another phenomenon that could be the result of the process of laying a foundation is what I refer to as the *advantage of first mention*. The advantage is this: After comprehending a sentence involving two participants, it is easier to remember the participant mentioned first than the participant mentioned second. For example, after reading the sentence,

(3) *Tina beat Lisa in the state tennis match.*

if subjects are asked whether the name *Tina* occurred in the sentence, they respond considerably faster if *Tina* was the first person mentioned in the sentence, as she was in (3), than if *Tina* was the second person mentioned in the sentence, as she is in,

(4) *Lisa beat Tina in the state tennis match.*

The first-mentioned participant is more accessible from comprehenders' mental representations, which is what I mean by the advantage of first mention.

The advantage of first mention has been observed numerous times by several researchers (Chang, 1980; Corbett & Chang, 1983; Gernsbacher, 1989; Stevenson, 1986; von Eckardt & Potter, 1985). As a point of interest, when Corbett and Chang (1983) observed this advantage, they included filler trials in which they measured the accessibility of concepts that were words other than participants' names; so the advantage does not depend on some strategy that subjects might employ when they think that they only have to remember the names of sentence participants.

One explanation of the advantage of first mention draws on the proposal that comprehension involves laying a foundation. For this reason, first-mentioned participants are more accessible—both because they form the foundations for their sentence level representations and because it is through them that subsequent information is mapped onto the developing representation. However, there are other explanations of the advantage of first mention, and these other explanations draw on the linguistic structure of English.

For example, first-mentioned participants might be more accessible because in English declarative sentences they are virtually always the syntactic relation known as *subject*, and they typically also fill the semantic role known as *agent*. In a series of experiments (Gernsbacher & Hargreaves, 1988), we tried to untangle these linguistic factors from the advantage of first mention. In our first experiment, we discovered that the advantage of first mention was not attributable to semantic agency. That is, the participant *Tina* was just as accessible when she was the agent of the action, as in (5), as when *Tina* was the recipient of the action or the semantic patient, as she is in (6).

(5) *Tina beat Lisa in the state tennis match.*

(6) *Tina was beaten by Lisa in the state tennis match.*

The crucial factor affecting accessibility was whether the participants were mentioned first, as *Tina* is in (5) and (6). Participants were less accessible when they were mentioned second, as *Tina* is in (7) and (8).

(7) *Lisa beat Tina in the state tennis match.*

(8) *Lisa was beaten by Tina in the state tennis match.*

These results are presented in the leftmost panel of Fig. 1. Before prematurely accepting the null hypothesis, we conducted a replication experiment with an increased subject sample size of 120. The results of the replication experiment were identical to those of the first experiment.

In our third experiment and its replication we investigated whether the advantage of first mention depended on the first-mentioned participants being literally the initial words of our stimulus sentences. If so, our laboratory task might be somewhat to blame as the first word of each sentence was preceded by an attention-getting warning signal, which was itself preceded by a brief blank period. To investigate this, we manipulated whether an adverbial phrase like *two weeks ago* was preposed at the beginning of the sentence, as in

(9) *Two weeks ago Tina mailed Lisa a box full of clothes.*

Or it was postposed at the end of the sentence, as in

(10) *Tina mailed Lisa a box full of clothes two weeks ago.*

Or it did not occur at all, as in

(11) *Tina mailed Lisa a box full of clothes.*

We discovered that the advantage of first mention remained regardless of whether the first-mentioned participants were literally the initial words of their stimulus sentences (see the center panel of Fig. 1). Thus, the advantage must depend on each participant's position relative to the other participants.

In our fifth, sixth, and seventh experiments, we investigated whether the advantage of first mention was due to the first-mentioned participants being syntactic subjects. This, of course, is the typical sequence of events in a language like English that is considered an SVO (subject–verb–object) language (Greenberg, 1963). However, in our fifth experiment, the advantage of first mention was not attenuated when the two participants were both subjects, e.g., when both *Tina* and *Lisa* were the syntactic subjects, as in (12), as opposed to *Tina* being the sole subject, as in (13).

(12) *Tina and Lisa argued during the meeting.*

(13) Tina argued with Lisa during the meeting.

(See the rightmost panel of Fig. 1.) In fact, in our sixth and seventh experiments, the advantage of first mention was not attenuated even when the first-mentioned participant was no longer its sentence's syntactic subject, as *Tina* is in

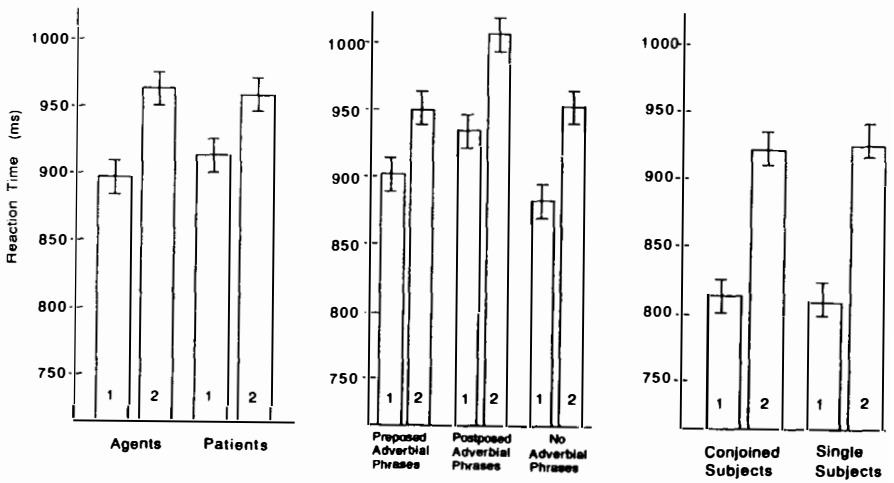

Fig. 1. Results from Gernsbacher and Hargreaves (1988; Experiments 1, 3, and 5). The data displayed are the subjects' mean verification latencies to first- vs. second-mentioned sentence participants when the sentence participants were agents vs. patients (leftmost panel), when the sentences had preposed adverbial phrases, postposed adverbial phrases, or no adverbial phrases (center panel), and when the sentence participants were conjoined subjects vs. single subjects (rightmost panel).

(14) *Because of Tina, Lisa was evicted from the apartment.*

We concluded that the advantage of first mention does not arise from any of the linguistic factors that we investigated. Instead we suggested that it is a result of general cognitive processes that occur naturally during comprehension. These involve laying a foundation and mapping subsequent information onto that foundation.

B. The Advantage of First Mention vs. the Advantage of Clause Recency

The advantage of first mention seems to contradict another well-known advantage—what I shall call the advantage of clause recency. The advantage of clause recency occurs immediately after subjects hear or read a two-clause sentence; words from the most recently read or heard clause are often more accessible than words from an earlier clause. For instance, the word *oil* is more accessible immediately after subjects hear (15) than it is immediately after they hear (16) (Caplan, 1972).

(15) *Now that artists are working fewer hours, oil prints are rare.*

(16) *Now that artists are working in oil, prints are rare.*

Presumably this advantage arises because the word *oil* was in the most recent clause in (15). So the advantage of clause recency is also an advantage for the order of mentioning concepts, but the advantage is for the most recently or second-mentioned concept (see also Chang, 1980; Kornfeld, 1973; von Eckardt & Potter, 1985).

In a series of experiments (Gernsbacher, Hargreaves, & Beeman, 1989), we resolved this discrepancy and discovered something about how comprehenders build mental representations of clauses. In these experiments, we measured the accessibility of sentence participants in two-clause sentences, e.g.,

(17) *Tina gathered the kindling, and Lisa set up the tent.*

The first-mentioned participants were the syntactic subjects of the first clauses, and the second-mentioned participants were the syntactic subjects of the second clauses.

We began with the proposal that comprehenders represent each clause of a multiclause sentence in its own substructure. So comprehending (17) would require first building a substructure to represent the clause *Tina gathered the kindling,* and then building a substructure to represent the clause *Lisa set up the tent.* We also predicted that comprehenders have greatest access to the information represented in the substructure that they are currently developing. We tested this prediction in our first experiment. Our goal was to measure accessibility of the sentence participants at the point where comprehenders were just finishing building their representation of the second clause. We thought that if we could capture that point, we would find an advantage of clause recency; in other words, we expected to observe an advantage of the second-mentioned participant.

To capture that point, we presented the test names coincident with the last words in the sentences, but we presented those test names at a different place on the computer screen than where we presented the sentences. We assumed that by the time our subjects shifted their eyes and their attention (Posner, 1980) to the test names, our coincident presentation was comparable to an extremely short delay. And indeed, at this point we observed a second- as opposed to first-mentioned participant's advantage; in other words, we observed an advantage of clause recency, similar in magnitude to those advantages observed by Caplan (1972) and others. Our data are displayed in the two leftmost bars of Fig. 2. These data suggest that comprehenders do have greatest access to information represented in the substructure that they are currently developing.

After comprehenders represent each clause, we assume that they must

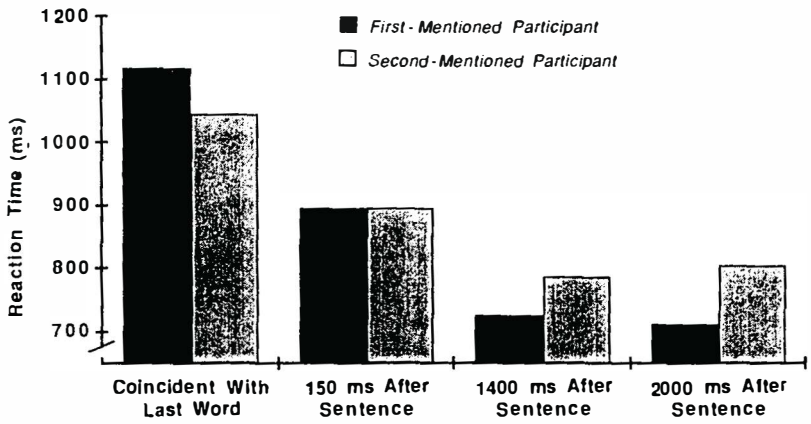

Fig. 2. Results from Gernsbacher, Hargreaves, and Beeman (1989; Experiments 1, 2, 3, and 5). The data displayed are the subjects' mean verification latencies to first- vs. second-mentioned sentence participants when the first-mentioned participants were the subjects of the first clauses of two-clause sentences, and the second-mentioned participants were the subjects of the second clauses.

map their second-clause representation onto their first-clause representation. In other words, to fully represent a two-clause sentence, comprehenders must incorporate the two substructures into one. Our goal in our second experiment was to catch comprehenders after they had built their representations of each clause, but before they had mapped their representation of the second clause onto their representation of the first clause. We predicted that at that point information would be equally accessible from each clause. And indeed, the first-mentioned and second-mentioned participants were equally accessible (see Fig. 2). We observed the same effect in a replication experiment.

In our fourth experiment, we predicted that if we measured accessibility a little bit later—say, a second later—we would find that by this point the first-mentioned participants would be more accessible. This would suggest that comprehenders had successfully mapped the two clauses together and that the first clause was serving as a foundation for the second. And indeed, by this time, the first-mentioned participants were more accessible (see Fig. 2). In fact, the advantage of first mention was identical in magnitude to the advantage we observed with simple sentences.

To review our results: At our earliest test point, we observed that the second-mentioned participants were more accessible or, in other words, we observed an advantage of clause recency. I suggest that at this point

comprehenders were still developing their representations of the second clauses. When we meassured accessibility 150 msec later, the two participants were equally accessible. I suggest that at this point comprehenders had built their representations of both clauses but had not begun mapping those representations together. When we measured accessibility after 1400 msec, we observed an advantage of first mention. I suggest that at this point comprehenders had finished mapping the second clause onto the first, and the information from the first clause was more accessible because it served as the foundation for the whole sentence level representation. Each of these results is displayed in Fig. 2.

An alternative explanation is that the change in accessibility that we observed over time was due to catching subjects at different stages while they were cyclically rehearsing the two participants' names (e.g., *Tina . . . Lisa . . . Tina . . . Lisa*). To rule out this explanation, we conducted one final experiment in which we delayed the test point even longer, for a total of 2000 msec. At that point the first-mentioned participants were still more accessible; in fact, at that point the first-mentioned participants were even more accessible than they had been at the 1400 msec test point (see two rightmost bars in Fig. 2). This finding suggests that the advantage of first mention is a relatively long-lived characteristic of the representation of a sentence. I suggest that this advantage arises because first-mentioned participants form the foundations for their sentence level representations, and it is through them that subsequent information is mapped onto the developing representation.

In contrast, the advantage of clause recency appears to be relatively short-lived. I suggest that the advantage of clause recency arises because comprehenders build a substructure to represent each clause of a multiclause sentence, and they have greatest access to information represented in the substructure that they are currently developing. Thus, two seemingly contradictory phenomena are not mutually exclusive when comprehension is viewed as structure building. In fact, according to the structure building framework, we should be able to observe both phenomena simultaneously. That was the goal in our sixth experiment.

In this sixth experiment, we measured the accessibility of each of four participants, e.g., the four participants mentioned in (18).

(18) *Dave and Rick gathered the kindling, and John and Bill set up the tent.*

As in (18), two participants (e.g., *Dave* and *Rick*) were the conjoined subjects of the first clause, and two participants (e.g., *John* and *Bill*) were the conjoined subjects of the second clause. In other words, two participants were the first- and second-mentioned participants of the first clause, and two participants were the first- and second-mentioned participants of the second clause.

We predicted that in both clauses we would observe an advantage of first mention: Within each clause, first-mentioned participants would be more accessible than second-mentioned participants. In addition, we predicted that if we could catch comprehenders at the point where they were completing their representations of the second clause, we would observe an advantage of clause recency: Both participants from the second clause would be more accessible than both participants from the first clause. And, indeed, that is what we found.

As shown in Fig. 3, in both clauses the first-mentioned participants were significantly more accessible than the second-mentioned participants; in other words, we observed an advantage of first mention. As also illustrated in Fig. 3, participants from the second clause were significantly more accessible than participants from the first clause; in other words, when we tested accessibility 150 msec after the end of each sentence, we also observed an advantage of clause recency. In a final experiment, when we delayed the test point to 2000 msec after each sentence, we no longer observed an advantage of clause recency—only an advantage of first mention.

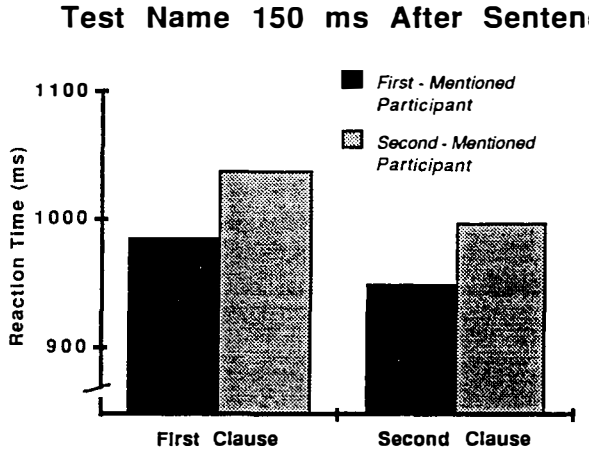

Fig. 3. Results from Gernsbacher, Hargreaves, and Beeman (1989; Experiment 6). The data displayed are the subjects' mean verification latencies to first- vs. second-mentioned sentence participants in the first clause of two-clause sentences, and first- vs. second-mentioned sentence participants in the second clause of two-clause sentences.

C. Functional Role of First Mention

Given the privileged role that initial information plays in comprehenders' mental representations, speakers and writers should seriously confront what Levelt (1981) dubbed the linearization problem: "what to say first, what to say next, and so on" (p. 305).

Indeed, functional grammarians argue that different orders of mention code different pragmatic dimensions; therefore, speakers' and writers' selection of a specific order serves a communicative function (Chafe, 1976; Firbas, 1974; Givón, 1979; Halliday, 1967). However, opinions differ over which dimension initial mention codes and which function speakers and writers intend to accomplish when they select among the grammatical forms that involve different orders of mention. According to one perspective, initial mention codes importance and functions to attract attention (Givón, 1986). According to another perspective, first mention codes givenness and functions to create a context for subsequent comprehension (Clark & Clark, 1977).

Both perspectives are supported by experiments employing a range of laboratory tasks designed to simulate sentence production. These tasks include elicited sentence formulation, oral sentence recall, sentence acceptability, sentence ratings, and sentence verification (of pictures, for example).

Experiments that have manipulated importance via perceptual salience, animacy, definiteness, or other markers have shown that important concepts are mentioned first. Similarly, experiments that have manipulated givenness via explicit prior mention, verbatim or pictorial cueing, or implicit presupposition have shown that given concepts are mentioned first (see citations in Gernsbacher, 1990). However, one cannot adopt the two perspectives simultaneously without entering into a paradox. That is, initial mention can only code importance and givenness simultaneously if one assumes that new information is always less important or that important information is always old. Both assumptions seem unintuitive. Thus, the two perspectives conflict.

Bock (1982) discusses a few resolutions to this conflict from the perspective of sentence production. In Gernsbacher and Hargreaves (in press), we did not attempt to resolve this conflict for sentence comprehension, but we did point out how the structure building account accomodates both functions. If first mention is selected in order to signal importance, then the function is accomplished because—by virtue of being first mentioned—initial information gets represented at the core or foundation of the structure. As mentioned above, this privileged position leads to greater accessibility, and presumably the goal of marking information as important is to gain this greater accessibility.

On the other hand, if first mention is selected in order to signal givenness, then the function is also accomplished because—by virtue of being first mentioned—initial information organizes the representation of subsequent information. That is, subsequent information gets mapped onto the developing structure vis-à-vis the initial information. Presumably, the mapping process proceeds more smoothly when new (subsequent) information is mapped onto given (initial) information rather than the other way around.

Thus, functional linguists suggest that speakers and writers exploit different grammatical forms, such as passivization or left dislocation, to accomplish certain communicative functions, such as attracting attention or signaling givenness. I suggest that the cognitive processes involved in laying a foundation for mental structures accomplish these functions.

III. Processes of Mapping and Shifting

According to the structure building framework, once a foundation is laid, incoming information that is coherent with the previous information is mapped onto the developing structure or substructure. Presumably the more coherent (relevant, related, or similar) the incoming information is, the easier the mapping process should be. How would ease in mapping be manifested? Again, one candidate is comprehension time, and again, data from reading time experiments support this assumption.

Sentences that literally or conceptually repeat a previous word or a phrase—and thereby signal coherence overtly—are read faster than comparable sentences that are not literally or conceptually repetitive (see citations in Gernsbacher, 1990). For example, comprehenders more rapidly read the sentence *The beer was warm* after they read (19a) than after they read (19b).

(19) a. *We got some beer out of the trunk. The beer was warm.*

b. *We checked the picnic supplies. The beer was warm.*

The benefit does not derive solely from literally repeating the word *beer*, as a sentence that simply mentions *beer*, such as (20), does not facilitate mapping too much more than the picnic supplies sentence (Haviland & Clark, 1974; see also Johnson-Laird, 1983, p. 379).

(20) *Andrew was especially fond of beer. The beer was warm.*

In addition, the assumption that coherent information is represented in the same mental substructure is supported by memory data. Sentences and phrases that are coreferenced by repetition are more likely to be remem-

bered when one phrase cues or primes the recall or recognition of the other; such phrases are also more likely to be "clustered" in comprehenders' recall protocols (Hayes-Roth & Thorndyke, 1979; Kintsch, Kozminsky, Streby, McKoon, & Keenan, 1975; McKoon & Ratcliff, 1980b).

On the other hand, according to the structure building framework, when incoming information is less coherent, comprehenders employ the process of shifting: They shift from actively building one substructure and initiate another. Laying the foundation for this new substructure requires additional processing. Again, this additional processing should be manifested in increased comprehension time. And again, numerous reading time experiments support this assumption: Sentences and words that change the ongoing topic, point of view, or setting take substantially longer to comprehend than those that continue it (see citations in Gernsbacher, 1990).

Consider the following example. This example draws on the narrative point of view, which is the narrator's location in relation to the action (Black, Turner, & Bower, 1979). For instance, (22) locates the narrator inside the lunchroom.

(22) *The door to Henry's lunchroom opened and two men came in.*

In contrast, (23) locates the narrator outside the lunchroom.

(23) *The door to Henry's lunchroom opened and two men went in.*

After reading (24), comprehenders presumably adopt the narrator's point of view, inside the living room.

(24) *Bill was sitting in the living room reading the evening paper.*

Then, they have difficulty reading a sentence that switches this point of view, as does (25), compared with a sentence that maintains the point of view, as does (26).

(25) *Before Bill had finished the paper, John went into the room.*

(26) *Before Bill had finished the paper, John came into the room.*

Comprehenders also have more difficulty retrieving information presented before a change in topic, point of view, or setting than they do retrieving information presented after such a change (A. Anderson, Garrod, & Sanford, 1983; Clements, 1979; Mandler & Goodman, 1982). Presumably, this is because comprehenders shift when they encounter a change in topic, point of view, or setting. If so, then the information that occurred before the change in topic, point of view, or setting will be represented in one substructure, while the information that occurred after the change in topic, point of view, or setting will be represented in another substructure.

A. Shifting as the Cause of Comprehenders' Rapid Inaccessibility to Information

The process of shifting from building one structure or substructure to initiating another also accounts for a well-known language comprehension phenomenon. Shortly after hearing or reading a passage, comprehenders quickly lose access to recently comprehended information (Gernsbacher, 1985). In particular, information typically considered "surface" information becomes less accessible (but see von Eckardt & Potter, 1985).

This phenomenon is well known partly because we experience it everyday and partly because it has been repeatedly demonstrated in the laboratory (see citations in Gernsbacher, 1990). In Gernsbacher (1985), I too demonstrated this phenomenon, but my demonstration was made with passages composed of professionally drawn pictures; these stories were "told" completely without words. An example sequence is shown in Fig. 4A. While subjects comprehended these nonverbal stories I measured how well they could remember each picture's original left-vs.-right orientation, as illustrated in Fig. 4B.

Two goals directed this research. First, I wanted to demonstrate that this phenomenon was not unique to language-based comprehension. This goal was met by my first four experiments. The first experiment demonstrated that comprehenders had more difficulty accessing recently comprehended information after they comprehended all four picture stories than after they comprehended each of the four picture stories. The second experiment demonstrated that comprehenders had more difficulty accessing recently comprehended information after they comprehended an entire picture story than after they comprehended each half of that story. So these first two experiments replicated the phenomenon in which comprehenders rapidly lose access to previously comprehended information, but in these experiments the phenomenon was observed during the comprehension of nonverbal stimuli. The data from these two experiments are summarized in Table I.

The third and fourth experiments replicated a more intriguing aspect of the phenomenon. Several language experiments have demonstrated that apart from the passage of time or the comprehension of more information, the structure of the passage greatly affects the time course of accessibility. More specifically, information becomes markedly less accessible just after comprehension crosses a constituent boundary; e.g., just after comprehenders finish a clause, a phrase, a sentence, a paragraph, or a mini-episode (see citations in Gernsbacher, 1990).

The third experiment demonstrated that comprehenders could segment the picture stories into their constituents or subepisodes. The fourth ex-

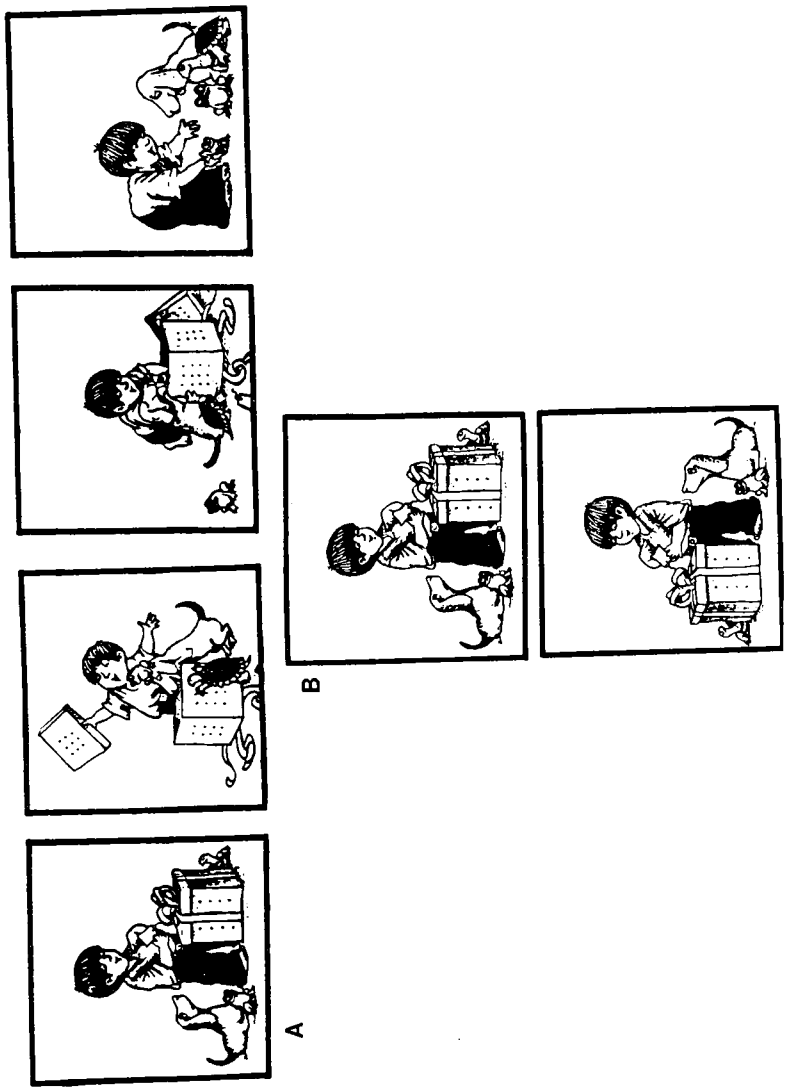

Fig. 4. A picture story used in Gernsbacher (1985). A, example sequence. B, example picture displayed in one orientation (top) and its reverse (bottom).

periment demonstrated that recently comprehended information was less accessible after crossing these constituents' boundaries than before, even though the test interval—in terms of the number of stimuli and the amount of time—was the same in the after-boundary vs. the before-boundary conditions (see Table I).

The second goal of my research was to investigate why this phenomenon occurs. Four explanations were considered. The first was the linguistics hypothesis: Information becomes less accessible because sentence comprehension requires syntatic detransformation. Though detransformation provides syntactic tags that can be used to reconstruct the original sentence, the tags are often lost (Mehler, 1963; Miller, 1962; Sachs, 1967).

One major problem with this explanation is that it requires a set of syntactic rules specifying the necessary transformations used during comprehension. In other words, it requires a psychologically "real" transformational grammar. Specifying such a grammar for English sentences has proved to be no easy task (Bresnan & Kaplan, 1982; Garnham, 1983). And though there have been novel attempts to specify grammars for nonverbal media—for example, Carroll (1980) attempted a grammar for cinematic films, and Bernstein (1976) attempted one for musical symphonies—the possibility of specifying a grammar to describe my picture stories seemed remote.

Another problem with the linguistic hypothesis was that over two decades of experiments using verbal stimuli alone, this explanation has steadily lost support (Fodor, Bever, & Garrett, 1974; Garnham, 1983; Gough & Diehl, 1978). So I abandoned the linguistics hypothesis and

TABLE I

SUBJECTS' MEAN PERCENTAGE CORRECT AND DISCRIMINATION (A') SCORES IN GERNSBACHER (1985)

Experiment	Manipulation	% Correct	A'
1	After comprehending ONE vs.	66	.752
	SEVERAL picture stories	57	.634
2	After comprehending HALF vs. an	74	.835
	ENTIRE picture story	62	.705
4	BEFORE a constituent boundary vs.	79	.872
	AFTER a constituent boundary	70	.795
5	After comprehending a NORMAL vs. a	68	.782
	SCRAMBLED picture story	62	.700
6	After comprehending a NORMAL vs. a	70	.787
	SCRAMBLED written story	72	.700

searched for an explanation outside the language domain. This approach is not unusual; when other phenomena originally believed to be unique to language processing were demonstrated outside that domain (e.g., categorical perception and selective adaptation), amodal explanations were sought for them too (Diehl, 1981).

The second explanation I considered was the memory limitations hypothesis, whereby recently comprehended information becomes less accessible because the limitations of a short-term memory are exceeded. These limitations might be quantitative; short-term memory can hold only a limited number of items. Or they might be temporal; short-term memory can hold information for only a limited period of time (Miller, 1956).

However, my fourth experiment and other constituent boundary experiments illustrate an aspect of the phenomenon that memory limitations cannot explain. These experiments demonstrate that apart from the amount of information or the passage of time, the structure of the information affects its accessibility. That is, accessing recently comprehended information does not depend completely on how much information has been held or how long that information has been held in a hypothetical short-term memory.

To account for such findings, a corollary assumption is often made: Recently comprehended information is held in short-term memory until a meaningful unit has been comprehended; then it is lost (Jarvella, 1979; Sanford & Garrod, 1981). However, this assumption undermines the original explanation. All constituents are not the same size, so they would not consume the same amount of space or be held for the same period of time. If while waiting for a constituent to end, short-term memory can hold a variable amount of information for a variable period of time, then why is the information ever lost? Perhaps the system is so "smart" that when anticipating a time or space limitation it chooses to expunge at a structurally appropriate interval. But this leaves us without an a priori specification of how long or how much information can be held, and no causal link. Therefore, I also considered the memory limitations hypothesis insufficient.

The third explanation was the recoding hypothesis, whereby recently comprehended information becomes less accessible because during comprehension it is recoded into a more meaningful representation, usually referred to as gist. So even though initially all verbatim information is vital for successful comprehension, the more successful the comprehension, the more likely it is that verbatim information becomes recoded into gist (Bransford & Franks, 1971, 1972).

Consider the analogy of baking a cake. As the cake bakes, several raw ingredients (salt, flour, butter, sugar) become increasingly "recoded." In fact, if the baking process is successful, it is difficult to extract any of the ingredients in their original raw forms. Now consider Bransford and Franks's (1971) seminal experiment. Subjects comprehended a series of thematically cohesive sentences and on a later recognition test they were poor at remembering structural information about sentence boundaries.

Less well known is a later experiment by Peterson and McIntyre (1973). In one condition, they perfectly replicated Bransford and Franks (1971). In a second condition, their input sentences were not thematically cohesive and, for these sentences, comprehenders were considerably better at remembering sentence boundaries. One explanation is that in Bransford and Franks's paradigm, the input sentences could easily be recoded into gist, but in Peterson and McIntyre's unrelated (second) condition, they could not—so they had to remain in their relatively raw form.

Other data converge on this explanation. For instance, comprehenders' memory for the original (active vs. passive) voice of a sentence is significantly worse when the input sentences form a cohesive story than when the sentences are semantically unrelated (J. R. Anderson & Bower, 1973, p. 224). Comprehenders make more synonym substitutions when recalling sentences originally processed as a thematic story than when the sentences seem unrelated (de Villiers, 1974; Luftig, 1981; Pompi & Lachman, 1967). Similarly, bilinguals' memory for the language in which different words were originally spoken is worse when the words compose a unified sentence rather than an unrelated list (Saegert, Hamayan, & Ahmar, 1975; see also Rose, Rose, King, & Perez, 1975).

In each of these situations, recoding the input into a more meaningful representation apparently caused some of its information to become less accessible. However, the situations that best support the recoding hypothesis least represent typical comprehension. In these situations the to-be-comprehended stimuli were semantically unrelated and void of thematic integrity (or at least it appeared that way to subjects). It is difficult to draw conclusions about comprehension from situations where comprehension—in the usual sense—cannot actually occur (for comparable arguments, see Moeser, 1976; Perfetti & Goldman, 1974).

A more valid test of the recoding hypothesis would involve two experimental conditions; in both, comprehension could occur, but recoding would be less likely in one than the other. That was one purpose of the fifth experiment (in Gernsbacher, 1985). A second purpose was to test another explanation, the shifting hypothesis. This fourth explanation was derived from the structure building framework.

According to the shifting hypothesis, recently comprehended information becomes less accessible because comprehenders shift from developing one substructure to develop another. Presumably, information

represented in one substructure is most available during the active processing of that substructure. Once a processing shift has occurred, information represented in the previous substructure becomes less available.

In my fifth experiment (Gernsbacher, 1985), half the stories were presented with their pictures in their normal, chronological order and half were presented with their pictures in a scrambled order. This scrambling manipulation served three purposes. First, it provided a more valid test of the recoding hypothesis because unlike lists of isolated or seemingly unrelated sentences, stories composed of scrambled stimuli possess a theme. With appropriate instructions, subjects attempt to obtain the gist of scrambled stories and meet with some success, though much less than with normal ones (see citations in Gernsbacher, 1990).

Second, the scrambling manipulation provided an empirical test of the shifting hypothesis because stimuli presented in a scrambled order are by definition relatively less coherent. Therefore, building a mental structure of a scrambled story should induce more shifting. Third, the scrambling manipulation pit the two hypotheses against one another because the predictions derived from each were in opposition. According to the recoding hypothesis, recently comprehended information becomes less available because it gets recoded into gist. Therefore, the lower the probability of recoding, the more accessible the information should be. Because comprehending scrambled stories leads to a lower probability of recoding, the prediction derived from the recoding hypothesis was that recently comprehended information would be *more* accessible in the scrambled than the normal condition.

But according to the shifting hypothesis, recently comprehended information becomes less accessible because of shifting from building one substructure to developing another; the higher the probability of shifting, the less accessible the information should be. Because comprehending scrambled stories leads to a higher probability of shifting, the prediction derived from the shifting hypothesis was that recently comprehended information would be *less* accessible in the scrambled than the normal condition.

The results of this fifth experiment using picture stories were clearly those predicted by the shifting hypothesis, i.e., information was less accessible in the scrambled than the normal condition (see Table I). These results were replicated in a sixth experiment using the more traditional stimuli, namely, written stories (see Table I). Thus, the cognitive process of shifting appears to be an adequate amodal explanation of why comprehenders rapidly lose access to recently comprehended information.

B. Linguistic Cues for Shifting

How do comprehenders know when to shift and initiate a new substructure? Presumably speakers and writers—and even picture story authors—signal their readers and listeners via various devices. For instance, when producing sentences, speakers and writers use certain devices to signal that they are beginning a new clause or phrase (Bever, 1970; Clark & Clark, 1977; Fodor et al., 1974; Frazier & Fodor, 1978; Kaplan, 1975; Kimball, 1973; Wanner & Maratsos, 1978). Indeed, one of Kimball's (1973) seven parsing principles was that "the construction of a new node is signalled by the occurrence of a grammatical function word" (p. 29). Thus, comprehenders might, as Clark and Clark (1977) suggested, use signals such as determiners (*a*, *an*, *the*) and quantifiers (*some*, *all*, *six*, etc.) to initiate a new substructure representing a new noun phrase. Similarly, they might use signals such as subordinating conjunctions (*because*, *when*, *since*, etc.) to initiate a new substructure representing a new clause (Clark & Clark, 1977, p. 62).

At the level of passages, speakers and writers use other devices to signal an upcoming change, e.g., a change in topic, point of view, or setting (Carpenter & Just, 1977; Halliday, 1967). One relatively subtle linguistic device is what I have referred to as an adverbial lead (Gernsbacher, 1984). This involves simply placing an adverb like *Then* or *Next* at the beginning of a sentence. In several experiments, we have found that adverbial leads stimulated behavioral responses indicative of processing shifts.

In many of these experiments, subjects read seven-sentence passages that began like

(27) *The lifeguard was watching the children swim. He noticed one child was struggling. He thought the child might be drowning.*

Then, either the fourth or fifth sentence began with an adverb like *then* or *next*, as in (28) or (29):

(28) *Next, he jumped into the water. He began to administer CPR.*

(29) *He jumped quickly into the water. Next, he administered CPR.*

In one experiment I measured sentence reading times and found that adverbial leads slowed comprehension (Gernsbacher, 1984, Experiment 1). This suggests that adverbial leads trigger comprehenders to begin laying a foundation for a new substructure. In a second experiment, I measured question-answering latencies and found that comprehenders had more difficulty accessing information presented before an adverbial lead than information presented afterward (Gernsbacher, 1984, Experi-

ment 2). This suggests that the information occurring after an adverbial lead is represented in a different mental substructure.

In another experiment, Wisegarver (1986) used the priming-in-item-recognition task pioneered by McKoon & Ratcliff (1980a, 1980b). In this task, subjects first read a passage and then attempt to recognize whether each of a short list of words occurred in that passage. Wisegarver (1986) found that a word from one sentence of a passage was a worse prime for a word from another sentence when an adverbial lead intervened between the two.

Finally, using different passages from the one illustrated above, Beeman and I (1991) found that comprehenders' ability to draw inferences between two facts was severely disrupted when one of those facts was presented prior to an adverbial lead and the other was presented after the adverbial lead. In sum, adverbial leads appear to stimulate behavior indicative of processing shifts; perhaps speakers and writers use them to signal their readers or listeners of an upcoming change.

IV. Mechanisms of Suppression and Enhancement

According to the structure building framework, the building blocks of mental structures are memory nodes. Presumably, memory nodes are activated by incoming stimuli. Once activated, they transmit processing signals that either suppress (decrease or dampen) or enhance (increase or boost) the activation of other memory nodes. In other words, the activation of memory nodes is controlled by the mechanisms of suppression and enhancement. Suppression and enhancement might be responsible for many linguistic as well as nonlinguistic phenomena.

A. Role of Suppression in Fine-Tuning the Meanings of Words

The mechanism of suppression appears to control a phenomenon I refer to as "fine-tuning" the activation of lexical concepts, e.g., fine-tuning the appropriate meaning of an ambiguous word. The reason why such a fine-tuning process is needed is that—contrary to intuition—immediately after comprehenders hear or read an ambiguous word such as *bug*, multiple meanings are activated. In fact, multiple meanings are activated—even when a particular meaning is specified by the preceding semantic context, as in "spiders, roaches, and other *bugs*," or the preceding syntactic context, as in "I like *the* watch" vs. "I like *to* watch" (see citations in Gernsbacher, 1990).

Cognitive psychologists usually attribute this multiple activation to some form of automatic (or semiautomatic) activation (Burgess & Simpson, 1988; Simpson, 1984; Simpson & Lorsbach, 1983). Computer models usually simulate the pattern by allowing all meanings of an ambiguous word to receive facilitation prior to getting any input from a semantic or syntactic processor (Charniak, 1983). However, behaviorally the phenomenon becomes more complex very shortly after the multiple meanings are simultaneously activated. As intuition suggests, only one meaning is available to consciousness after a period as brief as 200 msec. So the question arises, what happens to the inappropriate meanings?

Some have suggested that inappropriate meanings become less accessible through a mechanism that I have dubbed *mutual inhibition*. Their suggestion is that the appropriate meanings' growth in activation causes the inappropriate meanings' decline in activation, as in a seesaw effect (McClelland & Kawamoto, 1986; Waltz & Pollack, 1985). Unfortunately, the behavioral data do not demonstrate this compensatory pattern.

Another explanation is that the inappropriate meanings simply decay (J. R. Anderson, 1983). However, we tested this decay explanation and found that in its purest sense it cannot explain all the data (Gernsbacher & Faust, 1990).[3] This experiment examined the activation of multiple meanings of an ambiguous word like *quack*. In one condition, the ambiguous words were biased by a previous semantic context. For example, subjects read either (30) or (31).

(30) *Pam was diagnosed by a quack.*

(31) *Pam heard a sound like a quack.*

In this condition the typical, multiple activation phenomenon was observed: Immediately after the subjects read the ambiguous words, both meanings were activated, but within about 350 msec the inappropriate meanings were no longer activated. In a second condition, the ambiguous words were left ambiguous, as in (32).

(32) *Pam was annoyed by the quack.*

In this condition, both meanings remained activated at 350 msec; in fact, they were both activated at 750 msec (see also Hudson & Tanenhaus, 1984). If the decreased activation of an inappropriate meaning is due to decay, then surely one or both of the meanings should have decayed in this

[3] A third explanation is that this phenomenon is attributable to backward priming (Glucksberg, Kreuz, & Rho, 1986; van Petten & Kutas, 1987; but see Burgess, Tanenhaus, & Seidenberg, 1989).

neutral condition. Instead, I suggest that both meanings remained activated because neither was suppressed by the semantic context. More recent pilot work suggests that the strength of the context affects the time course of the suppression mechanism.

I also suggest that the mechanism of suppression operates to finely tune the multiple associations of unambiguous words. That is, all concepts have multiple associations, e.g., *apple* is associated with both *pie* and *tree* (Marshall & Cofer, 1970). However, in some contexts the association between *apple* and *pie* is more relevant, as in (33); in other contexts, the association between *apple* and *tree* is more relevant, as in (34).

(33) *James baked the apples.*

(34) *James picked the apples.*

At some point during comprehension associations must be finely tuned. Indeed, a wealth of data demonstrate that more relevant associations provide better memory cues. For instance, *pie* would cue (33) better, whereas *tree* would cue (34) better (see citations in Gernsbacher, 1990).

Just like the multiple meanings of ambiguous words, the multiple associations of unambiguous words are immediately activated (Gernsbacher & Faust, 1990). However, after a brief period, only the more relevant association remains activated (see also Kintsch, 1988). Again, I suggest that less relevant associations—like the inappropriate meanings of ambiguous words—are suppressed. Moreover, a less efficient suppression mechanism while fine-tuning the activation of lexical concepts appears to characterize less skilled comprehenders (Gernsbacher, Varner, & Faust, 1990; see also Merrill, Sperber, & McCauley, 1981).

B. Role of Suppression and Enhancement in Improving Referential Access

Another phenomenon that the mechanisms of suppression and enhancement appear to control is referential access via anaphora (Gernsbacher, 1989). All languages have devices called *anaphors* that are used to refer to previously mentioned concepts called *antecedents*. For example, to refer to the antecedent *John* in (35), one could use a variety of anaphors.

(35) *John went to the store.*

One could use a repeated name, such as *John*, a synonymous noun phrase, such as *the guy*, a pronoun, such as *he*, or even a zero anaphor, as in

(36) *John went to the store and ∅ bought a quart of milk.*

In the past few years, understanding how language users negotiate

anaphora has been the focus of considerable psycholinguistic research (see Gernsbacher, 1989, for a review). Why has anaphora captured so much attention? For one reason, anaphors are very common linguistic devices. Consider only pronoun anaphors; in English, they are some of the most frequently occurring lexical units. For instance, in Kucera and Francis's (1967) samples of literary text, pronouns accounted for nearly a third of the 50 most common lexical types and over 40% of their corpus of one million tokens. One would assume that pronouns occur even more frequently in informal, oral discourse.

But perhaps more important, the process of understanding anaphors presents an extremely interesting case of lexical access. Maybe more than any other lexical unit, the meaning of an anaphor greatly depends on the context in which it occurs. So how do comprehenders understand these ubiquitous but chameleon-like lexical units?

In Gernsbacher (1989), I suggested that the mechanisms of enhancement and suppression control referential access via anaphora. Recall that enhancement involves increasing or boosting activation, and suppression involves dampening activation. If anaphors enhanced or increased their antecedents' activation, that would surely improve those antecedents' accessibility. Similarly, if anaphors suppressed or dampened the activation *of other concepts*, that would surely improve those antecedents' accessibility. By suppressing the activation of other concepts, a rementioned concept would gain a privileged position in the queue of potential referents.

Six experiments demonstrated that anaphors such as pronouns and repeated proper names do improve their antecedents' accessibility by the mechanisms of suppression and enhancement (Gernsbacher, 1989). In each of these experiments, subjects read sentences that introduced two participants in their first clauses and referred to one of those two participants in their second clauses, e.g.,

(37) *Ann predicted that Pam would lose the track race, but* ***she/Pam*** *came in first very easily.*

As in (37), the second-clause anaphor was either a pronoun, like *she*, or a proper name, like *Pam*. At different points while subjects were reading each sentence, one participant's name was presented (e.g., *Ann* or *Pam*), and the subjects' task was to verify whether that participant had occurred in the sentence they were reading. Subjects' verification latencies provided an index of how the anaphors affected both the antecedents, like *Pam*, and what I shall refer to as the nonantecedents, like *Ann*.

The first experiment measured activation immediately before and imme-

diately after the pronoun vs. name anaphors, i.e., the participants' names were tested at the two points marked with asterisks in (38).

(38) *Ann predicted that Pam would lose the track race, but * **she/Pam** * came in first very easily.*

This experiment demonstrated that proper name anaphors immediately use both suppression and enhancement to improve their antecedents' referential access. The data from this experiment are displayed in Fig 5. What is displayed is the mean time it took subjects to verify that either the antecedents (e.g., *Pam*) or the nonantecedents (e.g., *Ann*) occurred in the experimental sentences as a function of whether the anaphors were names vs. pronouns.

As shown in Fig. 5, when the anaphors were names, responses to the antecedents were substantially faster after the anaphors than before. This effect supports the hypothesis that name anaphors immediately enhance their antecedents such that antecedents are more accessible after anaphors than before. Also when the anaphors were names, responses to the nonantecedents were substantially *slower* after the anaphors than before. So, in addition to enhancing the activation of their antecedents, the name anaphors also appeared to suppress the activation of the nonantecedents. It was as if rementioning one participant made the other participant less accessible. However, in this first experiment, the evidence of enhancement and suppression emerged with the name anaphors only. As shown in Fig. 5, there was no immediate change in activation as a result of subjects having read the pronouns.

All of these results were replicated in a second experiment, with the slight change that when activation was measured before the anaphors, it was measured at the end of the first clause instead of after the beginning of the second. In other words, the participants' names were tested at the two points marked with asterisks in (39).

(39) *Ann predicted that Pam would lose the track race, * but **she/Pam** * came in first very easily.*

Again, the name anaphors both immediately enhanced the activation of their antecedents and immediately suppressed the activation of other nonantecedents. And again there was no immediate change in activation before vs. after the pronouns. This pattern for the pronouns also replicated a study by Tyler and Marslen-Wilson (1982). They too found that pronouns did not immediately affect the activation of their antecedents.

However, the third experiment of Gernsbacher (1989) demonstrated that pronouns do suppress other nonantecedents; they simply take more time to do so. In this experiment activation was measured at two new test

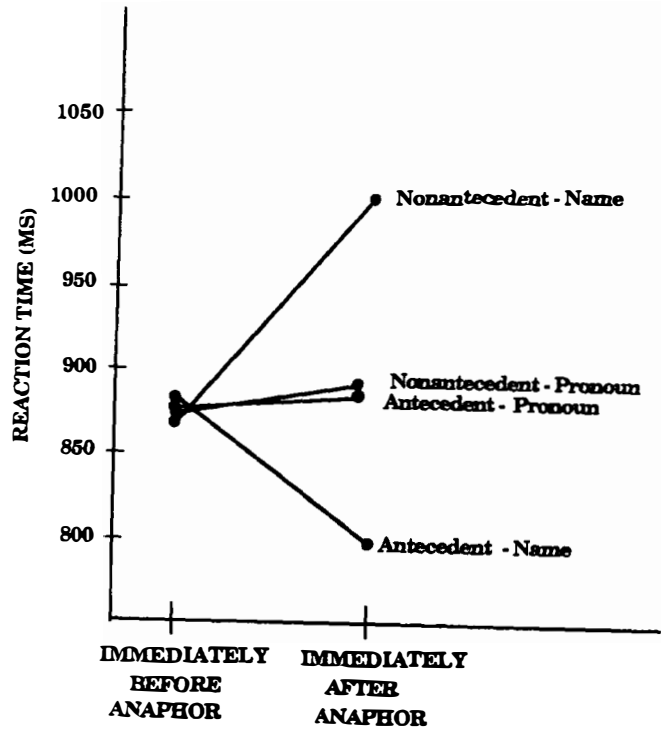

Fig. 5. Results of Gernsbacher (1989; Experiment 1). The data displayed are the subjects' mean verification latencies to antecedents vs. nonantecedents in sentences containing name vs. pronoun anaphors.

points, immediately after the pronoun or name anaphors and at the ends of the sentences, as in

(40) *Ann predicted that Pam would lose the track race, but **she/Pam** * came in first very easily. **

And indeed, by the ends of the sentences, the pronouns' nonantecedents had become considerably less activated. Thus, sometime over the course of the second clauses, the pronouns suppressed their nonantecedents. One reason that these pronouns might have taken longer to suppress their nonantecedents is that it was not until the second clause that the pronouns were semantically disambiguated; that is, prior to the second clause, the pronouns could have referred to either sentence participant. However, a fourth experiment demonstrated very similar results, even though the pronouns were disambiguated by a prior semantic context, as in

(41) *Bill lost a tennis match to John.*

(42) *Accepting the defeat,* ***he*** *walked quickly toward the showers.*

Or

(43) *Enjoying the victory,* ***he*** *walked quickly toward the showers.*

A fifth experiment demonstrated that pronouns still do not employ suppression immediately even when they match the gender of only one participant, as in

(44) *Tim predicted that Pam would lose the track race, but* ***she*** *came in first very easily.*

But once they do employ suppression, it is more powerful than when the pronouns are not gender-disambiguated.

The sixth and final experiment demonstrated that rementioned participants are not the only ones who improve their referential access by suppressing other participants; newly introduced participants do so as well. That is, introducing a new participant, as in (45), has the same effect as rementioning an old participant, as in (46).

(45) *Ann predicted that Pam would lose the track race, but Sue*

(46) *Ann predicted that Pam would lose the track race, but Pam*

Both suppress the activation of other participants. Thus, suppression seems to be a powerful mechanism controlling referential access.

C. Role of Enhancement and Suppression in Cataphoric Access

Just as there are anaphoric devices that enable access to previously mentioned concepts, I propose that there are also cataphoric devices that improve access to subsequently mentioned concepts. Recently, we (Gernsbacher & Shroyer, 1989) explored one device that might serve this cataphoric function. The device we studied was the unstressed, indefinite article *this*.

Most of us are familiar with the indefinite *this*; we use it to introduce concepts in jokes, as in "So *this* man walks into a bar" or "So a man walks into a bar with *this* parrot on his shoulder." We also use it to introduce concepts in narratives or conversations, as illustrated by one of Larson's (1982) cartoon characters, a cocktail waitress recounting the events of a bar room brawl.

(47) *So then* ***this*** *little sailor dude whips out a can of spinach,* ***this*** *crazy music starts playin', and well, just look at this place.* [emphasis mine]

Actually, only the first two occurrences of *this* in (47) are examples of the indefinite *this*; the third *this* as in "well, just look at *this* place" is an example of the stressed *this*. The indefinite *this* differs from both the stressed *this* and the deictic *this* as in "*This* is a mess" or "Look at *this*" because both the stressed and deictic *this* are definite (Perlman, 1969). According to linguists, a classic test of indefiniteness is occurrence in the existential-*there* construction. As demonstrated in (48)–(50), the indefinite article *this* and the indefinite article *a* pass this test, but the definite article *the* fails, making (50) agrammatical as indicated by the asterisk.

(48) *There was* ***this*** *guy in my class who*

(49) *There was* ***a*** *guy in my class who*

(50) **There was* ***the*** *guy in my class who*

The indefinite *this* is interesting for a couple of reasons. First, it is a relative newcomer to English; Wald (1983) suggests that its use dates back only to the late 1930s. Second, the indefinite *this* occurs considerably more often in informal, spoken dialects than formal or written ones—although some prescriptive grammarians dictate that it is unacceptable in any dialect.

Because it is an indefinite article, the indefinite *this*—like the indefinite *a* or *an*—is used to introduce new concepts into a discourse. In fact, of the 243 occurrences of the indefinite *this* that Prince (1981) observed in Terkel's (1974) book *Working*, 242 introduced a distinctly new concept; the only exception was arguably introducing the same lexical form but with a different referent. But more interestingly, in 209 of those 242 occurrences, the noun introduced with the indefinite *this* was referred to again and, as Prince said, "within the next few clauses."

This observation was quantified more explicitly by Wright and Givón (1987). They recorded 8- and 10-year olds telling one another jokes and informal stories. When the children introduced nouns with the indefinite *this*, they referred to those nouns an average of 5.32 times in the subsequent 10 clauses that they produced; in contrast, when they introduced nouns with the indefinite *a*, they referred to those nouns an average of only 0.68 times in their next 10 clauses. These data suggest that speakers use the indefinite *this* to introduce concepts that are going to play a pivotal role in the subsequent narrative. Thus, the indefinite *this* is a likely candidate for what I call a cataphoric device.

In Gernsbacher and Shroyer (1989), we asked the following question: Does introducing a concept with the indefinite *this*, as opposed to the more typical *a*, make that concept more accessible? To answer this question, we auditorily presented 20 informal narratives to subjects, telling them that at some point in each narrative the narrator would stop talking; when that happened, it was their job to continue telling the narrative. We constructed our narratives so that the last clause introduced a new noun. We manipulated whether this critical noun was marked by the indefinite *this* or the more typical indefinite *a*, e.g.,

(51) *I went to the coast last weekend with Sally. We'd checked the tide schedule 'n we'd planned to arrive at low-tide—cus I just love beachcombin'. Right off, I found three whole sanddollars. So then I started lookin' for agates, but I couldn't find any. Sally was pretty busy too. She found* ***this/an*** *egg*

From the transcriptions of our 45 subjects' continuations, we measured three manifestations of accessibility: frequency of mention, immediacy of mention, and anaphoric explicitness. We found reliable effects of all three measures: When the nouns were marked by *this*, subjects mentioned the nouns more frequently, often within the first clauses that they produced, and typically via less explicit anaphors such as pronouns. In contrast, when the nouns were marked by *a*, subjects mentioned the nouns less frequently, and typically via more explicit anaphors such as full noun phrases.

These results suggest that concepts initially marked with the indefinite *this* are subsequently more accessible. Therefore, the indefinite *this* operates as a cataphoric device. Indeed, Prince (1981) has suggested that the indefinite *this* parallels a device in American Sign Language in which a signer establishes an absent third person on his or her right so that the signer might later refer to that individual; an absent person who is not intended to be later referred to is not established this way. Clearly, this American Sign Language device is also operating cataphorically.

How do cataphoric devices improve the accessibility of their concepts? In Gernsbacher and Jescheniak (1990), we demonstrated that cataphoric devices—like anaphoric devices—improve referential access via the mechanisms of suppression and enhancement. Cataphoric devices improve their concepts' accessibility by suppressing the activation of other concepts and by making their concepts more resistant to suppression by other concepts.

D. Role of Suppression and Enhancement in the Loss of Access to Surface Information

The mechanisms of suppression and enhancement might also explain why "surface" information, as opposed to thematic information, becomes less accessible more rapidly during comprehension (Sachs, 1967, 1974). To understand how these mechanisms can account for this, one must consider what surface information is. Typically, surface information is defined as information about a stimulus that does not contribute to its meaning, e.g., the syntactic form of a sentence. But another definition is that the surface properties of any stimulus are those that change the most rapidly. For example, consider a passage of text. If the passage is well composed, then each sentence conveys the same thematic idea. But each sentence does not present the same syntactic form. Because the passage's syntactic form changes more rapidly than its thematic contact, its syntactic form is considered surface information while its thematic content is not.

Based on this definition, the mechanisms of suppression and enhancement explain why surface information becomes less accessible more rapidly than thematic information. Because surface information is constantly changing, the newer surface information is constantly suppressing the old. In contrast, because thematic information is constantly being reintroduced, it is repeatedly enhanced. The net result is that thematic information is more activated than surface information; therefore, thematic information is more accessible.

This definition, accompanied by the mechanisms of suppression and enhancement, can also explain why surface information is less accessible after comprehension of thematically organized than seemingly unrelated materials (A. Anderson et al., 1983; de Villiers, 1974; Peterson & McIntyre, 1973). With unrelated sentences, surface information is no longer more rapidly changing than thematic information; therefore, it would be less likely to be suppressed or more likely to be enhanced.

For instance, in J. R. Anderson and Bower's (1973) experiment, they presented sentences either grouped together as a related story or randomly arranged as an unrelated list. In both conditions, half the sentences were presented in the active voice and half in the passive voice. Because the sentences in the unrelated condition had no thematic continuity, their greatest common denominator was their syntactic form. On the other hand, the greatest common denominator of the sentences in the related condition was their thematic content.

This definition of surface information and the mechanisms of suppression and enhancement can also explain another pattern of results: Surface

information (tested by synonym substitution) is more accessible after comprehending abstract than concrete sentences. In contrast, thematic information (tested by subject–object reversal) is more accessible after comprehension of concrete than abstract sentences (Begg & Paivo, 1969; Johnson, Bransford, Nyberg, & Cleary, 1972; Moeser, 1974; Pezdek & Royer, 1974). However, in studies demonstrating this pattern, the abstract sentences differed fundamentally from the concrete sentences; the abstract sentences were less "comprehensible" according to several criteria (Holmes & Langford, 1976; Holyoak, 1974; Klee & Eysenck, 1973; Moeser, 1974; Schwanenflugel & Shoben, 1983).

In other words, the abstract sentences had less thematic content than the concrete ones. So comprehending the words of abstract sentences might have been like comprehending the sentences of unrelated groups (not thematically cohesive). On the other hand, comprehending the words of concrete sentences might have been like comprehending the sentences of related groups (thematically cohesive). Thus, performance with the abstract sentences could have resulted from less enhancement of their thematic information or less suppression of their surface information. On the other hand, performance with the concrete sentences could have resulted from greater enhancement of their thematic information or greater suppression of their surface information. Evidence already exists to support this explanation: When the abstract sentences were each embedded in their own contextual paragraph, i.e., a thematic idea was supplied, the pattern disappeared (Pezdek & Royer, 1974). With the added thematic continuity, comprehending abstract sentences mimicked comprehending concrete ones.

In sum, the mechanisms of suppression and enhancement during structure building appear to play a fundamental role in many comprehension phenomena: the fine tuning of lexical concepts, the accessibility of concepts via anaphoric and cataphoric reference, and rapid inaccessibility of surface as opposed to thematic information.

V. Individual Differences in General Comprehension Skill

According to the structure building framework, many of the processes and mechanisms involved in language comprehension are general cognitive processes and mechanisms. This orientation suggests that some of the reasons that individuals differ in comprehension skill might not be specific to language. In this last section, I describe how the structure building framework has provided a guide for understanding which cognitive processes and mechanisms underlie differential comprehension skill.

Experience informs us that individuals differ in comprehension skill. Laboratory research documents this as well (see reviews by Carr, 1981; Gibson & Levin, 1975; Perfetti, 1985; Smith & Spoehr, 1974). Unfortunately, the focus of much of this research has been on comprehension of one modality (i.e., the printed word) and on individuals who differ at one stage of skill development, i.e., beginning readers. So it's not too surprising that the processes and mechanisms previously suggested to underlie differences in comprehension skill are processes and mechanisms specific to reading. But when studying adult comprehension skill, one can go beyond those sources.

This is because at an adult level of proficiency, skill at comprehending written language is highly correlated with skill at comprehending spoken language (Daneman & Carpenter, 1980; Jackson & McClelland, 1979; Palmer, MacLeod, Hunt & Davidson, 1985; Perfetti & Lesgold, 1977; Sticht, 1972). Furthermore, the high correlations between comprehending written and spoken language and the strong parallels between comprehending language and nonlinguistic media (Baggett, 1975, 1979; Gernsbacher, 1983, 1985; Jenkins, Wald, & Pittenger, 1978) suggest the hypothesis that differences in adult comprehension skill might not depend completely on facility with language.

In Gernsbacher et al. (1990), we tested this hypothesis by creating a "multimedia" comprehension battery (Gernsbacher & Varner, 1988). The battery comprises six stimulus stories: two are presented via written sentences, two via auditory sentences, and two via pictures. The battery was administered to 270 college-aged subjects: the correlation between reading and listening was .92, between reading and picture viewing .82, and between listening and picture viewing .72. In addition, a factor analysis revealed only one possible factor, most likely a "general" comprehension skill. To explain differences in this general comprehension skill, one must look for general cognitive processes.

A starting point for investigation comes from a finding observed by Perfetti and Goldman (1976) and Perfetti and Lesgold (1977). They pinpointed a characteristic of less skilled comprehenders that appears during both reading and listening: Less skilled comprehenders have worse access to recently comprehended information. That is, although all comprehenders have difficulty remembering the wording of a recently comprehended sentence, less skilled comprehenders have even more difficulty. Because I previously demonstrated that this phenomenon was not unique to language comprehension, I hypothesized that poorer access to recently comprehended information might be a good "marker" of less skilled comprehenders regardless of the modality they were comprehending.

We tested this hypothesis by selecting a set of less and a set of more

skilled comprehenders from the extreme thirds of the distribution of subjects who had been tested on the multimedia battery (Gernsbacher et al., 1990, Experiment 2). These subjects comprehended six new stimulus stories: two in each of the three modalities. At two points during each story, the comprehenders' access to recently comprehended information was tested. The two points were after the subjects had comprehended half of a story and after they had comprehended an entire story.

The results of this experiment, expressed in average percent correct, are displayed in Fig. 6. The more skilled comprehenders are indicated by the hashed lines and the less skilled by the unfilled bars. As illustrated in the figure, the less skilled comprehenders did indeed have poorer access to recently comprehended information. And this was the case in all three modalities. Thus, less skilled comprehenders' poorer access to recently comprehended information is not limited to language-based comprehension.

On the face of it, these findings might suggest that less skilled comprehenders are plagued by smaller memory capacities. But within the normal range of comprehension skill, which is the range of interest to us

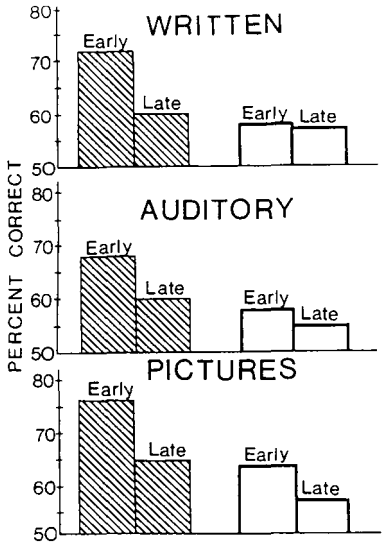

Fig. 6. Results of Gernsbacher, Varner, and Faust (1990; Experiment 2). The data displayed are averages of subjects' percentage correct recognition of a recently comprehended sentence or picture. The more skilled comprehenders are indicated by the hashed bars and the less skilled comprehenders by the unfilled bars.

here, less skilled comprehenders cannot be distinguished from more skilled comprehenders by traditional immediate or short-term memory measures (see citations in Gernsbacher, 1990).

In the spirit of Perfetti and his colleagues, I suggest that poorer access to recently comprehended information is not the *cause* of poorer comprehension skill; it is only a symptom. To understand the underlying cause or causes, one must understand why any comprehender loses access to recently comprehended information. According to the structure building framework, this results from shifting from actively building one structure or substructure to initiating another. Because information represented in one substructure is most available during the active processing of that substructure, once the comprehender has shifted to a new substructure, the information represented in the previous substructure becomes less available.

But meshing this explanation with the trademark of less skilled comprehenders—namely, poorer access to recently comprehended information—yields the rather unusual hypothesis that less skilled comprehenders suffer from shifting too often. That is, instead of continuing to map incoming information onto the structure that they are developing, less skilled comprehenders have a tendency to shift and initiate a new substructure.

We tested this hypothesis by selecting two more sets of more and less skilled comprehenders from the subjects tested with the comprehension battery (Gernsbacher et al., 1990, Experiment 3). These subjects also comprehended six new stimulus stories, two in each modality. And information accessibility was again tested at two test points: after half a story, and after an entire story. However, unlike our second experiment, our third experiment included a manipulation that was specifically designed to induce shifting. The manipulation was scrambling the sentences or pictures within a story. That is, of the six stories that the subjects comprehended, half were presented scrambled and half were presented in normal order, one in each modality.

By presenting half of the stories scrambled and half in their normal order, we could compare a situation in which we know that all comprehenders have to shift more frequently (during the scrambled stories) with a situation in which we hypothesize that less skilled comprehenders might also be shifting too frequently (during the normal stories).

The results of this experiment, again expressed in average percent correct, are shown in Fig. 7. Again, the more skilled comprehenders are indicated by hashed lines and the less skilled by unfilled bars. As illustrated in the top panel, this third experiment replicated the second experiment by demonstrating that less skilled comprehenders have poorer access to re-

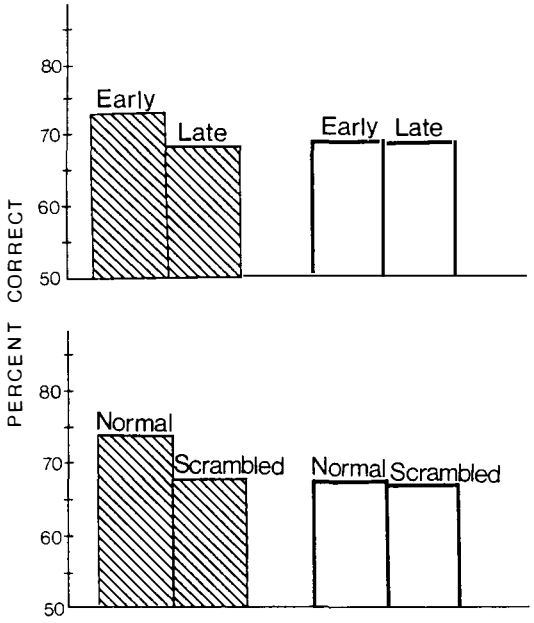

Fig. 7. Results of Gernsbacher, Varner, and Faust (1990; Experiment 3). The data displayed are subjects' average latencies to reject an inappropriate meaning of an ambiguous hended sentence or picture (all three modalities averaged). Top panel displays the difference between the two test points; bottom panel displays the effect of the scrambling manipulation. The more skilled comprehenders are indicated by the hashed bars and the less skilled comprehenders by the unfilled bars.

cently comprehended information. Again this difference was observed for all three modalities.

The novel finding of this experiment is illustrated in the bottom panel. For the more skilled comprehenders, scrambling the stories significantly reduced their access to recently comprehended information. However, for the less skilled comprehenders, there was virtually no difference between the normal vs. scrambled stories. One interpretation of these data is that for less skilled comprehenders, comprehending normal stories is like comprehending scrambled ones, i.e., it involves almost as many processing shifts. Thus, these data support the hypothesis that less skilled comprehenders shift too often during ordinary comprehension.

Why might less skilled comprehenders shift too often? Consider the consequences 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 could not be mapped onto the developing structure, its activation might lay the foundation for a new substructure. Thus, one consequence of an inefficient suppression mechanism would be the development of too many substructures—in other words, a greater tendency toward shifting.

In our fourth experiment, we tested the hypothesis that less skilled comprehenders are less able to selectively suppress irrelevant information. We did this with a task that measures how well comprehenders can suppress irrelevant information. We called this task *context verification* and the procedure was as follows: Subjects read a sentence and were then presented with a probe word. Their task was to verify whether the probe word matched the context of the sentence just read. In half the trials, the probe word did indeed match the context, but we were more interested in trials in which the probe word did not match the context.

In half of those trials, the last word of the sentence was an ambiguous word, e.g.,

(52) *The man dug with the* ***spade***.

The probe word was the meaning of the ambiguous word that was inappropriate to the context, e.g., ACE. We compared how rapidly subjects verified that a word like ACE was not related to the sentence with how rapidly they verified that ACE was not related to the same sentence but with the last word replaced by an unambiguous word, e.g.,

(53) *The man dug with the* ***shovel***.

This comparison gave us a measure of how activated the inappropriate meaning of the ambiguous word was. The slower subjects were to reject ACE after the "spade" sentence, the more activated the inappropriate meaning must have been (i.e., the less they were able to suppress the inappropriate meaning). We referred to this measure as the amount of interference the comprehenders experienced.

We measured interference at two test points: immediately after subjects finished reading each sentence and three-fourths of a second later. We predicted that at the immediate test point both the less and more skilled comprehenders would show interference. This prediction was based on the vast literature demonstrating that immediately after an ambiguous word is read, multiple meanings are activated regardless of context. Our novel predictions concerned what would happen at the delayed test point. If the decreased activation of the inappropriate meanings is due to suppression, and if this suppression mechanism is less efficient in less skilled comprehenders, then the less skilled comprehenders should still be experi-

encing a reliable amount of interference. And, indeed, that is what we found.

The results of this experiment, expressed in msec of interference, are shown in Fig. 8. Immediately after the more skilled comprehenders read the ambiguous word, they experienced a significant amount of interference, suggesting that the inappropriate meaning was highly activated. However, three-fourths of a second later, they were no longer experiencing a reliable amount of interference, suggesting that the inappropriate meaning had become considerably less activated—perhaps via the mechanism of suppression.

In contrast, for our less skilled comprehenders, even as late as three-fourths of a second after they read the ambiguous word, the inappropriate meaning was still strongly activated. That is, the less skilled comprehenders were still experiencing a significant amount of interference; in fact, they were experiencing the same level of interference as they had experienced immediately after the ambiguous word. This finding suggests that less skilled comprehenders are plagued with a less rapid (and therefore less efficient) suppression mechanism. This, in turn, could lead to their greater tendency toward shifting and their poorer access to recently comprehended information.

VI. Summary and Conclusions

In this chapter, I have identified and described three general cognitive processes involved in language comprehension, i.e., laying a foundation for a mental structure, mapping coherent or relevant information onto that

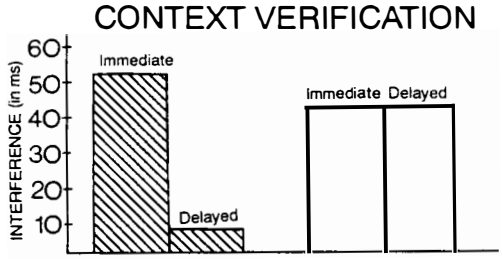

Fig. 8. Results of Gernsbacher, Varner, and Faust (1990; Experiment 4). The data displayed are subjects' average latencies to reject an inappropriate meaning of an ambiguous word minus their average latencies to reject the same words preceded by an unambiguous word (see text for a fuller description). The more skilled comprehenders are indicated by the hashed bars and the less skilled comprehenders by the unfilled bars.

structure, and shifting to develop a new structure when the incoming information is less coherent or relevant. I also suggested that two general cognitive mechanisms underlie the processes of structure building. They are suppression and enhancement.

These general cognitive processes and mechanisms account for many linguistic and nonlinguistic comprehension phenomena. For example, the process of laying a foundation accounts for the advantage of first mention: After comprehending a sentence involving two participants, it is easier to access the first-mentioned participant than the second-mentioned participant. This advantage is not due to linguistic or structural factors such as the first-mentioned participant's greater tendency to be semantic agents or syntactic subjects. Rather I suggest that the advantage arises because comprehension involves laying a foundation. And for this reason, first-mentioned participants are more accessible both because they form the foundations for their sentence level representations and because it is through them that subsequent information is mapped onto the developing representation.

The process of laying a foundation also accounts for the change in accessibility of concepts from multiclause sentences. When comprehenders are still developing their representations of a final clause, concepts in that final clause are more accessible than concepts from an initial clause. After comprehenders have built their representations of both clauses, but before they begin mapping those representations together, concepts from both clauses are equally accessible. A little bit later, concepts from the first clause become more accessible. I suggest that at that point, comprehenders have finished mapping the second clause onto the first, and the first clause serves as the foundation for the whole sentence level representation. The greater accessibility of concepts from the first clause strengthens over time, demonstrating that order of mention is a relatively long-lived characteristic of the mental representation of a sentence.

The process of laying a foundation also accomplishes what linguists suggest are the functional roles of order of mention. According to some linguists, initial mention codes importance and functions to attract attention; according to others, first mention codes givenness and functions to create a context for subsequent comprehension. If first mention is selected in order to signal importance, then the function is accomplished because—by virtue of being first mentioned—initial information gets represented at the core or foundation of the structure. This causes the information to be more accessible, which is most likely the goal of marking information as important. If first mention is selected in order to signal givenness, then the function is also accomplished because—by virtue of being first mentioned—initial information organizes the representation of subsequent

information. That is, subsequent information gets mapped onto the developing structure vis-à-vis the initial information.

Other processes involved in structure building account for other comprehension phenomena. For example, the process of shifting accounts for why comprehenders rapidly lose access to recently comprehended information. According to this explanation, information becomes less accessible because comprehenders shift from developing one substructure in order to develop another. Presumably, information represented in one substructure is most available during the active development of that substructure. Once a comprehender has shifted to initiate a new substructure, information represented in the previous substructure becomes less available. In Gernsbacher (1985), I demonstrated that comprehenders' rapid loss of access to recently comprehended information was not specific to language-based comprehension, and I tested the shifting explanation against a recoding explanation (information becomes less accessible because it is recoded into gist). The explanation based on the cognitive process of shifting clearly accounted for the phenomenon during both language and nonlanguage comprehension.

The process of shifting also predicts comprehenders' responses to speakers' and writers' cues for a new phrase, clause, topic, setting, or point of view. Comprehenders slow their comprehension when they encounter these cues. This suggests that these cues trigger comprehenders to begin laying a foundation for a new substructure. Comprehenders also have more difficulty accessing information presented before these cues than information presented after. This suggests that the information presented after these cues is represented in a different mental substructure than that of information presented before.

The mechanisms of suppression and enhancement also account for many comprehension phenomena. For example, suppression helps fine-tune the meanings of ambiguous words and the associations of unambiguous words by suppressing the activation of ambiguous words' inappropriate meanings and unambiguous words' less relevant associations.

Both suppression and enhancement play a role in referential access via anaphora, in other words, the act of referring to previously mentioned concepts (antecedents) via anaphors such as pronouns and repeated names. Some anaphors, such as repeated names, improve their antecedents' accessibility by enhancing or increasing those antecedents' activation. Other anaphors, such as pronouns as well as repeated names, improve their antecedents' accessibility by suppressing or dampening the activation of other concepts.

Suppression and enhancement also control referential access via cataphoric devices. That is, just as there are anaphoric devices that enable

access to previously mentioned concepts, cataphoric devices improve access to subsequently mentioned concepts. The unstressed indefinite *this* appears to operate in such a way. Cataphoric devices improve their concepts' accessibility by enhancing the activation of those concepts, by suppressing the activation of other concepts, and by making their concepts more resistant to suppression.

Suppression and enhancement also explain why surface information often becomes less accessible more rapidly than thematic information. In a cohesive passage, the surface information is the most rapidly changing characteristic, whereas the thematic information is constantly being conveyed. Because surface information is constantly changing, the newer surface information is constantly suppressing the old. In contrast, because thematic information is constantly being reintroduced, it gets repeatedly enhanced. The net result is that thematic information is more activated than surface information and thus more accessible.

Finally, the structure building framework provides a blueprint for investigating individual differences in "general" comprehension skill. For example, beginning with the finding that less skilled comprehenders have poorer access to recently comprehended information, we have found that this phenomenon occurs during the comprehension of nonlinguistic stories as well. We have also traced it to less skilled comprehenders' tendency to shift too often. And we have suggested that this tendency results from a less efficient suppression mechanism.

Thus, the structure building framework and its component processes and mechanisms account for many comprehension phenomena. This framework should also be useful for understanding the comprehension of other media, e.g., music (Lerdahl & Jackendoff, 1983; Sloboda, 1985). This is because in many domains the goal of comprehension is to build a coherent representation of the entire stimulus.

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