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19. This research investigated language comprehension according to the Structure Building Framework (Gernsbacher, 1990). In particular, this research investigated the role of two structure building mechanisms in language comprehension. They are Suppression and Enhancement. The first series of experiments investigated the role of suppression in word understanding. The results demonstrated that the mechanism of suppression dampens the activation of the inappropriate meanings of ambiguous words; they do not decrease in activation simply because their activation is consumed by appropriate meanings or because they decay. Suppression also dampens the activation of less relevant associations of unambiguous words. A second series of experiments investigated the role of suppression in improving the accessibility of concepts marked by cataphoric devices. Cataphoric devices are counterparts to anaphoric devices: Anaphoric devices mark concepts that have been mentioned before, and cataphoric devices mark concepts that are likely to be mentioned again. The results demonstrated that when concepts are marked with cataphoric devices, like spoken stress and the indefinite *this*, they are better at suppressing the activation of other concepts, and they are more resistant to being suppressed by other concepts. A third series of experiments investigated the role of suppression and enhancement in adult comprehension skill. The results demonstrated that less-skilled comprehenders less-efficiently suppress the inappropriate meanings of ambiguous words (e.g., the playing card vs garden tool meaning of *spade*); the incorrect forms of homophones (e.g., *patients* vs *patience*), the typical-but-absent members of scenes (e.g., a *tractor* in a *farm* scene), and words superimposed on pictures or pictures surrounding words. Less-skilled comprehenders do not less efficiently enhance the activation of contextually appropriate information; they suffer only from less-efficient suppression mechanisms.

Language Comprehension as
Structure Building

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According to the Structure Building Framework (Gernsbacher, 1990), the goal of comprehension is to build coherent mental structures. The building blocks of these mental structures are memory cells. Memory cells represent previously stored memory traces. This representation might be either in the traditional sense of an individual cell representing an individual trace, or in the distributed sense of a group of cells representing an individual trace.

Memory cells are automatically activated by incoming stimuli. Once activated, the information they represent can be used by cognitive processes.[1] Furthermore, according to the Structure Building Framework (Gernsbacher, 1990), activated memory cells transmit processing signals. These processing signals either suppress or enhance the activation of other memory cells. So, once memory cells are activated, two mechanisms modulate their level of activation: They are suppression and enhancement.

Suppression decreases or dampens the activation of memory cells when the information they represent is no longer as necessary for the structure being built. Enhancement increases or boosts the activation of memory cells when the information they represent is relevant to the structure being built. By modulating the activation of memory cells, suppression and enhancement contribute to structure building.

The notion that incoming stimuli activate memory representations is familiar. What is novel about the Structure Building Framework's proposal is that activated memory cells transmit processing signals. This proposal more fully captures the analogy of neural activity — an analogy that inspires many models of cognition.

The familiar notion that incoming stimuli activate memory cells captures only one aspect of the analogy, the electrical transmission of information (along axons). But the novel proposal that activated memory cells also transmit processing signals completes the analogy. The transmission of processing signals (suppression and enhancement) parallels the chemical transmission of information (across synapses, via neurotransmitters).

Suppression and enhancement are general cognitive mechanisms. They are not dedicated solely to language; they play vital roles in nonlinguistic processes, too. But language comprehension processes — particularly those involved in structure building — draw heavily on these two mechanisms.

The research I performed under AFOSR grant 89-0258 investigated the role of suppression and enhancement. In particular, I investigated the role that suppression plays in how comprehenders understand words; the role that suppression plays in how comprehenders access cataphorically marked concepts, and the role that both suppression and enhancement play in adult comprehension skill.

The Role of Suppression in Understanding Words

According to many models of word understanding, when comprehenders first hear or read a word, information provided by that word activates various potential meanings. Then, constraints provided by lexical, semantic, syntactic, and other sources of information alter those meanings' levels of activation. Eventually, one meaning becomes most strongly activated. That meaning is what comprehenders access and incorporate into their developing mental structures (these ideas are culled from the models of Becker, 1976; Kintsch, 1988; Marslen-Wilson & Welsh, 1978; Norris, 1986; and McClelland & Rumelhart, 1981).

What the Structure Building Framework adds to these ideas is the proposal that suppression and enhancement modulate the different meanings' levels of activation. The mechanism of suppression, in particular, could play a vital role in how comprehenders understand the appropriate meanings of ambiguous words (words like *bug* that have at least two diverse meanings).

Contrary to at least my grandmother's intuitions, immediately after comprehenders hear or read an ambiguous word, multiple meanings are often activated. In fact, multiple meanings are often activated even though one meaning is strongly implied by the context.

For example, immediately after comprehenders hear the word *bug*, both the "insect" meaning and the "covert microphone" meaning are activated. Both meanings are activated even when the context is biased toward the "insect" meaning, as in

> (1) The man was not surprised when he found several spiders, roaches, and other **bugs** ....

(Swinney, 1979). This immediate activation of multiple meanings, regardless of context, is demonstrated in the following experimental task: Subjects listen to a series of sentences. At a critical point during each sentence, they are shown a test word. The subjects must decide rapidly whether that test word is an English word. They press one button if they decide that it is, and another button if they decide that it is not. Their reaction times and accuracy are recorded.

Presumably, the subjects' reaction times and accuracy reflect how activated the test words are (and how activated concepts related to those test words are). So, the faster and more accurately the subjects respond, the more activated such concepts must be.

For example, if sentence (1) was presented in such an experiment, then immediately after subjects heard the word, *bug,* they might see the test word, *ANT*. That test word is related to the contextually appropriate meaning of *bug* (the meaning biased by the context). In another condition of the same experiment, immediately after subjects heard the word, *bug,* they might see the test word, *SPY*. That test word is related to a contextually inappropriate meaning of *bug* (a meaning not biased by the context).

Subjects should decide that both *ANT* and *SPY* are English words (because, of course, they are). But subjects might make their decision about one test word more rapidly than they make their decision about another. This should depend on which meaning is more activated. If the "insect" meaning is more activated than the "covert microphone" meaning, then subjects should respond more rapidly to *ANT* than to *SPY*. But if the "covert microphone" meaning is just as activated as the "insect" meaning, then subjects should respond just as rapidly to *SPY* as to *ANT*.

As it turns out, when subjects are tested immediately after they hear the word *bug* in the context "spiders, roaches, and other *bugs*," they respond just as rapidly to *SPY* as to *ANT*. In other words, subjects respond to test words related to the contextually inappropriate meanings *(SPY)* just as rapidly as they respond to test words related to the contextually appropriate meanings *(ANT)*. This suggests that immediately after comprehenders hear ambiguous words, both appropriate and inappropriate meanings are activated.

But researchers must also demonstrate that the appropriate and inappropriate meanings are more activated than other concepts (rather than that the two sets of meanings are equally activated, but no more activated than anything else). Typically, researchers demonstrate this with a control condition. For instance, in Swinney's (1979) experiments, he compared subjects' responses to test words like *SPY* and *ANT* with their responses to a test word like *SEW*, which is unrelated to any meaning of *bug*.

Then, to estimate how much more activated appropriate and inappropriate meanings are than other concepts, researchers take reaction times to test words related to either meaning and subtract them from reaction times to test words unrelated to either meaning. In other words, researchers compute the following: Estimated Activation = $RT_{unrelated}$ - $RT_{related}$.

Figure 1 illustrates such an estimate made from Swinney's (1979) data.[2] Focus on the two leftmost bars labelled IMMEDIATE; those two bars illustrate the data that were collected immediately after comprehenders heard the ambiguous words. The first bar estimates the appropriate meanings' activation. That estimate was made by subtracting subjects' reaction times to test words related to the appropriate meanings from their reaction times to test words unrelated to any meaning. For example, Estimated Activation(Appropriate) = RT_{SEW} - RT_{ANT}.

The second of the two leftmost bars labelled IMMEDIATE estimates the inappropriate meanings' activation. That estimate was made by subtracting subjects' reaction times to test words related to the inappropriate meanings from their reaction times to test words unrelated to any meaning. For example, Estimated Activation(Inappropriate) = RT_{SEW} - RT_{SPY}.

As Figure 1 illustrates, when activation is measured immediately after comprehenders hear ambiguous words, both appropriate and inappropriate meanings are more activated than unrelated concepts; that is, both bars are taller than the baseline.

But this is only what happens when activation is measured immediately after comprehenders hear ambiguous words. As even my grandmother's intuition suggests, comprehenders do not keep multiple meanings activated forever. If they did, they would never unambiguously understand any utterance or passage. Instead, multiple meanings are activated only momentarily.

If subjects continue listening to sentence (1) and are tested only four syllables after hearing the word, *bug*, they still respond rapidly to *ANT*. But they respond no more rapidly to *SPY* than they respond to *SEW*. In other words, they respond no more rapidly to test words related to contextually inappropriate meanings than they respond to test words unrelated to any meaning.

Figure 1 illustrates this. Look at the two rightmost bars labelled DELAYED. Those two bars illustrate data that were collected four syllables after comprehenders heard the ambiguous words. Again, the first bar estimates the appropriate meanings' activation (e.g., RT_{SEW} - RT_{ANT}). The second bar estimates the inappropriate meanings' activation (e.g., RT_{SEW} - RT_{SPY}).

As Figure 1 illustrates, with a delay of four syllables, inappropriate meanings are considerably less activated than appropriate meanings; indeed, inappropriate meanings are no more activated than unrelated concepts (which is why the bar does not rise beyond the baseline). Inappropriate meanings become less activated even more quickly than within four syllables, often within only 200 ms. That is probably why comprehenders are typically aware of only one meaning — the contextually appropriate one.

This phenomenon, immediate activation of multiple meanings but continued activation of only appropriate meanings, is also demonstrated with similar laboratory tasks. It is demonstrated when subjects read sentences one word at a time, and occasionally, instead of seeing the next word of a sentence, they see the test words. Again, their task is to decide rapidly whether each test word is an English word (Kintsch & Mross, 1985; Till, Mross, & Kintsch, 1988).

The phenomenon is also demonstrated when subjects listen to sentences and are visually presented with test words. But instead of rapidly deciding whether each test word is an English word, they simply pronounce each test word as rapidly as possible. Or they simply name the color of ink in which each test word is printed (Conrad, 1974; Lucas, 1987; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982; Tanenhaus, Leiman, & Seidenberg, 1979).

Each of these laboratory tasks demonstrates that multiple meanings of ambiguous words are often immediately activated — regardless of semantic context. But only contextually appropriate meanings remain activated a short while later.

This phenomenon occurs even when one meaning is a noun and the other is a verb. For example, the word *watch*, refers to both an object, *a timepiece*, and an action, *looking*. Sentence (2) implies the noun meaning of *watch*, while sentence (3) implies the verb meaning.

(2) I like **the** watch.

(3) I like **to** watch.

Immediately after comprehenders hear the word, *watch*, in either sentence (2) or (3), both its noun and its verb meaning are momentarily activated. This occurs even though the definite article *the* makes the verb meaning inappropriate, and the infinitive marker *to* makes the noun meaning inappropriate. So, multiple meanings are immediately activated despite syntactic context just like multiple meanings are immediately activated despite semantic context (Seidenberg et al., 1979).

Figure 2 illustrates this phenomenon with data from Seidenberg et al. (1979). As the two bars labelled IMMEDIATE illustrate, multiple meanings are immediately activated despite syntactic contexts. But as the two bars labelled DELAYED illustrate, when activation is measured after a delay (which for these data was only 200 ms), the syntactically inappropriate meanings are no more activated than unrelated concepts.

Why multiple meanings are immediately activated without regard to context intrigues researchers, perhaps because the phenomenon challenges introspection. Many laboratory investigations have searched for its boundary conditions (Blutner, & Sommer, 1988; Glucksberg, Kruez, & Rho, 1987; Tabossi, 1988; Tabossi, Colombo, & Job, 1987; van Petten & Kutas, 1987; Williams, 1988).

But equally intriguing are the following questions: What happens to the inappropriate meanings? How do they become less activated? Unfortunately, scant empirical attention has been directed toward answering these questions.

According to the Structure Building Framework (Gernsbacher, 1990), inappropriate meanings become less activated via the mechanism of suppression. The memory cells representing the semantic or syntactic context transmit processing signals. These processing signals suppress the contextually inappropriate meanings. Dampening the activation of inappropriate meanings could be one of the most important roles that the mechanism of suppression plays in comprehension.

But other theories assume that inappropriate meanings become less activated via other mechanisms. For instance, according to some theories, inappropriate meanings are inhibited by appropriate meanings, and according to other theories, inappropriate meanings simply decay. Unfortunately, neither assumption had been tested empirically. That was the purpose of the first set of experiments I conducted under AFOSR 89-0258.

Are inappropriate meanings mutually inhibited?

Some theories propose that inappropriate meanings become less activated through a mechanism I shall call *compensatory inhibition* (McClelland & Kawamoto, 1986; Waltz & Pollack, 1985). These theories assume that all concepts compete for a fixed amount of activation. So when multiple meanings of ambiguous words are immediately activated, they are sharing this fixed sum. Later, inappropriate meanings must decrease in activation presumably because appropriate meanings have increased. Like a seesaw, when one meaning increases, the other must come down.

But if reaction times reflect activation, which is what many reaction time researchers assume (Posner, 1978), the behavioral data do not demonstrate this compensatory pattern. Simply put: The appropriate meanings do not increase in activation when the inappropriate meanings decrease.

For instance, look at Figures 1 and 2. In neither figure are the appropriate meanings' estimated activation levels higher at the delayed test point than they were at the immediate test point. But in both figures, the inappropriate meanings' estimated activation levels are lower at the delayed test point than they were at the immediate test point. So even though the inappropriate meanings decrease, the appropriate meanings do not increase. This is the pattern typically observed in these experiments.

Perhaps appropriate meanings do not observably increase in activation because after a delay they must then compete with other concepts for the fixed sum of activation. By definition, Swinney's (1979) four-syllable delay introduced new syllables (and possibly new concepts). For example, sentence (1) continued,

(4) The man was not surprised when he found several spiders, roaches, and other bugs **in the corner of the room.**

We need some way to introduce a delay without introducing new concepts. One way would be to place the ambiguous words at the ends of their sentences. However, then we would have to worry about special strategies or processes that comprehenders might engage in when they finish a sentence (see Tanenhaus & Hudson, 1984, for a similar argument).

In the experiment I conducted while supported by AFOSR 89-0258, I introduced a delay without making the ambiguous words sentence-final and without introducing new concepts. I selected 48 ambiguous words that were just as likely to be thought of as verbs as nouns, according to ambiguity norms (Cramer, 1970; Kausler & Kollasch, 1970; Nelson, McEvoy, Walling, & Wheeler, 1980). For each ambiguous word, I constructed two experimental sentences. The two sentences were identical until after the ambiguous word occurred, with the following exception: In one sentence, the ambiguous word was preceded with the infinitive marker *to*, whereas in the other sentence, the ambiguous word was preceded with the definite article *the*. For example,

(5) Jack tried **to** punch ....

(6) Jack tried **the** punch ....

For each ambiguous word, I selected two test words: One was related to the verb meaning, and the other was related to the noun meaning. The two test words for sentences (5) and (6) are illustrated in Table 1.

For each ambiguous word, I also constructed two control sentences, which were identical to the two experimental sentences up to where the ambiguous words occurred. In the control sentences, the experimental ambiguous words were replaced with other ambiguous words (which matched the experimental words in length and familiarity). For example,

(7) Jack tried to **bluff** ....

(8) Jack tried the **rolls** ....

The control words (e.g., *bluff* and *rolls)* were unrelated to the test words (e.g., *HIT* and *DRINK).* This relationship is also illustrated in Table 1. Finally, I constructed 48 "lure" sentences that resembled the experimental and control sentences. The test words for the lure sentences were pronounceable strings of letters that did not form English words (e.g., *HUP, DRACK).*

TABLE 1
Example Stimuli

SENTENCES	TEST WORDS **HIT**	 **DRINK**
Jack tried to punch	**Related** to APPROPRIATE Meaning	**Related** to INAPPROPRIATE Meaning
Jack tried the punch	**Related** to INAPPROPRIATE Meaning	**Related** to APPROPRIATE Meaning
Jack tried to bluff	**Unrelated** to Any Meaning	**Unrelated** to Any Meaning
Jack tried the rolls	**Unrelated** to Any Meaning	**Unrelated** to Any Meaning

All of the sentences were presented visually, word-by-word in the center of a computer screen. Immediately after the ambiguous word disappeared (e.g., *punch),* or the control word disappeared (e.g., *bluff),* the test word appeared. The test words appeared at the top of the screen in capital letters. Subjects decided rapidly whether each test word was an English word. They should have decided "yes" for the experimental and control sentences, and "no" for the lure sentences.

After the ambiguous or control words, the sentences continued in meaningful but different ways. For example,

(9) Jack tried the punch **but he didn't think it tasted very good**.

However, remember that the test words always appeared immediately after the ambiguous or control words; so, activation was always measured before the sentences diverged.

I measured activation at two test intervals. These test intervals were produced by manipulating the rate at which the words in the sentences appeared. There were two presentation rates: At the faster rate, each word appeared for 16.667 ms per character, plus a constant 150 ms. At the slower rate, each word appeared for 50 ms per character, plus a constant 450 ms. Figure 3 illustrates these presentation rates.

In both the fast and slow presentation rate, a constant 150 ms intervened between the appearance of each word in a sentence. And in both the fast and slow presentation rate, a constant 150 ms intervened between the ambiguous (or control) word and its test word. The difference in these rates created the difference between the two test points. With the faster rate, a five-letter word (like *punch)* appeared for 233 ms; with the slower rate, the same five-letter word appeared for 700 ms. So, the difference between the two test points for five-letter words was 467 ms. Figure 4 illustrates this difference.

For continuity with the other experiments I have discussed, I shall call the test point produced by the faster rate IMMEDIATE, and the test point produced by the slower rate DELAYED.

I tested 80 subjects, whose data appear in Figure 5. As Figure 5 illustrates, at the immediate test point (caused by the faster presentation rate), both appropriate and inappropriate meanings are reliably more activated than unrelated concepts. Indeed, at this immediate point, appropriate and inappropriate meanings are activated at the same level.

But as Figure 5 also illustrates, after the delay (caused by the slower presentation rate), only the appropriate meanings are reliably more activated than unrelated concepts. Indeed, the inappropriate meanings are no more activated than unrelated concepts, and the inappropriate meanings are considerably less activated than the appropriate meanings.

These data replicate those of Swinney (1979) and others. These data also demonstrate that when the inappropriate meanings decrease in activation, the appropriate meanings do not increase; in other words, there is no compensation. If reaction times reflect activation levels, then there is no evidence that inappropriate meanings lose activation because appropriate meanings take a larger share (of a fixed sum).

Do inappropriate meanings simply decay?

Another explanation for why inappropriate meanings become less activated is that they *decay*. In many models of cognition, mental representations automatically decay when they are not continuously stimulated (Anderson, 1983). Inappropriate meanings might decay because they do not continuously receive stimulation from a biasing semantic or syntactic context. I empirically tested this decay explanation in the following experiment.

I selected 48 ambiguous words that were just about as likely to be thought of as one noun as another (according to ambiguity norms). For example, the word *quack* is just as likely to be interpreted as "an incompetent doctor" as "the sound a duck makes."

For each of the 48 ambiguous words, I constructed three experimental sentences. One experimental sentence was biased toward one meaning of the ambiguous word, for example,

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

A second experimental sentence was biased toward another meaning of the ambiguous word, for example,

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

The third experimental sentence was neutral: Neither its semantic nor its syntactic context was biased toward either meaning of the ambiguous word, for example,

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

To ensure that my sentences were effectively biased or neutral, I had 50 subjects read the beginnings of the sentences (e.g., *Pam was annoyed by the quack ....).* These subjects decided which meaning was intended. I used biased sentences only if 95% of these subjects agreed with the meaning I intended, and I used neutral sentences only if these subjects were roughly split over which of the two meanings I intended.

For each of the 48 ambiguous words, I selected two test words. One was related to one of the biased meanings (e.g., *DOCTOR),* and the other was related to the other biased meaning (e.g., *DUCK).* The test words and experimental sentences are illustrated in Table 2.

TABLE 2
Example Stimuli

SENTENCES	TEST WORDS **DOCTOR**	 **DUCK**
Pam was diagnosed by a quack	**Related** to APPROPRIATE Meaning	**Related** to INAPPROPRIATE Meaning
Pam heard a sound like a quack	**Related** to INAPPROPRIATE Meaning	**Related** to APPROPRIATE Meaning
Pam was annoyed by the quack	**Neutral**	**Neutral**
Pam was annoyed by the pupil	**Unrelated** to Any Meaning	**Unrelated** to Any Meaning

For each of the 48 ambiguous words, I also constructed a control sentence. The control sentences were identical to the neutral experimental sentences to the point where the ambiguous words occurred. In the control sentences, the experimental ambiguous words were replaced with unrelated ambiguous words (matched with the experimental words for length and familiarity). For example,

(13) Pam was annoyed by **the pupil** ....

The ambiguous words in the control sentences were unrelated to the test words. This relationship is also illustrated in Table 2.

I also constructed 48 lure sentences that resembled the experimental and control sentences, but the test words for the lure sentences were pronounceable strings of letters that did not form English words. All the sentences were presented visually, as in the experiment I described before. And as in the experiment I described before, the sentences continued in meaningful but different ways after the ambiguous or control words. For example,

(14) *Pam heard a sound like a quack* **but couldn't imagine where it was coming from.**

However, it was before the sentences diverged that I measured activation. I again manipulated the presentation rate (as illustrated in Figures 3 and 4), so that I could measure activation at two test points without introducing new concepts.

To summarize, there were three experimental sentences. One was biased toward one meaning of the ambiguous words; one was biased toward another meaning; and the third was neutral — there was no semantic or syntactic bias. While subjects read these experimental sentences, I measured how activated the multiple meanings of the ambiguous words were. And I made this measurement at two test points.

The decay explanation and the suppression explanation make identical predictions about the biased sentences. The biased sentences should replicate earlier experiments: At the Immediate test point, both appropriate and inappropriate meanings should be activated (in relation to the unrelated control sentences). But at the Delayed test point, the inappropriate meanings should be less activated.

Where the decay and the suppression explanations differ is their predictions about the neutral sentences. According to the decay explanation, inappropriate meanings become less activated because they automatically decay. And they decay because they lack stimulation from a semantic or syntactic context. Because neutral sentences also lack stimulation from a semantic or syntactic context, multiple meanings of ambiguous words should also decay. In other words, the decay explanation predicts that with neutral sentences, both meanings should be less activated after the delay than they are immediately. This is because neither meaning receives stimulation from a semantic or syntactic context.

In contrast, according to the suppression explanation, inappropriate meanings become less activated because the memory cells representing semantic or syntactic contexts transmit processing signals; these processing signals suppress the inappropriate meanings' activation. So, the suppression explanation predicts that only the inappropriate meanings of the biased sentences should become less activated after the delay; the multiple meanings of the neutral sentences should be just as activated after the delay as they are immediately. This is because there are no bases from which suppression signals can be transmitted.

So, the decay explanation predicts that with the neutral sentences, both meanings should be less activated after the delay than they are immediately. But the suppression explanation predicts that both meanings should be just as activated after the delay as they are immediately.

I tested 80 subjects, whose data appear in Figure 6. As Figure 6 illustrates, at the immediate test point, the appropriate meanings (of the biased sentences), the inappropriate meanings (of the biased sentences), and both meanings of the neutral sentences are reliably more activated than unrelated concepts.

As Figure 6 also illustrates, after the delay, the inappropriate meanings of the biased sentences are less activated; indeed, they are (statistically) no more activated than unrelated concepts. In contrast, both meanings of the neutral sentences are still reliably more activated than unrelated concepts. The same is true of the appropriate meanings (of the biased sentences).

Indeed, as Figure 6 illustrates, with the neutral sentences, the ambiguous words' multiple meanings are just as activated after the delay as they are immediately. These results confirm the predictions made by the suppression explanation, not the decay explanation. The suppression explanation, drawn from the Structure Building Framework, predicts that inappropriate meanings become less activated because the memory cells representing semantic or syntactic contexts transmit processing signals; these processing signals suppress the inappropriate meanings' activation. With a neutral context, multiple meanings remain activated because there are no bases from which suppression signals can be transmitted.

Does suppression dampen less relevant associations of unambiguous words?

The mechanism of suppression might also enable comprehenders to more clearly understand unambiguous words. This is because all words have multiple associations. For example, if a group of people is asked to say the first word they think of after they hear the word *apple,* about 40% will say "pie," and another 40% will say "tree" (Marshall & Cofer, 1970). So, both *pie* and *tree* are associated with *apple* .

But in some contexts the association between *apple* and *pie* is more relevant, for example, in the context,

(15) Jim **baked** the apples.

In other contexts, the association between *apple* and *tree* is more relevant, for example, in the context,

(16) Jim **picked** the apples.

Perhaps like the multiple meanings of ambiguous words, the multiple associations of unambiguous words are immediately activated. But at some point, these associations must be fine tuned. To build cohesive mental structures, comprehenders should keep activated only the most relevant associations.

Memory data demonstrate that at some point after words are first heard or read, their associations are fine tuned. These data demonstrate that more relevant associations are more effective recall cues.

For example, if subjects are given the cue *pie,* they have a higher probability of recalling sentence (15) than sentence (16). But, if subjects are given the cue *tree,* they have a higher probability of recalling sentence (16) than sentence (15) (Anderson & Ortony, 1975; Anderson, Pichert, Goetz, Schallert, Stevens, & Trollip, 1976; Barclay, Bransford, Franks, McCarrell, & Nitsch, 1974; Dreher & Singer, 1981; Garnham, 1979; Greenspan, 1986; Gumenik, 1979; Tabossi & Johnson-Laird, 1980; Till, 1977; Whitney & Kellas, 1984).

Perhaps like the multiple meanings of ambiguous words, the multiple associations of unambiguous words are immediately activated. But a short while later, the mechanism of suppression dampens the activation of the less relevant associations. I tested this hypothesis in the following experiment.

I selected 48 unambiguous, common nouns. Each noun had two relatively equal primary associations, according to association norms (Jenkins, 1970; Keppel & Strand, 1970; Marshall & Cofer, 1970; Miller, 1970; Postman, 1970). By primary, I mean that they were the first association that subjects gave in an association listing task (e.g., the first word that people thought of when they heard *apple)*. By relatively equal, I mean that the two associations were listed by the same proportion of subjects, plus or minus 5%.

For each of the 48 unambiguous nouns, I constructed two experimental sentences. The two sentences were identical except for their verbs: In one sentence the verb was more relevant to one primary association of the noun, for example, *baked the apples;* in the other sentence the verb was more relevant to the other primary association of the noun, for example, *picked the apples*. For each noun, its two primary associations were its two test words (e.g., *pie* and *tree)*.

For each of the 48 nouns, I also constructed two control sentences. The two control sentences were identical to the two experimental sentences up to where the unambiguous nouns occurred. In the control sentences, the experimental nouns were replaced with other unambiguous nouns (that they matched in length and familiarity). For example,

(17) Jim baked the **salmon**.

(18) Jim picked the **movies**.

These control sentences were unrelated to the test words, as illustrated in Table 3, on the next page.

I also constructed 48 lure sentences that resembled the experimental and control sentences but had test words that were pronounceable strings of letters, not English words. All the sentences were presented visually, as in the experiments I have described before. And as in the experiments I have described before, the sentences continued in meaningful but different ways after the experimental or control nouns. However, it was before the sentences diverged that I measured activation. Again, I manipulated the presentation rate (as Figures 3 and 4 illustrate), so that I could measure activation at two test points without introducing new concepts.

I tested 80 subjects, whose data appear in Figure 7. As Figure 7 illustrates, at the immediate test point, both more and less relevant associations are reliably more activated than unrelated concepts. Indeed, at this immediate point, more and less relevant associations are activated at the same level.

But as Figure 7 also illustrates, after the delay, less relevant associations are less activated. Although they are still marginally more activated than unrelated concepts, they are also marginally less activated than more appropriate meanings.

Like multiple meanings of ambiguous words, multiple associations of unambiguous words are immediately activated. But after a brief period, more relevant associations remain as highly activated, while less relevant associations lose activation (see also Kintsch, 1988). According to the Structure Building Framework (Gernsbacher, 1990), less relevant associations of unambiguous words — like inappropriate meanings of ambiguous words — are suppressed by processing signals transmitted by semantic and syntactic contexts.

TABLE 3
Example Stimuli

SENTENCES	TEST WORDS **PIE**	**TREE**
Jim baked the apples	**Related** to MORE RELEVANT Association	**Related** to LESS RELEVANT Association
Jim picked the apples	**Related** to LESS RELEVANT Association	**Related** to MORE RELEVANT Association
Jim baked the salmon	**Unrelated** to Any Association	**Unrelated** to Any Association
Jim picked the movies	**Unrelated** to Any Association	**Unrelated** to Any Association

Conclusions

From these experiments, I draw the following conclusions:

- The contextually inappropriate meanings of ambiguous words do not decrease in activation simply because their activation is consumed by the activation of appropriate meanings.
- The inappropriate meanings of ambiguous words do not decrease in activation simply because their activation decays.
- Rather, the mechanism of suppression dampens the activation of inappropriate meanings.
- Suppression also dampens the activation of less relevant associations of unambiguous words.

So, the mechanism of suppression plays a vital role in how comprehenders understand words. And understanding words is vital to building coherent mental structures.

The Role of Suppression in Cataphoric Access

Another comprehension phenomenon in which both the mechanisms of suppression and enhancement play a vital role is modulating reference, both anaphoric reference and cataphoric reference (a process I will be introducing later). By anaphoric reference, I mean the use of linguistic devices called ***anaphors*** to refer to previously mentioned concepts.

All languages have anaphoric reference. For example, in English, to refer to *John* in the sentence,

(19) **John** was writing an annual report.

we could use a variety of anaphoric devices. We could use a repeated name, for example,

(20) **John** was writing an annual report. **John** was having trouble thinking up enough example sentences.

We could use a synonymous noun phrase, for example,

(21) **John** was writing an annual report. **The idiot** was having trouble thinking up enough example sentences.

We could use a pronoun,

(22) **John** was writing an annual report. **He** was having trouble thinking up enough example sentences.

We could even use a zero anaphor (the absence of an anaphor),

(23) **John** was writing an annual report and **Ø** was having trouble thinking up enough example sentences.

In the past few years, understanding how language users negotiate anaphoric reference has been the focus of quite a bit of psycholinguistic research (see Gernsbacher, 1989, for a review).

Why has anaphoric reference captured so much attention? For one reason, anaphors are very common. Consider only pronouns; in English, they are some of the most frequently occurring words.[3] For instance, pronouns account for more than 40% of a sample of one million words of literature, and nearly a third of the 50 words that occur most frequently in that sample (Kucera & Francis, 1967). Pronouns probably occur even more frequently in informal, spoken discourse. Other types of anaphors also occur frequently in both written and spoken discourse.

Anaphoric reference also interests psycholinguists because it presents an interesting case of word comprehension: Perhaps more than other words, anaphors depend greatly on their context for their meaning. Consider the pronoun *it*. Its meaning is constrained only to the extent that its referent must be inanimate and singular;[4] beyond that, *it* can take on a host of different meanings. In just this chapter alone, *it* has more than 50 unique referents. Anaphors like *it* seem transparent.

But despite this ubiquity and transparency, comprehenders must figure out to whom or to what each anaphor refers; in other words, for each anaphor, comprehenders must access from their mental representations a unique referent. How does this happen?

Consider again how the meaning of a typical, nonanaphoric word is accessed. As I mentioned earlier in this chapter, this process is typically described in terms of activation. Various meanings are activated. Constraints then alter the potential meanings' activation. Eventually, one meaning becomes most strongly activated. This most strongly activated meaning is what comprehenders build into their developing mental structures.

Anaphoric reference might work similarly. An anaphor's referent is similar to a word's meaning. So, immediately after comprehenders hear or read an anaphor, potential referents might be activated. Constraints might alter the activation of those potential referents, so that eventually one concept is most strongly activated. The most strongly activated concept should be the referent that comprehenders access and build into their developing mental structures (Kintsch, 1988; Walker & Yekovich, 1987).

Behavioral data support this proposal. Consider the sentence,

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

In this sentence, the referent of the pronoun *she* is the participant *Pam;* the other participant, *Ann,* is whom I shall call a nonreferent. When Corbett and Chang (1983) measured activation after comprehenders finished reading this sentence (and others like it), they found that *Pam* was more activated than *Ann*. In other words, they found that a pronoun's referent was more activated than other nonreferents.[5]

According to the Structure Building Framework (Gernsbacher, 1990), the mechanisms of suppression and enhancement modulate activation levels. So, the mechanisms of suppression and enhancement might enable an anaphor's referent to become the most activated concept. This could happen in the following way.

A referent could become the most activated concept if it is enhanced (its activation level is increased). A referent could also become the most activated concept if *other concepts* are suppressed. That is, a rementioned concept could rise to the top of the queue of potential referents if the activation levels of other concepts are decreased.

But why would the mechanisms of suppression and enhancement do this? According to the Structure Building Framework (Gernsbacher, 1990), suppression and enhancement are triggered by activated memory cells. So, in the case of anaphoric reference, they could be triggered by memory cells that represent information about the referent's identity. The most available source of information about a referent's identity comes from the anaphor.

However, anaphors differ in how much information they provide about their referents. Some anaphors, such as repeated noun phrases, provide explicit information about their referents; they match their referents exactly (e.g., "*John* was writing a book. *John* was having trouble thinking up enough examples."). Other anaphors, such as the pronoun *it*, are less explicit; they often match several potential referents, and the information to uniquely identify their referents comes mostly from the context.

Intuitively, more explicit anaphors seem easier to understand than less explicit anaphors. And, empirically, sentences containing more explicit anaphors are read faster than sentences containing less explicit anaphors (Haviland & Clark, 1974; Yekovich & Walker, 1978).

Furthermore, the referents of more explicit anaphors are more activated than the referents of less explicit anaphors (Corbett & Chang, 1983; McKoon & Ratcliff, 1980). For example, compare sentence (25) with (26).

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

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

The anaphor in sentence (26), the repeated proper name *Pam*, is very explicit; it matches its referent exactly. In contrast, the anaphor in sentence (25), the pronoun *she*, is considerably less explicit. *She* could refer to either participant, and only the semantic information in the second clause identifies who *she* is.[6]

As I mentioned before, when Corbett and Chang (1983) measured activation after comprehenders read sentences like (25) and (26), the referents (e.g., *Pam)* were more activated than the nonreferents (e.g., *Ann)*. More intriguing, this difference was greater when the anaphors were explicit proper names, as in sentence (26).

In other words, the more explicit the anaphors, the greater the difference between the referents' versus nonreferents' activation. That is what would happen if the information available in an anaphor triggers the mechanisms of suppression and enhancement: The more explicit the anaphor, the more it would suppress nonreferents and enhance its own referent. In a series of experiments that I shall describe shortly, I tested this prediction.

Information about a referent's identity also comes from sources outside the anaphor, for instance, the semantic, pragmatic, and syntactic context. These other sources might also trigger suppression and enhancement, but they might do so more slowly or less powerfully. In Gernsbacher (1989) I found empirical evidence that

- Comprehenders access referents for anaphors in the same way they access meanings for words: They access the most activated mental representations.

- The mechanisms of suppression and enhancement play a role in anaphoric reference by modulating activation. Suppression decreases the activation of other (nonreferent) concepts, while enhancement increases the activation of referents.

- Suppression and enhancement are triggered by information that specifies the referent's identity. The primary source of this information is the anaphor itself. That is why more explicit anaphors should trigger more suppression and enhancement than less explicit anaphors.

- Information from other sources (such as semantic, syntactic, and pragmatic context) should also trigger suppression and enhancement, but more slowly and less powerfully.

So, according to the Structure Building Framework, the mechanisms of suppression and enhancement make a referent the most activated concept. Comprehenders can then access that referent and incorporate it into their developing mental structures.

Just as there are anaphoric devices, I propose that there are **cataphoric devices**. Anaphoric devices improve access to *previously* mentioned concepts, and I propose that cataphoric devices improve access to *subsequently* mentioned concepts. So, anaphoric devices enable comprehenders to access concepts that have been mentioned before, while cataphoric devices enable comprehenders to access concepts that are likely to be mentioned again.

For instance, the unstressed, indefinite article *this* operates as a cataphoric device. We often hear the indefinite *this* in introductions to jokes, for example, "So *this* man walks into a bar" or "So a man walks into a bar with *this* parrot on his shoulder." We also use the indefinite *this* 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.

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

Only the first two occurrences of *this* in (27) 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* (as in "Look at *this* place!") and the deictic *this* (as in "*This* is a mess" or "Look at *this!*"). They differ because both the stressed and deictic *this* are definite and stressed, while the indefinite *this* is indefinite and unstressed (Perlman, 1969).

According to linguists, a classic test of indefiniteness is occurrence in the existential-*there* construction. As (28) through (30) demonstrate, the indefinite article *this* and the indefinite article *a* can occur in existential-*there* constructions, but the definite article *the* cannot.

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

(29) There was **a** guy in my class who ...

(30) (?) There was **the** guy in my class who ...

The indefinite *this* is a relative newcomer to English; its use dates back only to the late 1930s (Wald, 1983). It occurs almost exclusively in informal spoken dialects rather than formal or written ones — although some prescriptive grammarians dictate that it is unacceptable in any dialect.

Because it is an indefinite article, *this* introduces new concepts into discourse. In fact, Prince (1981) observed 243 occurrences of the indefinite *this* in Terkel's (1974) book *Working*. Of those 243 occurrences, 242 introduced a distinctly new concept. More interestingly, of those 242 concepts, 209 were referred to again.

In fact, when eight- and ten-year olds introduced concepts with the indefinite *this*, they referred to those concepts an average of 5.32 times in their next 10 clauses. When they introduced concepts with the indefinite *a/an*, they referred to those concepts only .68 times in their next 10 clauses (Wright & Givón, 1987).

These descriptive data suggest that speakers use the indefinite *this* to mark key concepts. Suzanne Shroyer and I tested this proposal empirically (Gernsbacher & Shroyer, 1989). We auditorally presented 20 informal narratives to 45 subjects, telling them that at some point in each narrative the original narrator would stop talking; when that happened, it was the subjects' job to continue. We constructed our narratives so that the last clause of each introduced a new concept. We manipulated whether this concept was marked with the indefinite *this* or the indefinite *a/an*. For example, subjects heard (and then continued) the following narrative:

(31) I went to the coast last weekend with Sally. We'd checked the tide schedule 'n we'd planned to arrive at low-tide - 'cuz I just love beachcombin'. Right off, I found 3 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 ...

We transcribed our subjects' continuations and measured how frequently they referred to the experimental concepts.

When the concepts were marked with the indefinite *this*, subjects mentioned those concepts more frequently, often within the first clauses that they produced, and typically via less explicit anaphors such as pronouns. In contrast, when the concepts were marked with the indefinite *a/an*, subjects mentioned them less frequently, and typically via more explicit anaphors such as repeated noun phrases.

These data empirically demonstrate that concepts initially marked with the indefinite *this* are likely to be mentioned again. Indeed, Prince (1981) suggests 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.

In spoken English, a more salient cataphoric device is contrastive stress. Contrastive stress occurs when speakers vary their intonation and place spoken emphasis on certain words. Stressed words are higher pitched, louder, and longer (Fry, 1955; Lieberman, 1960).

Speakers deliberately stress certain concepts (Bolinger, 1972; Cruttenden, 1986; Levelt, 1989). The concepts they stress are most likely to be new (Terken & Nooteboom, 1987) and important (Bock & Mazella, 1983). Indeed, comprehension proceeds more smoothly when new and important concepts are more (rather than less) stressed. So, spoken stress also marks new concepts that are going to play a pivotal role in the subsequent discourse.

Do cataphoric devices improve their concepts' representational status?

I propose that cataphoric devices, such as spoken stress or the indefinite *this*, do more than signal that certain concepts are likely to be mentioned again. (In the same way, anaphoric devices do more than signal that certain concepts have been mentioned before.) I suggest that cataphoric devices improve their concepts' status in listeners' mental representations. In particular, I propose the following three hypotheses:

- When concepts are marked with cataphoric devices, they are more highly activated.
- When concepts are marked with cataphoric devices, they are better at suppressing the activation of other concepts.
- When concepts are marked with cataphoric devices, they better resist being suppressed by other concepts.

Cataphoric devices seem as crucial to language as anaphoric devices. This is because when people communicate, they introduce many concepts. While some of these concepts are never referred to again, others play a pivotal role in the discourse. Speakers would benefit if those key concepts achieved a privileged status in listeners' mental representations. Speakers could refer to those key concepts assured that their listeners could easily access them. Listeners would benefit too: They could use key concepts as cornerstones for their developing mental representations.

In the second set of experiments conducted under AFOSR 89-0258, I tested whether concepts marked with cataphoric devices gained a privileged status in listeners' mental representations. I began by constructing 48 experimental narratives. These were short, ranging from 30 to 80 words and averaging about 50 words. Actually, they seemed more like excerpts or the beginnings of longer conversational accounts. All were spoken informally, complete with colloquial refrains, false starts, and hesitations. I specifically selected topics with which I suspected undergraduate subjects would be familiar. This is an example:

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

Each narrative introduced many concepts, for example, *Vicky, a garage sale, an ashtray*. Some of these concepts were experimental concepts. I manipulated whether these experimental concepts were marked with a cataphoric device. For example, I manipulated whether the concept *ashtray* in the above narrative was marked with spoken stress.

I measured the activation of these experimental concepts by presenting one of the concepts visually and then measuring how rapidly and accurately subjects verified that they had heard that concept. For example, I presented the test word ASHTRAY, and I measured how rapidly and accurately subjects verified that ASHTRAY had occurred in the narrative they were hearing. Presumably, the faster and more accurately subjects respond, the more activated the concept is.

Are cataphorically marked concepts more activated?

In my first experiment I tested the hypothesis that cataphorically marked concepts are activated at a higher level. I tested this hypothesis using the cataphoric device, spoken stress.

I asked a female speaker to record the 48 experimental narratives in two ways. In the first version, she was to produce the experimental concept without giving it undue stress (e.g., *ashtray);* in the second version she was to emphasize the experimental concept (e.g. *ASHTRAY).*[7] These two versions are illustrated in Table 4.

I digitized these two versions. Then, using a sound wave editor I visually inspected the digitized narratives and electronically spliced the stressed concept out of its original version. I then electronically spliced that stressed concept into a digitized copy of the unstressed version. I performed this cross-splicing to control for differences in intonation contour (Cutler, 1976).

Each experimental concept was followed by a filler phrase, such as "an ashtray, *'n y'know,*" or "a computer,*'n man,*" or "a pizza, *but 'uh.*" It was after these filler phrases that I measured activation. For example, after subjects heard *an ashtray, 'n y'know*, or after they heard *an ASHTRAY, 'n y'know*, I visually presented the test word ASHTRAY.

After the filler phrases, the two versions diverged. When the experimental concept was stressed, the speaker continued talking about that concept. When the experimental concept was unstressed, the speaker talked about something else. I did this to mimic what normally happens in conversation: Stressed concepts are typically talked about. But keep in mind that I measured activation before the two versions diverged (at the point marked with a triangle in Table 4).

To encourage the subjects to comprehend the narratives, rather than just respond to the test words, I required them to write a logical continuation for about half of the narratives. I also included 32 "lure" narratives. The lure narratives were written and spoken in the same style as the experimental narratives, including the fact that one word was highly stressed. However, the stressed word was not the test word; rather, the test words for the lure narratives did not occur in their respective narratives, so the correct answer was "no."

TABLE 4
Example Stimuli

NARRATIVE	TEST WORD
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an **ashtray**, 'n y'know, Δ she even wanted to buy some clothes, but I was gettin' real hungry, so I said ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an **ASHTRAY**, 'n y'know, Δ I really didn't see the attraction. I mean it had this picture of Lady Di on it and I guess it only cost ...	ASHTRAY

To summarize, in this first experiment, I presented two versions of a conversational narrative. In one version, the experimental concept was stressed *(ASHTRAY);* in the other version, it was not *(ashtray).* I measured the activation of the experimental concepts (ASHTRAY) when they were stressed versus unstressed.

If concepts marked with cataphoric devices such as spoken stress are activated at a higher level, then subjects should respond more rapidly and accurately to the test words when they were stressed than when they were unstressed.

I tested 80 subjects, whose data are illustrated by Figure 8. These are subjects' responses to the experimental concepts (ASHTRAY) when those concepts were either stressed *(ASHTRAY)* or unstressed *(ashtray),* and when they were tested immediately after being introduced (literally, after their filler phrases). The bars illustrate the subjects' average correct reaction times, and the squares illustrate their average error rates.

As Figure 8 illustrates, when concepts are marked with spoken stress, they are activated at a higher level, as indicated by subjects' reaction times and their errors. So, this first experiment demonstrated one way that cataphorically marked concepts gain a privileged status in listeners' mental representations: They are more highly activated.

Are cataphorically marked concepts better at suppressing the activation of other concepts?

In my first experiment I also tested another hypothesis: Concepts marked with cataphoric devices are better at suppressing the activation of other concepts. Again I tested this hypothesis with spoken stress.

To do this, I constructed two more versions of each of the 48 experimental narratives, as illustrated in Table 5. In both of the two new versions, I again introduced the first experimental concept (e.g., *ashtray)*, but in only its unstressed form. Following this first experimental concept, I introduced a second experimental concept, for example, *a vase.*

TABLE 5
Example Stimuli

NARRATIVE	TEST WORD
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an ashtray, 'n y'know, then she saw a **vase**, 'n I swear, Δ she was pickin' up puzzles that probably had a bunch of pieces missin', and sayin' ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an ashtray, 'n y'know, then she saw a **VASE**, 'n I swear, Δ she must a' thought it was real crystal or somethin' but it was just ...	ASHTRAY

I asked the same female speaker to record these two additional versions in two ways. In one version, she was to produce the second experimental concept without giving it undue stress *(vase)*. In the other version, she was to emphasize the second experimental concept *(VASE)*. Again, to control for differences in intonation contours, I digitized these two versions and electronically spliced the stressed concept out of its original version and spliced it into a copy of the unstressed version.

Each second experimental concept *(vase)* was followed by a filler phrase *('n I swear)*. It was after these filler phrases that I measured activation. For example, after subjects heard *a vase,'n I swear,* or after they heard, *a VASE,'n I swear,* I visually presented the test word ASHTRAY. These test points are illustrated with a triangle in Table 5.

If concepts marked with cataphoric devices such as spoken stress are better at suppressing previously introduced concepts, then subjects should respond more slowly and less accurately to the first experimental concepts (ASHTRAY) when the second experimental concepts were stressed *(VASE)* rather than unstressed *(vase)*. That is, if stressed (second) concepts are better at suppressing previously mentioned (first) concepts, then those first concepts should be less activated.

Figure 9 illustrates subjects' responses to first experimental concepts (ASHTRAY), when second experimental concepts are stressed *(VASE)* versus unstressed *(vase),* and when activation is measured after the second concepts. The bars illustrate reaction times, and the squares illustrate errors. Keep in mind that I measured subjects' responses to first concepts (ASHTRAY), although I manipulated whether second concepts were stressed *(vase* vs *VASE)*. As Figure 9 illustrates, when second concepts are stressed, first concepts become *less* activated, as measured by reaction time and errors.

So, this first experiment demonstrated another way that cataphorically marked concepts gain a privileged status in listeners' mental representations: In addition to being more highly activated, they are better at suppressing the activation of other concepts.

Are cataphorically marked concepts more resistant to suppression?

In a second experiment, I tested another hypothesis for how cataphorically marked concepts gain a privileged status: They are more resistant to being suppressed by other concepts. Again, I tested this hypothesis with the cataphoric device, spoken stress.

I presented the 48 experimental narratives from the first experiment. Each narrative occurred in four versions, as illustrated in Table 6. In two versions, the first experimental concepts were either stressed (*ASHTRAY*) or unstressed (*ashtray*), and I measured activation immediately after those first concepts' filler phrases. Those two versions are illustrated as the top two examples in Table 6.

TABLE 6
Example Stimuli

NARRATIVE	TEST WORD
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an **ashtray**, 'n y'know, Δ ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an **ASHTRAY**, 'n y'know, Δ ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an **ashtray**, 'n y'know, then she saw a vase, 'n I swear, Δ ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy an **ASHTRAY**, 'n y'know, then she saw a vase, 'n I swear, Δ ...	ASHTRAY

Comparing those two versions shows us how activated the first concepts are before I introduce the second concepts. This is the comparison I made in the first experiment. Making this comparison again allowed us to re-test the hypothesis that concepts marked with cataphoric devices, such as spoken stress, are activated at a higher level.

In the remaining two versions, I introduced a second concept, for example, *a vase*. In both of these versions, the second concepts were unstressed. And in both of these versions, I measured activation after the second concepts' filler phrases. What I manipulated was whether the first experimental concepts were stressed *(ASHTRAY)* or unstressed *(ashtray)*. These two versions are illustrated as the bottom two examples in Table 6.

Comparing all four versions allows us to examine how a stressed versus unstressed first concept is affected by a second concept. If cataphorically marked concepts are more resistant to being suppressed. then stressed first concepts should be less affected by the introduction of second concepts.

I tested 72 subjects, whose data appear in Figure 10. First, examine how activated stressed versus unstressed concepts are immediately after they are introduced. Figure 10 illustrates subjects' responses to the first experimental concepts when they are stressed *(ASHTRAY)* versus unstressed *(ashtray)*, and when activation is measured immediately after their filler phrases. Again, the bars illustrate the subjects' reaction times, and the squares illustrate their error rates.

As Figure 10 illustrates, concepts marked with spoken stress are activated at a higher level, as indicated by subjects' reaction time and their errors. This result replicates the first experiment and again demonstrates one way that cataphorically marked concepts gain a privileged status.

Now, examine the data that test the hypothesis that cataphorically marked concepts better resist suppression. To test this hypothesis, I manipulated whether the first experimental concepts were stressed *(ASHTRAY)* versus unstressed *(ashtray)*, and I measured their activation before versus after I introduced a second, unstressed concept *(vase)*. If cataphorically marked concepts better resist suppression, then when first concepts are stressed, they should be less affected by second concepts.

Figure 11 displays the subjects' reaction times to first concepts when they are stressed (the filled squares) versus unstressed (the unfilled squares), and when activation is measured immediately after the first concepts' filler phrases (and therefore before the second concepts were introduced) versus when activation is measured immediately after the second concepts' filler phrases.

Examine what happens when first concepts are unstressed. Those data are illustrated by the unfilled squares. When first concepts are unstressed, they are greatly affected by the introduction of a second concept. As Figure 11 illustrates, first concepts become considerably *less* activated.

Now, examine what happens when first concepts are stressed. Those data are illustrated by the filled squares. When first concepts are stressed, they are less affected by the introduction of the second concepts. Indeed, as Figure 11 illustrates, reaction times to the first concepts are unchanged.

In other words, when first concepts are unstressed they lose activation when a second concept is introduced. According to the Structure Building Framework (Gernsbacher, 1990), this is because they are suppressed. But when first concepts are stressed, they greatly resist this suppression. This difference between how much stressed versus unstressed concepts are affected by the introduction of another concept is manifested in a reliable interaction.

Figure 12 illustrates the same results, using subjects' error rates as a measure of activation. As Figure 12 illustrates, when first concepts are stressed, they are less affected by the introduction of second concepts. Indeed, errors increase by only 2%. But when first concepts are unstressed, errors increase by 5%. This difference between how much stressed versus unstressed first concepts are affected by the introduction of another concept is again manifested in a reliable interaction.

So, this second experiment supported two hypotheses about how cataphorically marked concepts gain a privileged status in listeners' mental representations: Cataphorically marked concepts are more highly activated, and they better resist suppression by other concepts.

Together, these first two experiments support the three hypotheses I listed earlier: Concepts that receive spoken stress are activated at a higher level; they are better at suppressing the activation of other concepts; and they are more resistant to being suppressed by other concepts. These first two experiments powerfully demonstrate the privileged status given concepts that are marked with the cataphoric device, spoken stress.

TABLE 7
Example Stimuli

NARRATIVE	TEST WORD
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy **an** ashtray, 'n y'know, Δ ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy **this** ashtray, 'n y'know, Δ ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy **an** ashtray, 'n y'know, then she saw a vase, 'n I swear, Δ ...	ASHTRAY
I swear, my friend Vicky, every time we go to a garage sale, she just goes crazy. I mean like last Saturday we went to one near campus, 'n she just had to buy **this** ashtray, 'n y'know, then she saw a vase, 'n I swear, Δ ...	ASHTRAY

In a third experiment, I extended these results to a more subtle cataphoric device: the unstressed indefinite article *this*. In this third experiment, I replicated the second experiment substituting the indefinite *this* for spoken stress. To do this, I presented four versions of the 48 experimental narratives, as illustrated in Table 7.

Two of the four versions were identical to those I had presented in the second experiment. They were (1) when the first concepts were unstressed and activation was measured immediately after the first concept (illustrated by the top example in Table 7), and (2) when the first concepts were unstressed and activation was measured immediately after the second concept (illustrated by the third example in Table 7).

To make the remaining two versions, I took the two versions of the experimental narratives in which the first concepts were stressed and electronically replaced the stressed concepts with unstressed concepts. Then, I asked the speaker who had recorded the narratives to record several tokens of the unstressed article *this*, varying her pitch for the different tokens. Finally, I electronically replaced the indefinite *a/an*s with acoustically-matched tokens of the indefinite *this*. These two versions are illustrated in the second and fourth examples of Table 7.

As Table 7 illustrates, in all four versions, both the first and second concepts were unstressed. The critical differences were whether the first concepts were introduced with *this* versus *a/an*, and whether activation was measured after the first versus second concepts.

Comparing the first two versions illustrated in Table 7 shows whether concepts marked with the indefinite *this* are activated at a higher level. Comparing all four versions shows how a concept marked with the indefinite *this* versus *a/an* is affected by a second concept. If concepts marked with the indefinite *this* better resist suppression, then concepts introduced with the indefinite *this* should be less affected by other concepts.

Introducing concepts with the indefinite *this* versus *a/an* is a subtle manipulation. In fact, the experimenters, whom I typically keep blind to the experimental manipulations and hypotheses, were stymied in their attempts to guess the manipulation — even after hearing the experimental narratives numerous times.

I tested 80 subjects. First, examine how activated concepts are immediately after they are introduced with the indefinite *this* versus the indefinite *a/an*. Figure 13 illustrates those data. Again, the bars illustrate the subjects' reaction times, and the squares illustrate their error rates.

As Figure 13 illustrates, concepts introduced with the indefinite *this* are activated at a higher level, as indicated by subjects' reaction times and their errors. This result replicates the first and second experiments and demonstrates that the cataphoric device, the indefinite *this*, operates similarly to the cataphoric device, spoken stress: Both improve their concepts' representational status by activating concepts at a higher level.

Now, examine the data that test the hypothesis that concepts introduced with the indefinite *this* better resist suppression. Those data are illustrated in Figure 14. The filled squares illustrate subjects' reaction times to first concepts when they are introduced with *this*. The unfilled squares illustrate subjects' reaction times to first concepts when they are introduced with *a/an*.

As Figure 14 illustrates, when first concepts are introduced with *a/an*, they are affected by the introduction of a second concept. In other words, they become considerably *less* activated after the second concept. According to the Structure Building Framework (Gernsbacher, 1990), they are suppressed.

As Figure 14 also illustrates, when first concepts are introduced with *this*, they too are affected by the introduction of a second concept: They too become *less* activated. However, as Figure 14 illustrates, concepts introduced with *this* are less affected by a second concept than are concepts introduced with *a/an*. In other words, concepts introduced by *this* better resist suppression. This difference between how much concepts introduced with *this* versus *a/an* are affected by other concepts produces an interaction.

Figure 15 illustrates the same results, using subjects' error rates as a measure of activation. As Figure 15 illustrates, when first concepts are introduced with the indefinite *this*, they are less affected by the introduction of second concepts. Indeed, errors increase by only 1%. Concepts introduced with the indefinite *a/an* are more affected by the introduction of second concepts; errors increase by almost 4%. This difference between how much concepts introduced with the indefinite *this* versus the indefinite *a/an* are affected by other concepts produces a reliable interaction.

Conclusions

From these experiments I draw the following conclusions:

- Concepts marked with cataphoric devices, like spoken stress and the indefinite *this*, are more highly activated.
- Concepts marked with cataphoric devices, like spoken stress and the indefinite *this*, are better at suppressing the activation of other concepts.
- Concepts marked with cataphoric devices, like spoken stress and the indefinite *this*, are more resistant to being suppressed by other concepts.

So, the mechanism of suppression plays a vital role in how comprehenders access concepts that are marked by cataphoric devices such as spoken stress or the indefinite *this*.

The Role of Suppression and Enhancement in Adult Comprehension Skill

According to the Structure Building Framework (Gernsbacher, 1990), the same processes and mechanisms that build coherent mental structures during language comprehension build coherent mental structures during the comprehension of nonlinguistic media. This commonality might arise because, as Lieberman (1984) and others have suggested, language comprehension evolved from nonlinguistic cognitive skills. Or the commonality might arise simply because the mind is best understood by reference to a common architecture.

Both proposals support my orientation that many processes and mechanisms involved in comprehending language are also involved in comprehending nonlinguistic media. This orientation also suggests that some of the reasons why individuals differ in comprehension skill might not be specific to language. My previous research investigated this hypothesis (Gernsbacher et al., 1990), and the research conducted under AFOSR 89-0258 continued that investigation.

In Gernsbacher et al. (1990), we conducted four experiments. In the first experiment, we tested the hypothesis that skill at comprehending linguistic media is highly related to skill at comprehending nonlinguistic media. We tested this hypothesis by constructing and administering a Multi-Media Comprehension Battery (Gernsbacher & Varner, 1988). The battery comprises six stories: two are presented with written sentences; two are presented with spoken sentences; and two are presented with nonverbal pictures. Twelve comprehension questions are asked after each story, similar to the questions found in more traditional comprehension tests.

We administered the Multi-Media Comprehension Battery to a large sample of college-aged subjects and found that skill at comprehending written and spoken stories is highly related to skill at comprehending nonverbal picture stories. A principal components analysis suggested only one underlying factor — what I call General Comprehension Skill.

In Gernsbacher et al. (1990), we began to answer this question by tracing whether a marker of less-proficient language comprehension skill also marks less-proficient General Comprehension Skill. The marker is poor access to recently comprehended information. To be sure, all comprehenders quickly lose access to recently comprehended information (Sachs, 1967). But in Gernsbacher et al.'s (1990) second experiment, we found that less-skilled comprehenders have even poorer access to recently comprehended information, and they have poorer access regardless of whether they are comprehending written, auditory, or picture stories. In other words, poorer access to recently comprehended information does mark less-proficient General Comprehension Skill.

Why does poorer access to recently comprehended information mark less-proficient General Comprehension Skill? According to the Structure Building Framework (Gernsbacher, 1990), all comprehenders lose access to recently comprehended information when they shift from actively building one substructure and initiate another. This explanation suggests that less-skilled comprehenders shift too often; that is, they develop too many substructures. In the third experiment, we found evidence to support this suggestion.

Why does a greater tendency toward shifting characterize less-proficient General Comprehension Skill? According to the Structure Building Framework (Gernsbacher, 1990), mental structures are built by enhancing the activation of relevant information while suppressing the activation of less relevant information. All comprehenders shift to initiate substructures when the incoming information seems less relevant. But less-skilled comprehenders might shift too often because they less efficiently suppress irrelevant information. When irrelevant information remains activated, its activation lays the foundation for a new substructure. So, one consequence of an inefficient suppression mechanism is that too many substructures are begun — in other words, one consequence of an inefficient suppression mechanism is the greater tendency toward shifting exhibited by less-skilled comprehenders.

In Gernsbacher et al.'s (1990) fourth experiment, we tested the hypothesis that less-skilled comprehenders have less efficient suppression mechanisms. We selected two groups of more- versus less-skilled comprehenders from the extreme thirds of the distribution of subjects whom we had previously tested with the Multi-Media Comprehension Battery. When these subjects returned to the lab, they performed the following task: They read a sentence, for example,

(33) She dropped the plate.

Then, they saw a test word, for example, *BREAK*. The subjects' task was to verify whether the test word matched the meaning of the sentence they just read. On half the trials, the test word did indeed match the meaning, but we were more interested in the trials in which the test word did not match the meaning.

On half of those trials, the last word of the sentence was an ambiguous word, for example,

(34) He dug with the **spade**.

The test word on those trials was related to one meaning of the ambiguous word; however, it was not the meaning implied by the sentence. For example, the test word for sentence (34) was *ACE*. We measured how long subjects took to reject a test word like *ACE* after they read a sentence like (34). We compared that latency with how long subjects took to reject *ACE* after they read the same sentence but with the last word replaced by an unambiguous word, for example,

(35) He dug with the **shovel**.

This comparison showed us how quickly comprehenders could suppress the inappropriate meanings of ambiguous words; the more time comprehenders needed to reject *ACE* after the *spade* versus *shovel* sentence, the more activated the *ACE*-related meaning of *spade* must have been. We presented the test words at two intervals: Immediately (100 ms) after subjects finished reading each sentence, and after a 850-ms delay.

The results of this experiment are displayed in Figure 16, expressed in ms of interference. We computed interference by subtracting subjects' latency to reject test words like *ACE* after reading unambiguous words like *shovel* from their latency to reject test words like *ACE* after reading ambiguous words like *spade*. The more-skilled comprehenders are represented in Figure 16 by hashed lines, and the less-skilled comprehenders are represented by unfilled bars.

As Figure 16 illustrates, immediately after both the more- and less-skilled comprehenders read the ambiguous words, they experienced a significant amount of interference. In fact, the amount of interference experienced immediately by the less-skilled comprehenders did not differ statistically from the amount experienced immediately by the more-skilled comprehenders. So, 100 ms after both more- and less-skilled comprehenders read ambiguous words, inappropriate meanings are activated.

But as Figure 1 also illustrates, after the 850-ms delay, the more-skilled comprehenders were no longer experiencing a reliable amount of interference. I suggest that the more-skilled comprehenders had, by that time, effectively suppressed the inappropriate meanings. But unlike the more-skilled comprehenders, the less-skilled comprehenders were still experiencing a significant amount of interference after the delay. In fact, the less-skilled comprehenders were experiencing the same amount of interference after the delay as they experienced immediately. These data demonstrate that less-skilled comprehenders are less able to reject the contextually inappropriate meanings of ambiguous words.

In the research conducted under AFOSR 89-0258, I continued to investigate the provocative finding that less-skilled comprehenders are less able to reject the inappropriate meanings of ambiguous words. I propose that the ability to reject the inappropriate meanings of ambiguous words derives from a general cognitive mechanism — the mechanism of suppression. Less-skilled comprehenders are less able to reject the inappropriate meanings of ambiguous words because they are plagued by less-efficient suppression mechanisms.

Successful comprehension must involve efficiently suppressing irrelevant information. In many situations, irrelevant or inappropriate information is automatically activated, unconsciously retrieved, or naturally perceived. But for successful comprehension, this irrelevant or inappropriate information must not affect ongoing processes; it must be suppressed.

In my earlier research, I found that less-skilled comprehenders were less efficient in suppressing the inappropriate meanings of ambiguous words. In this next series of experiments, I investigated whether less-skilled comprehenders are also less efficient in suppressing other information that is activated while they are comprehending linguistic as well as nonlinguistic media.

First, I investigated whether less-skilled comprehenders are less efficient in suppressing the incorrect forms of homophones that are activated during reading. Next, I investigated whether less-skilled comprehenders are less efficient in suppressing objects that are activated during the comprehension of nonverbal scenes. And finally, I investigated whether less-skilled comprehenders are less efficient at suppressing information across modalities, for example, suppressing words while they are viewing pictures or suppressing pictures while they are reading words.

This research also investigated a counter-hypothesis: Perhaps less skilled comprehenders are less able to reject contextually inappropriate information, not because they have less-efficient suppression mechanisms, but because they are less appreciative or cognizant of context. Perhaps less-skilled comprehenders' enhancement mechanisms are at fault — not their suppression mechanisms. By this logic, less-skilled comprehenders have difficulty rejecting *ACE* after reading *He dug with the spade* because they fail to appreciate that the context of ***digging with a spade*** implies a garden tool, not a playing card.

I tested this counter-hypothesis in two experiments. In one experiment, I investigated whether less-skilled comprehenders were less efficient at enhancing the contextually appropriate meanings of ambiguous words; in another experiment, I investigated whether less-skilled comprehenders were less efficient at enhancing the contextually appropriate objects in nonverbal scenes.

To summarize, this research answered five questions:

- Are less-skilled comprehenders less efficient at suppressing the incorrect forms of homophones?
- Are less-skilled comprehenders less efficient at suppressing information that is activated when they view nonverbal scenes?
- Are less-skilled comprehenders less efficient at suppressing information across modalities?
- Are less-skilled comprehenders less efficient at enhancing the contextually appropriate meanings of ambiguous words?
- Are less-skilled comprehenders less efficient at enhancing the contextually appropriate objects in a nonverbal scene?

To answer these five questions, I conducted five experiments. Each experiment was based on a well-established finding in the cognitive psychology literature. I based these experiments on these well-established findings so that I could anticipate what normative data would look like; I used those expectations to make predictions about more- versus less-skilled comprehenders.

The subjects in these experiments were U.S. Air Force recruits who were tested during their sixth day of basic training. I eliminated subjects if their accuracy on the laboratory tasks suggested they were not giving the task enough effort. I selected more- versus less-skilled comprehenders according to the subjects' scores on the Multi-Media Comprehension Battery (Gernsbacher & Varner, 1988). Each subject was tested for three hours. During the first hour, they were tested with the Multi-Media Comprehension Battery (as described in the Appendix). During the second and third hours, they participated in the experiments I describe next.

Are less-skilled comprehenders less efficient at suppressing the incorrect forms of homophones?

Reading a string of letters activates an array of information. Virtually always reading a letter string activates orthographic information — information about the individual letters in the string and their relative position to one another. Often, reading a letter string activates semantic information, lexical information, and phonological information. In fact, semantic, lexical, and phonological information is often activated even when the string does not compose an English word (Coltheart, Davelaar, Jonasson, & Besner, 1977; Rosson, 1985).

Automatic activation of phonological information was the focus of my next experiment. By automatic activation of phonological information I mean the phenomenon in which reading the letter string *rows* activates the phonological sequence */roz/*. In fact, reading *rows* can activate */roz/*, which can activate *rose*. In other words, reading a homophone *(rows)* can activate a phonological sequence *(/roz/)*, which can then activate another form of the homophone *(rose)*. How do we know that a letter string often activates phonological information, which in turn activates other forms of homophones? Consider the following finding: Comprehenders have difficulty quickly rejecting the word *rows* as not being an exemplar of the category *FLOWER* (Van Orden, 1987; van Orden, Johnston, & Hale, 1988).

But to successfully comprehend a written passage, these incorrect forms cannot remain activated. According to the Structure Building Framework, comprehension involves the mechanism of suppression. The same structure building mechanism that suppresses the inappropriate meanings of ambiguous words, could also suppress the incorrect forms of homophones. If this is the same mechanism, and if this general suppression mechanism is less efficient in less-skilled comprehenders, then less-skilled comprehenders should also less-efficiently suppress the incorrect forms of homophones.

Related evidence already supports this prediction. Consider the sentence:

(36) She **blue** up the balloon.

Six-year olds are more likely to accept that sentence than are 10-year olds — even when they clearly know the difference between *blue* and *blew* (Doctor & Coltheart, 1980; see also Coltheart, Laxon, Rickard, & Elton, 1988). If we assume that 6-year olds are less skilled than 10-year olds at comprehension, this finding suggests that less-skilled comprehenders are less able to suppress the incorrect forms of homophones that are often automatically activated.

I tested this hypothesis more directly, with adult subjects whom I knew differed in their General Comprehension Skill. The subjects were US Air Force recruits who were drawn from a sample of 455 subjects whom I tested with the Multi-Media Comprehension Battery.[8] I drew 48 subjects from the top third of the distribution (those who scored the highest) and 48 subjects from the bottom third of the distribution (those who scored the lowest).

When these more- versus less-skilled comprehenders returned to the lab, they performed a laboratory task similar to the task I used in my previous research. They read short sentences, and following each sentence, they saw a test word. The subjects verified whether the test word fit the meaning of the sentence they just read. On 80 trials, the test word did indeed fit the sentence's meaning, but on 80 trials it did not. I was interested in those trials in which the test word did **not** fit the meaning.

On half of those trials, the last word of the sentence was one form of a homophone, for example,

(37) He had lots of **patients**.

On these trials, the test word was related to the homophone's other form, for example, the test word *CALM* is related to *patience.* I compared how long subjects took to reject *CALM* after reading sentence (37) with how long they took to reject *CALM* after reading the same sentence with the last word replaced by a nonhomophone, for example,

(38) He had lots of **students**.

This comparison showed us how activated the incorrect form was; the more time subjects took to reject *CALM* after the *patients*- versus *students*-sentence, the more activated the *patients* form of the homophone must have been.[9]

I presented the test words at two intervals: Immediately (100 ms) after subjects finished reading each sentence, and after a one-second Delay. I predicted that at the Immediate interval, both the more- and less-skilled comprehenders would take longer to reject test words following homophones than nonhomophones. For example, both groups would take longer to reject *CALM* after reading the *patients* sentence than after reading the *students* sentence. This result would corroborate the results of van Orden (1987; van Orden et al., 1988). This result would also demonstrate that comprehenders of both skill levels often activate phonological information during reading.

My novel predictions concerned what would happen after the Delayed interval. I predicted that after the one-second delay, the more-skilled comprehenders would not take longer to reject test words following homophones versus nonhomophones; more-skilled comprehenders should be able to successfully suppress incorrect forms. I made a different prediction for the less-skilled comprehenders. If less-skilled comprehenders are characterized by less-efficient suppression mechanisms, then even after the one-second delay, the incorrect forms of the homophones should still be highly activated.

Figure 17 illustrates the 96 subjects' data. I estimated activation by subtracting subjects' latencies to reject test words like *CALM* after reading nonhomophones like *students* from their latencies to reject test words like *CALM* after reading homophones like *patients.* First, examine what happened at the Immediate test interval. As Figure 17 illustrates, immediately after both the more- and less-skilled comprehenders read the homophones, the inappropriate forms were highly activated; in fact, they were almost equally activated for the more- versus less-skilled comprehenders. So, 100 ms after comprehenders of both skill levels read homophones, other forms are often activated.

Now, examine what happened after the one-second Delayed interval. As Figure 17 illustrates, one second after the more-skilled comprehenders read the homophones, the incorrect forms were no longer reliably activated; the more-skilled comprehenders had successfully suppressed them. But as Figure 17 also illustrates, the less-skilled comprehenders were less fortunate: Even after the Delayed interval, the incorrect forms were still highly activated; in fact, they were as activated after one second as they were immediately. So, a second after the less-skilled comprehenders read the homophones, they were unable to suppress the incorrect forms. These data support the hypothesis that less-skilled comprehenders are plagued by less-efficient suppression mechanisms.

Are less-skilled comprehenders less efficient at suppressing typical-but-absent members of scenes?

According to the Structure Building Framework, many of the cognitive processes and mechanisms involved in comprehending language are involved in comprehending nonlinguistic stimuli, for instance, naturalistic scenes. Other researchers also consider scene perception as "comprehension" (Biederman, 1981; Friedman, 1979; Mandler & Johnson, 1976).

The mechanisms of enhancement and suppression are critical to scene comprehension. Indeed, Biederman writes about the difficulty in "suppressing the interpretations of visual arrays that comprise scenes" (Biederman, Bickle, Teitelbaum, & Klatsky, 1988, p. 456). This difficulty is manifested in the following phenomenon: After briefly viewing a scene, subjects are more likely to incorrectly report that an object was present if that object is typically found in that type scene. For instance, subjects are more likely to incorrectly report that a tractor was present in a farm scene than a kitchen scene, and they are more likely to incorrectly report that a kettle was present in a kitchen scene than a farm scene (Biederman, Glass, & Stacy, 1973; Biederman, Mezzanotte, & Rabinowitz, 1982; Biederman, Teitlebaum, & Mezzanotte, 1983; Palmer, 1975).

To successfully comprehend a scene, observers must suppress these typical-but-absent objects, just as readers and listeners must suppress the inappropriate meanings of ambiguous words and the incorrect forms of homophones. The same structure building mechanism that suppresses the activation of inappropriate linguistic information could suppress the activation of inappropriate nonlinguistic information. If this is the same mechanism, and if this general suppression mechanism is less efficient in less-skilled comprehenders, then less-skilled comprehenders should also be less efficient in suppressing the activation of typical-but-absent objects when viewing scenes.

I tested this hypothesis using Biederman et al.'s (1988) stimuli.[10] Biederman et al. (1988) replicated the phenomenon in which subjects incorrectly report that an object is present in a scene when the object is typical of that scene (for instance, subjects incorrectly report that a tractor was present in a farm scene). But instead of briefly viewing actual scenes, the subjects in Biederman et al.'s (1988) experiments viewed clock-face arrangements of objects, as illustrated in Figure 18. For instance, the top left panel of Figure 18 illustrates a clock-face arrangement of six objects normally found in a farm scene: *a barn, a pig, a pitchfork, a farmer, a rooster, and an ear of corn.* I shall refer to these clock-face arrangements as scenic arrays.

I presented all of Biederman et al.'s (1988) scenic arrays that comprised three, four, five, and six objects. However, I slightly modified Biederman et al.'s task so that it would better parallel my linguistic tasks. In my experiment, subjects first viewed a scenic array; then, they saw the name of a test object. Their task was to verify whether the named test object had been present in the array they just viewed. On 80 trials, the test object had been present, but in 80 it had not. In this experiment, I was interested in the trials in which the test object had **not** been present.

On half of those trials, the objects in the array were typical of a particular scene, for instance, objects that typically occur in a farm scene, as illustrated in top left panel of Figure 18. On these trials, the test object was something that also typically occurs in this type scene, but it had not been present in the scenic array that the subjects just viewed. For instance, a *TRACTOR* typically occurs in a farm scene, but no *TRACTOR* occurs in the scenic array illustrated in the top panel of Figure 18.

I compared how long subjects took to reject *TRACTOR* after viewing the farm array with how long they took to reject *TRACTOR* after viewing another scenic array, for instance, objects belonging to a kitchen scene, as illustrated in the bottom panel of Figure 18. This comparison showed us how activated the typical-but-absent object was: The longer subjects took to reject *TRACTOR* after viewing the typical *(farm)* array versus the atypical *(kitchen)* array, the more activated the typical-but-absent object must have been.

I presented the names of the test objects at two intervals: Immediately (50 ms) after subjects viewed each array, and after a one-second Delay. I predicted that at the Immediate interval, both the more- and less-skilled comprehenders would take longer to reject test objects following typical than atypical scenic arrays. For example, both groups would take longer to reject *TRACTOR* after viewing the farm array than after viewing the kitchen array. This result would corroborate the results of Biederman and his colleagues. This result would also demonstrate that comprehenders of both skill levels immediately activate typical-but-absent object when viewing scenic arrays.

My novel predictions concerned what would happen after the Delayed interval. I predicted that after the one-second delay, the more-skilled comprehenders would not take longer to reject test objects following typical than atypical arrays. After one second, more-skilled comprehenders should be able to successfully suppress typical-but-absent objects. But I made a different prediction for the less-skilled comprehenders. If less-skilled comprehenders are characterized by less-efficient suppression mechanisms, then even after the one-second delay, the typical-but-absent objects should still be highly activated.

Figure 19 displays the 40 subjects' data. I estimated activation by subtracting subjects' latencies to reject names of test objects like *TRACTOR* after viewing atypical *(kitchen)* arrays from their latencies to test objects like *TRACTOR* after viewing typical *(farm)* arrays. First, examine what happened at the Immediate test interval. As Figure 19 illustrates, immediately after both the more- and less-skilled comprehenders viewed the scenic arrays, the typical-but-absent objects were highly activated. In fact, the typical-but-absent objects were about equally activated for the more- versus less-skilled comprehenders.

Now, examine what happened after the one-second Delayed interval. As Figure 19 illustrates, one second after the more-skilled comprehenders viewed the scenic arrays, the typical-but-absent objects were no longer reliably activated; the more-skilled comprehenders had successfully suppressed them. But as Figure 19 also illustrates, the less-skilled comprehenders were less fortunate: Even after the Delayed interval, the typical-but-absent objects were highly activated; in fact, they were as activated after the one-second delay as they were immediately. So, even a full second after the less-skilled comprehenders viewed the arrays, they were still unable to suppress the typical-but-absent objects. These data support the hypothesis that less-skilled comprehenders are plagued by less-efficient suppression mechanisms.

Are less-skilled comprehenders less efficient at suppressing information across modalities?

To negotiate the environment, we must make sense of stimuli that originate from various modalities. We would be severely handicapped if we were skilled at only reading written words, or only listening to spoken words, or only comprehending graphic displays. Information originates from different modalities, often simultaneously. We read while listening to music, and we drive while carrying on a conversation.

Comprehenders often experience interference across modalities. For instance, it is harder to name a pictured object such as an *ashtray* if a letter string such as *INCH* is written across the picture, as illustrated in the upper left panel of Figure 20. The opposite is also true: It is harder to read a word such as *RIVER* if it is superimposed on a picture, as illustrated in the bottom left panel of Figure 20 (Smith & McGee, 1980).

Successful comprehension often requires suppressing information across modalities. The same structure building mechanism that suppresses information within modality, could suppress information across modalities. If this is the same mechanism, and if this general suppression mechanism is less efficient in less-skilled comprehenders, then less-skilled comprehenders should also be less efficient in suppressing information across modalities.

I tested this hypothesis in the following way. I modified Tipper and Driver's (1988) experimental task. In my modification, subjects first viewed a context display. Each context display contained a line-drawn picture of a common object and a familiar word. For example, the top panel in Figure 20 illustrates a picture of an *ashtray* with the word *INCH* written across it. The bottom panel of Figure 20 illustrates the word *RIVER* superimposed on a picture of a *baseball player*. All context displays contained both a picture and a word.

After subjects viewed each context display, they were shown a test display. Each test display contained either another picture or another word. Half the time, the test display contained another picture, and I referred to those trials as Picture trials; half the time, the test display contained another word, and I referred to those trials as Word trials. Subjects were told before each trial whether that trial would be a Picture trial or a Word trial.

The top panel of Figure 20 illustrates a Picture trial. On Picture trials, subjects were told to focus on the picture in the context display and ignore the word. For example, for the Picture trial shown in Figure 20, subjects should have focused on the *ashtray* and ignored the word *INCH*. Following each context display, subjects were shown a test display. On the Picture trials, the test display contained another picture. The subjects' task (on Picture trials) was to verify whether the picture shown in the test display was related to the picture shown in the context display. For the Picture trial shown in Figure 20, subjects should have responded "yes," because the picture shown in the test display, the *pipe*, was related to the picture shown in the context display, the *ashtray*.

The bottom panel of Figure 20 illustrates a Word trial. On Word trials, subjects were supposed to focus on the word in the context display and ignore the picture. For example, for the Word trial shown in Figure 20, subjects should have focused on the word *RIVER* and ignored the *baseball player*. The test display on Word trials contained another word. The subjects' task was to verify whether the word written in the test display was related to the word written in the context display. For the Word trial shown in Figure 20, subjects should have responded "yes," because the word written in the test display, *STREAM*, was related to the word written in the context display, *RIVER*.

On 40 Picture trials and 40 Word trials, the test display was related to what the subjects were to focus on in the context display, just as they are in Figure 20. However, I was more interested in the 80 trials in which the test display was unrelated to what the subjects were supposed to focus on in the context display. On half of those trials, the test display was unrelated to what the subjects were to focus on in the context display, but it was related to what they were supposed to ignore.

For example, the top panel in Figure 21 illustrates an experimental Picture trial. The context display contains a picture of a *hand* with the superimposed word *RAIN*. Because this is a Picture trial, subjects should have focused on the picture (the *hand*) and ignored the word. The test display is a picture of an *umbrella*. So the test display, the *umbrella*, is unrelated to what the subjects were supposed to focus on in the context display, the *hand*; therefore, the subjects should have responded "no." But the test display is related to what the subjects were supposed to ignore, the word *RAIN*. I measured how long subjects took to reject the test display, the picture of the *umbrella*, after viewing the context display, the picture of the *hand* with the superimposed word *RAIN*. And I compared that with how long subjects took to reject the same test display, the picture of the *umbrella*, after viewing the same context display, the picture of the *hand*, but with another word superimposed, *SOUP*. This comparison showed us how quickly comprehenders could suppress information across modalities.

Experimental Word trials worked similarly, as illustrated by the third panel of Figure 21. When reading this context display, subjects should have focused on the word *MONTH* and ignored the surrounding picture of a *broom*. Then, they should have rejected the test display, the word *SWEEP*, because it is unrelated to the word *MONTH*. I measured how long subjects took to reject the word *SWEEP* after reading the word *MONTH* surrounded by the *broom*. And I compared that with how long subjects took to reject *SWEEP* after viewing the same context display with the picture of a *broom* replaced by a picture of a *sandwich* (as illustrated by the bottom panel of Figure 21). This comparison showed us how quickly comprehenders could suppress information across modalities.

As in my other experiments, I presented the test displays at two intervals: Immediately (50 ms) after the context-setting display, and after a one-second Delayed interval. I predicted that at the Immediate interval, both the more- and less-skilled comprehenders would take longer to reject a test display when it was related to the ignored picture or word in the context display. This result would corroborate Tipper and Driver (1988). This result would also demonstrate that both more-and less-skilled comprehenders have immediate difficulty suppressing information across modalities.

My novel predictions concerned what would happen after the Delayed interval. I predicted that after the one-second delay, the more-skilled comprehenders would not take longer to reject test displays when they were related to the ignored pictures/words. After one second, more-skilled comprehenders should be able to successfully suppress information across modalities. I made a different prediction for the less-skilled comprehenders. If less-skilled comprehenders are characterized by less-efficient suppression mechanisms, then even after the one-second delay, the ignored pictures and words should still be highly activated.

Figure 22 displays the 160 subjects' data. I estimated activation by subtracting subjects' latencies to reject test displays that were unrelated to ignored pictures/words from their latencies to reject test displays that were related to ignored pictures/words.[11] First, examine what happened at the Immediate test interval. As Figure 22 illustrates, immediately after both the more- and less-skilled comprehenders saw the context displays, the ignored pictures/words were highly activated; in fact, they were almost equally activated for the more- versus less-skilled comprehenders. So, 50 ms after viewing pictures with superimposed words or reading words surrounded by pictures, comprehenders of both skill levels have difficulty suppressing related pictures or words, even when they are told explicitly to ignore them.

Now, examine what happened after the one-second Delayed interval. As Figure 22 illustrates, one second after the more-skilled comprehenders saw the context displays, the ignored pictures/words were no longer reliably activated; the more-skilled comprehenders had successfully suppressed them. But as Figure 22 also illustrates, the less-skilled comprehenders were less fortunate: Even after the Delayed interval, the ignored pictures/words were still highly activated; in fact, they were as activated after the Delayed interval as they were immediately. So, one second after less-skilled comprehenders view pictures with superimposed words or read words surrounded by pictures, they still have difficulty suppressing the ignored pictures or words. These data support the hypothesis that less-skilled comprehenders are plagued by less-efficient suppression mechanisms.

Conclusions

From these experiments, I draw the following conclusions:

- Less-skilled comprehenders are less efficient at suppressing the inappropriate meanings of ambiguous words.
- Less-skilled comprehenders are less efficient at suppressing the incorrect forms of homophones.
- Less-skilled comprehenders are less efficient at suppressing typical-but-absent objects in nonverbal scenes.
- Less-skilled comprehenders are less efficient at suppressing words while viewing pictures or suppressing pictures while reading words.

So, a critical characteristic of less-skilled comprehenders is their inefficiency in suppressing inappropriate or irrelevant information while they are comprehending both linguistic and nonlinguistic information. This in turn could account for their tendency to shift too often, their tendency to build too many substructures, and their poorer access to recently comprehended information.

In the experiments I just described, I found that less-skilled comprehenders were less efficient at rejecting irrelevant or inappropriate information. I suggested that less-skilled comprehenders have less-efficient suppression mechanisms. A counter-explanation is that less-skilled comprehenders have difficulty suppressing inappropriate information — not because they have less-efficient suppression mechanisms — but because they less fully appreciate what is contextually appropriate. Perhaps they have less efficient enhancement mechanisms.

Are less-skilled comprehenders less efficient at enhancing the contextually appropriate meanings of ambiguous words?

According to the Structure Building Framework, comprehension requires enhancing the activation of memory cells when those cells are relevant to the structure being built. So, perhaps less-skilled comprehenders' enhancement mechanisms, not their suppression mechanisms, are at fault. By this logic, less-skilled comprehenders have more difficulty rejecting *ACE* after reading *He dug with the spade* because they less fully appreciate that the context of ***digging with a spade*** implies a garden tool, not a playing card.

This explanation seems unlikely given the repeated finding that less-skilled comprehenders are not less appreciative of predictable sentence contexts — just the opposite: Less-skilled comprehenders often benefit from predictable contexts more than more-skilled comprehenders do. For example, the word *dump* is very predictable in the following context:

(39) The garbage men had loaded as much as they could onto the truck. They would have to drop off a load at the garbage **dump**.

In contrast, *dump* is less predictable in the following context:

(40) Albert didn't have the money he needed to buy the part to fix his car. Luckily, he found the part he wanted at the **dump**.

All comprehenders pronounce the word *dump* more rapidly when it occurs in the very predictable context than when it occurs in the less predictable context; in other words, all comprehenders benefit from the predictable contexts. But less-skilled comprehenders benefit even more than more-skilled comprehenders.

Consider the data displayed in Figure 23 from an experiment by Perfetti and Roth (1981). Perfetti and Roth measured more- versus less-skilled fourth-grade comprehenders' latencies to pronounce target words like *dump* when those target words occurred in high- versus low-predictability contexts. High-predictability contexts were those for which at least 80% of another group of subjects could correctly predict the target word (such as *dump).* Low-predictability contexts were those that only 3% correctly guessed.

For Figure 23, I estimated activation by subtracting subjects' latencies to pronounce target words (like *dump)* in high-predictability contexts from subjects' latencies to pronounce target words in low-predictability contexts. The bigger the difference between the high- versus low-predictability conditions, the more the subjects benefitted from the high predictability contexts. As Figure 23 illustrates, the high-predictability contexts led to greater activation for both more- and less-skilled fourth graders. But the less-skilled comprehenders benefitted even more.

This finding does not support the hypothesis that less-skilled comprehenders are characterized by less-efficient enhancement mechanisms. Neither does this finding support the counter explanation that less-skilled comprehenders are less efficient at suppressing inappropriate information because they less fully appreciate what is contextually appropriate.

I also evaluated this counter-explanation with adult comprehenders and a task similar to those I used in my previous experiments. Subjects read short sentences, and following each sentence, they saw a test word. As in my other experiments, the subjects' task was to verify whether the test word fit the meaning of the sentence they just read. However, in this experiment I was most interested in the 80 trials in which the test word <u>did</u> indeed match the meaning of the sentence (and, therefore, the subjects should have responded "yes").

On half of those trials, the last word of the sentence was an ambiguous word, for example, *spade*, and the verb in the sentence biased one meaning of the ambiguous word, for example,

(41) He **dug with** the spade.

The test word was related to the meaning of the ambiguous word that was biased by the verb, for example, *GARDEN*. In a comparison condition I presented the same sentence, but the biasing verb was replaced with a neutral verb, for example,

(42) He **picked up** the spade.

The *spade* in sentence (42) could be either a garden tool or a playing card.

I measured how rapidly subjects accepted test words after reading sentences with biasing verbs versus neutral verbs.[12] This comparison showed us how fully comprehenders could appreciate the biasing contexts: The faster subjects were to accept *GARDEN* after reading the sentence with the biasing verb phrase *dug with* versus the neutral verb phrase *picked up*, the more fully they appreciated the biasing context.

I presented the test words at two intervals: Immediately (100 ms) after subjects finished reading each sentence, and after a one-second Delay. I predicted that both the more- and less-skilled comprehenders would benefit from the biasing contexts; that is, both groups of comprehenders would accept test words more rapidly when the sentences contained biasing as opposed to neutral verbs. However, I was especially interested in whether the less-skilled comprehenders would benefit less than the more-skilled comprehenders.

If less-skilled comprehenders are less efficient at rejecting contextually inappropriate information (as I found in my previous experiments) because they are less appreciative of context, then the less-skilled comprehenders should have benefitted less from the biasing contexts. In contrast, if less-skilled comprehenders are less efficient at rejecting inappropriate information because they have less efficient suppression mechanisms, then the less-skilled comprehenders should have benefitted just as much from the biasing contexts as the more-skilled comprehenders did. Based on previous literature, I predicted that the less-skilled comprehenders would benefit even more from the biasing contexts than the more-skilled comprehenders did.

Figure 24 displays the 120 subjects' data. I estimated activation by subtracting subjects' latencies to accept test words like *GARDEN* after reading sentences with biasing verbs like ***dug with*** from their latencies to accept *GARDEN* after reading sentences with unbiased verbs like ***picked up***.

As Figure 24 illustrates, at both the Immediate and the Delayed test intervals, the biased verbs led to greater activation, and this occurred for both more- and less-skilled comprehenders. Indeed, as Figure 24 also illustrates, at both test intervals, the less-skilled comprehenders benefitted from the biasing verbs more than the more-skilled comprehenders benefitted. These data do not support the hypothesis that less-skilled comprehenders are characterized by less-efficient enhancement mechanisms.

Are less-skilled comprehenders less efficient at enhancing typical objects in nonverbal scenes?

Just as sentence comprehension requires enhancing the contextually appropriate meanings of words, scene comprehension requires enhancing the objects present in the visual array. And, just as less-skilled comprehenders might be less efficient at enhancing the contextually appropriate meanings of words, they might also be less efficient at enhancing the objects present in a visual scene.

I tested this hypothesis in the following way. Subjects first viewed a scenic array of objects, and then they read the name of a test object. For instance, subjects first viewed the scenic array illustrated in the top panel of Figure 25, and then they saw the test object, *TRACTOR*. The subjects' task was to verify whether the test object had been present in the array they just viewed. On 80 trials, the test object had not been present, but on 80 it had. In this experiment, I was interested in the trials in which the test object had been present (and, therefore, the subjects should have responded "yes").

On half of those trials, the other objects in the array were typical of the scene in which the test object typically occurs. For example, the other objects in the array shown in the top panel of Figure 25 typically occur in a farm scene, just as a *tractor* does. In a comparison condition, the other objects were atypical of the scene in which the test object typically occurs. For example, the other objects in the array shown in the bottom panel of Figure 25 do not typically occur in a farm scene.

I compared how rapidly subjects accepted *TRACTOR* after viewing it in an array of typical objects with how rapidly they accepted *TRACTOR* after viewing it in an array of atypical objects. This comparison showed us how fully comprehenders could appreciate the typical contexts: The faster subjects were to accept *TRACTOR* after viewing the array of typical versus atypical objects, the more fully the subjects must have appreciated the context.

I presented the names of the test objects at two intervals: Immediately (50 ms) after subjects finished viewing each scenic array, and after a one-second Delay. I expected that both the more- and less-skilled comprehenders would benefit from the typical contexts. That is, both groups of comprehenders would accept test objects more rapidly when the arrays contained typical objects as opposed to atypical objects. This result would corroborate Biederman et al. (1988).

However, I was interested in whether the less-skilled comprehenders would benefit less from the typical contexts. If less-skilled comprehenders are less efficient at rejecting contextually inappropriate information (as I found in my previous experiments) because they are less appreciative of context, then they should have benefitted less from the typical contexts. In contrast, if less-skilled comprehenders are less efficient at rejecting inappropriate information because they have less efficient suppression mechanisms, then they should have benefitted just as much from the typical contexts as the more-skilled comprehenders did.

Figure 26 displays the 40 subjects' data. I estimated activation by subtracting subjects' latencies to accept test objects like *TRACTOR* after viewing a *tractor* in a typical *(farm)* array from their latencies to accept *TRACTOR* after viewing a *tractor* in an atypical *(kitchen)* array.

As Figure 26 illustrates, at both the Immediate and the Delayed test intervals, the typical contexts led to more for both the more- and less-skilled comprehenders experienced. Indeed, as Figure 26 also illustrates, the less-skilled comprehenders benefitted more from the typical contexts than the more-skilled comprehenders. These data do not support the hypothesis that less-skilled comprehenders are characterized by less-efficient enhancement mechanisms. Neither do these data support the counter-explanation that less-skilled comprehenders have difficulty rejecting inappropriate information because they less fully appreciate what is contextually appropriate.

Conclusions

From these experiments, I draw the following conclusions:

- Less-skilled comprehenders are not characterized by less-efficient enhancement mechanisms.
- Less-skilled comprehenders are fully capable of appreciating both semantic and scenic contexts.
- Less-skilled comprehenders often capitalize on context more than more-skilled comprehenders do.

Notes

1. A simple analogy for understanding mental activation is a lighted Christmas tree. The lights on the tree are analogous to the concepts stored (or represented) in the mind. Activating a mental representation is like illuminating a light bulb: Activation makes that concept accessible, just like illumination makes the bulb visible. One light might represent one concept. Or the representation might be distributed so that a pattern of activation represents a concept. For instance, different patterns (and meanings) are produced when different groups of light bulbs are illuminated in a movie marquis, or when different colored cards are held up in a card section at a football game. The movie marquis and the card section are analogous to distributed mental representations.

2. This graph, and the other graphs in this first section, differ from the figures I typically use to illustrate reaction times. Typically, I scale reaction time on the y-axis: The shorter the bar, the faster the reaction time. And faster reaction times *(shorter bars)* indicate higher levels of activation. In contrast, this figure, and Figures 2, 5, and 6, scale estimated activation (the difference between reaction time to the unrelated versus related items). So, these graphs are symbolically opposite to the ones I typically use. In these graphs, *longer bars* indicate higher levels of activation.

3. Pronouns are not nearly so frequent in other languages, for instance, Mandarin Chinese (Li & Thompson, 1979; 1981), Japanese (Hinds, 1978), or Spanish (Huang, 1984). In those languages, zero anaphors are more often the rule and pronouns are the exception. In fact, an English text would require ten times the number of pronouns as its Chinese translation (Li & Thompson, 1979).

4. In some situations, animacy and number constraints are relaxed. For example, *it* is often used to refer to animates when the gender is unclear, as in "What a beautiful baby. Is *it* a boy or a girl?" And *they* is often used to refer to individuals when the gender is unimportant, as in "I asked someone how to get to Straub Hall, but *they* didn't know where it was either." (Gernsbacher, 1986).

5. I am not suggesting that once an anaphor's referent is accessed, comprehenders then activate that referent. Rather, I am suggesting that because an anaphor's referent is activated, it can then be accessed — and incorporated into the developing discourse representation. Consider again the analogy with word identification: Comprehenders do not figure out the identity of a word, and then activate that word. Rather, it is because the lexical representation is activated that the word can be accessed.

6. I am using the term *cataphoric* in the sense that linguists do. For instance, Quirk and Greenbaum (1976, p. 302) write that certain expressions "point back (anaphoric) or forward (cataphoric) in discourse." Cataphoric devices include, but are broader than, cataphoric pronouns. Their communality lies in the connotation of cataphoric as forward.

7. I shall indicate stressed words by capitalizing them.

8. Air Force recruits are high school graduates, and typically 20% have completed some college courses. The subjects' ages ranged from 17 to 23, and approximately 18% were female.

9. To ensure that the homophones would be familiar to our subjects, 25 students from the University of Oregon judged — without time pressure — whether the test words fit the meanings of our experimental and filler sentences. I only used experimental sentences and test words if 95% of our students agreed that the test words did **not** fit their sentences' meanings, and I only used filler sentences and test words if 95% of our students agreed that the test words **did** fit their sentences' meanings.

10. I am grateful to I. Biederman for providing me with his stimuli.

11. Although both more- and less-skilled comprehenders responded more rapidly on Picture trials than Word trials, there were no interactions with modality (Picture vs Word). So, I have collapsed across this variable in our figures.

12. To ensure that the biased verbs were biased and the neutral verbs were neutral, 25 students at University of Oregon read all of the experimental and comparison sentences and made unspeeded judgments about the meanings of the ambiguous words. I only used biased verbs if 95% of our students selected the meaning of the ambiguous word that I intended, and I only used neutral verbs if our students were roughly split over which meaning I intended (e.g., when given the sentence *He picked up the spade,* approximately 50% chose *GARDEN TOOL* and approximately 50% chose *PLAYING CARD).*

FIGURE 1
(From Swinney, 1979)

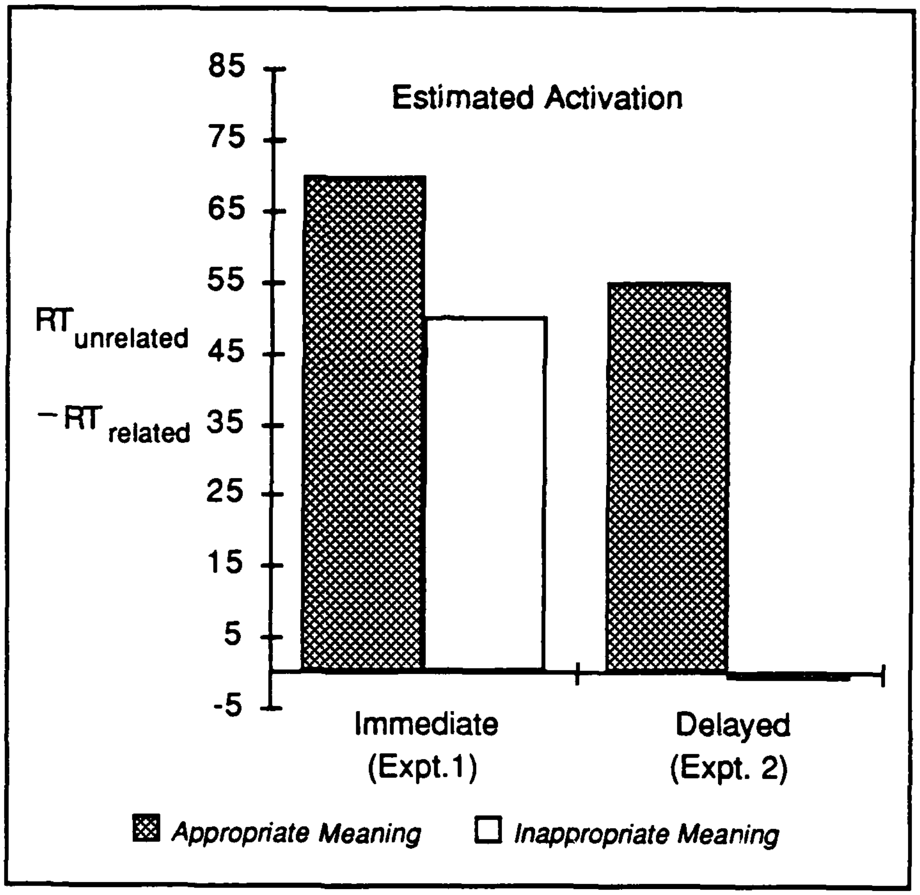


FIGURE 2
(From Seidenberg et al., 1982; Experiment 3)

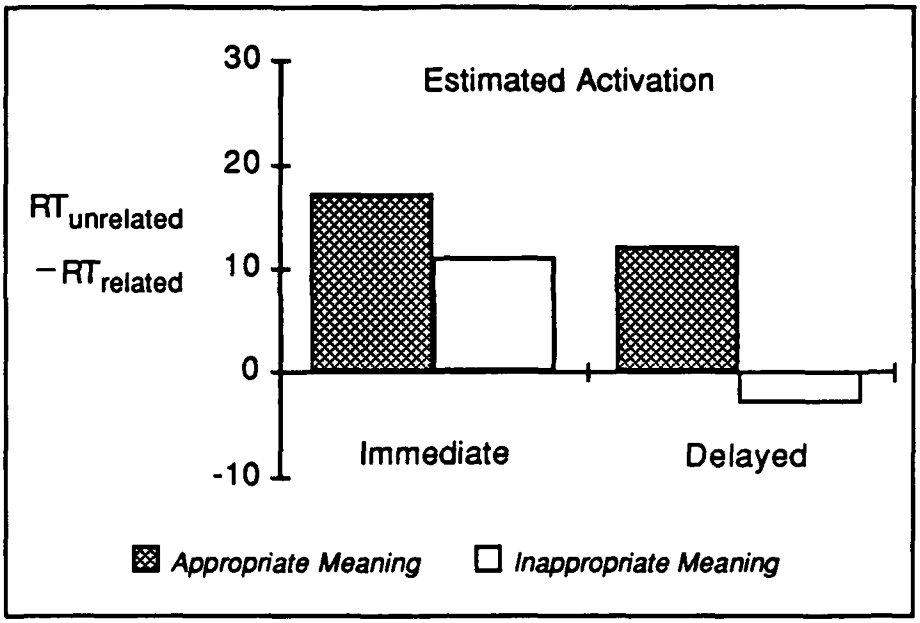


FIGURE 3

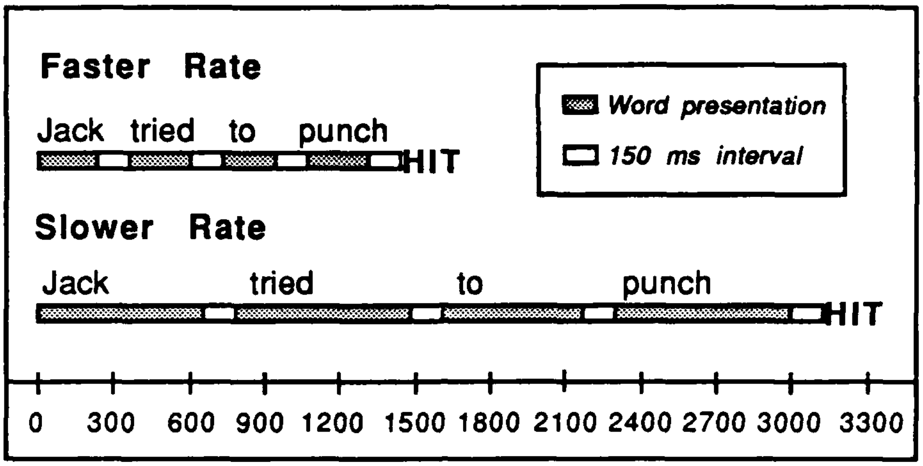


FIGURE 4

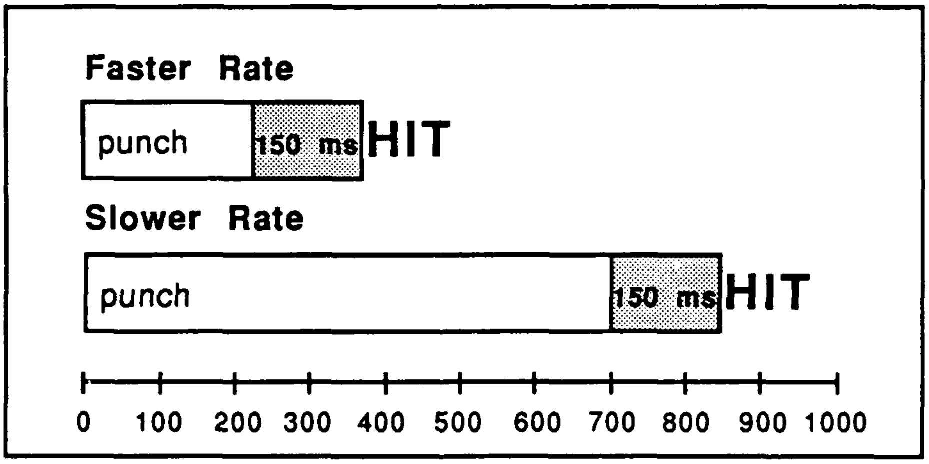


FIGURE 5

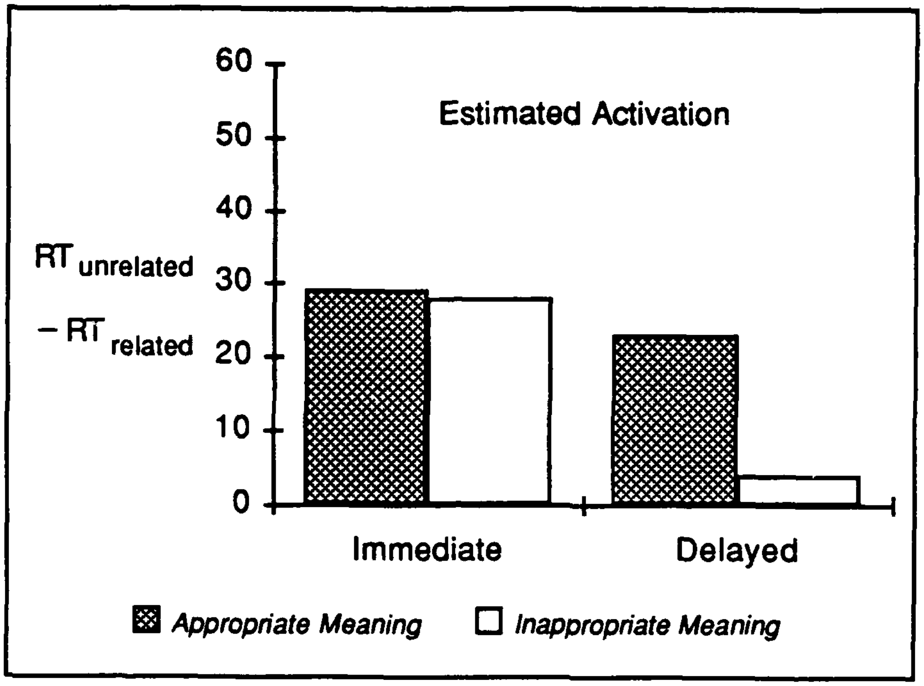

Estimated Activation
60
50
40
30
20
10
0
RT unrelated
− RT related
Immediate
Delayed
Appropriate Meaning
Inappropriate Meaning

FIGURE 6

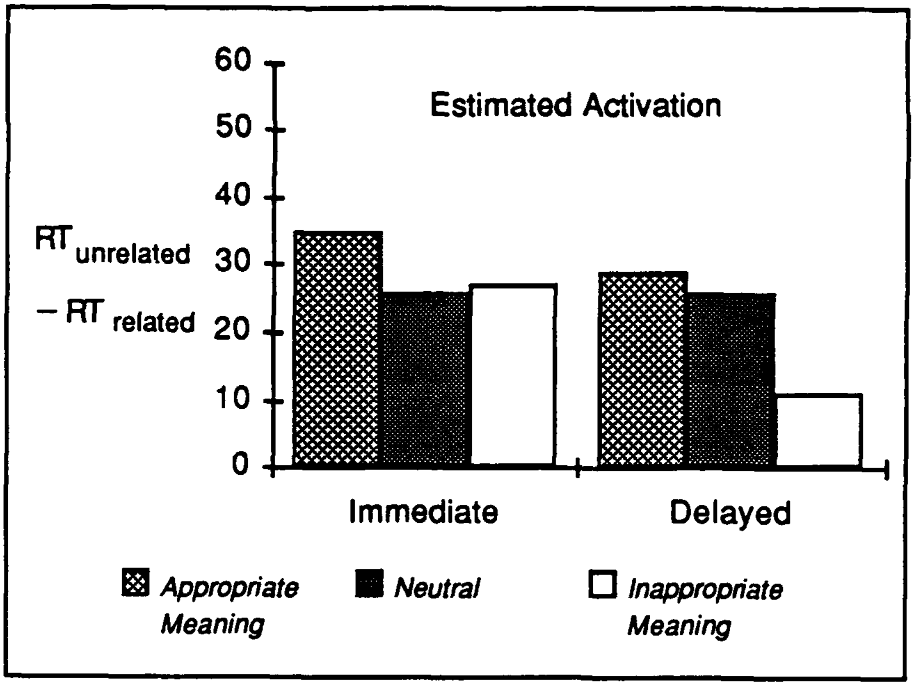

Estimated Activation
60
50
40
30
20
10
0
RT unrelated
− RT related
Immediate
Delayed
Appropriate Meaning
Neutral
Inappropriate Meaning

FIGURE 7

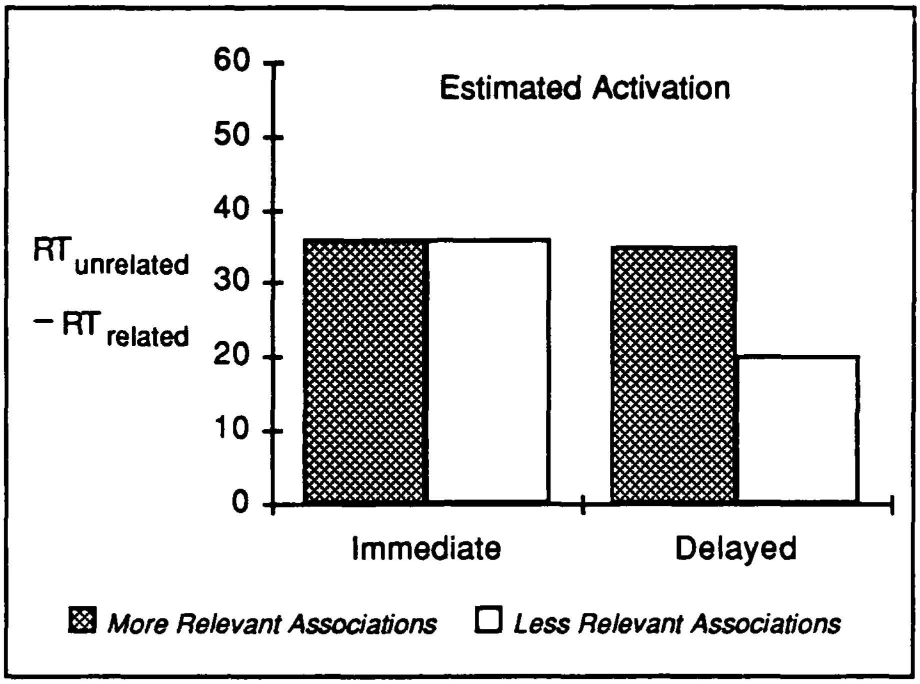

Estimated Activation
RT unrelated
− RT related
60
50
40
30
20
10
0
Immediate
Delayed
More Relevant Associations
Less Relevant Associations

FIGURE 8

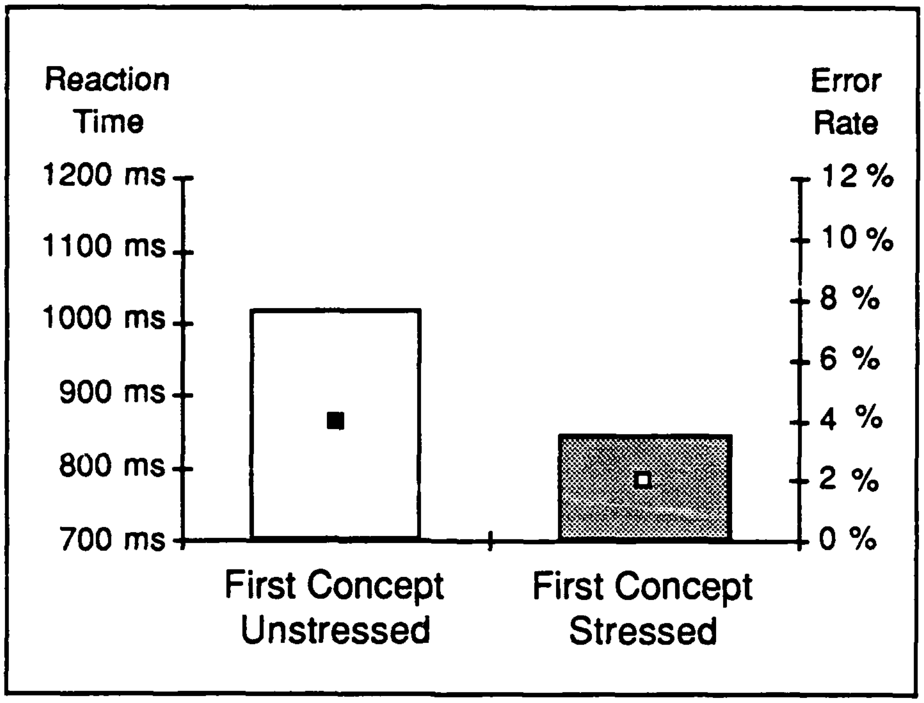

Reaction Time
1200 ms
1100 ms
1000 ms
900 ms
800 ms
700 ms
Error Rate
12 %
10 %
8 %
6 %
4 %
2 %
0 %
First Concept Unstressed
First Concept Stressed

FIGURE 9

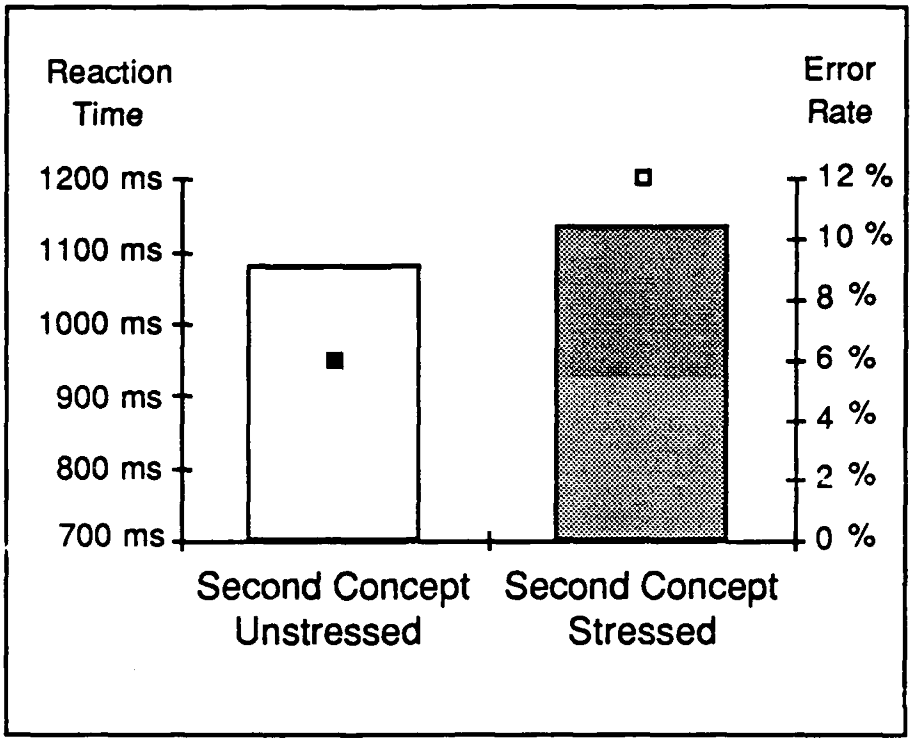

Reaction
Time
Error
Rate
1200 ms
1100 ms
1000 ms
900 ms
800 ms
700 ms
12 %
10 %
8 %
6 %
4 %
2 %
0 %
Second Concept
Unstressed
Second Concept
Stressed

FIGURE 10

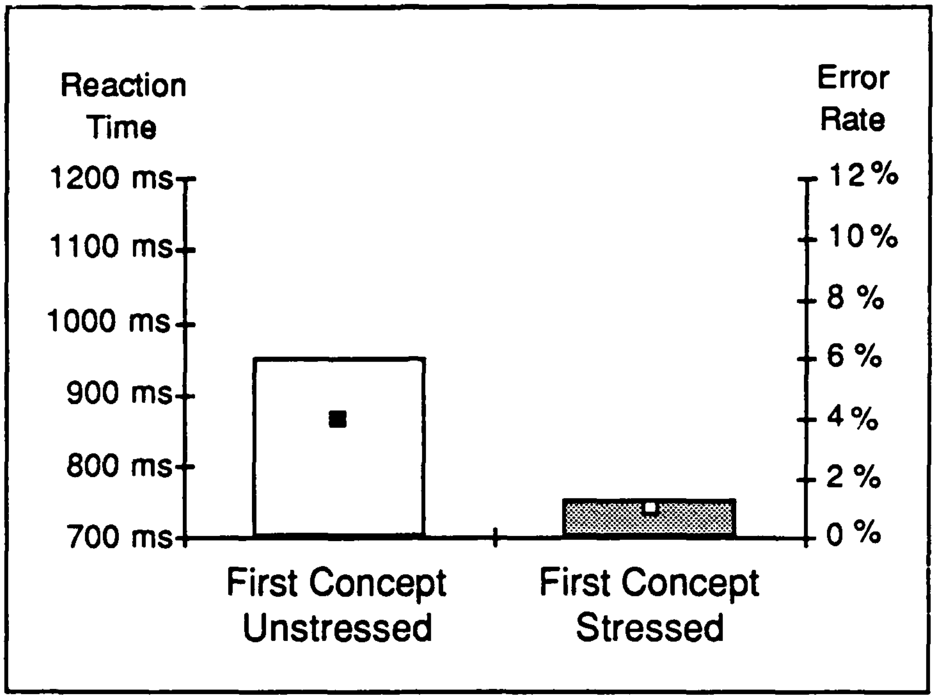

Reaction Time
1200 ms
1100 ms
1000 ms
900 ms
800 ms
700 ms
Error Rate
12%
10%
8 %
6 %
4 %
2 %
0 %
First Concept Unstressed
First Concept Stressed

FIGURE 11

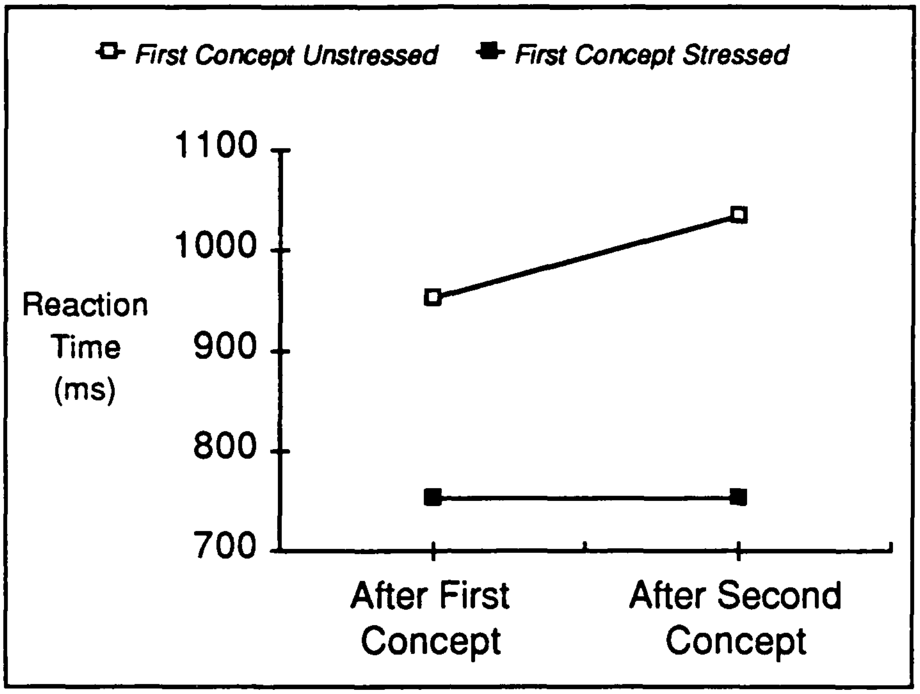

First Concept Unstressed
First Concept Stressed
1100
1000
900
800
700
Reaction Time (ms)
After First Concept
After Second Concept

FIGURE 12

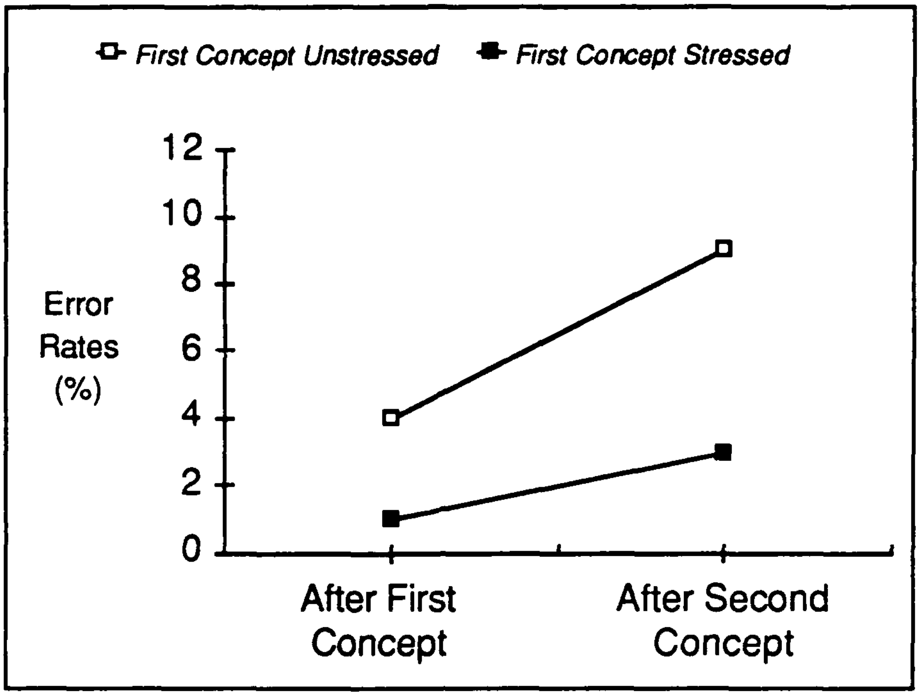

First Concept Unstressed
First Concept Stressed
Error Rates (%)
12
10
8
6
4
2
0
After First Concept
After Second Concept

FIGURE 13

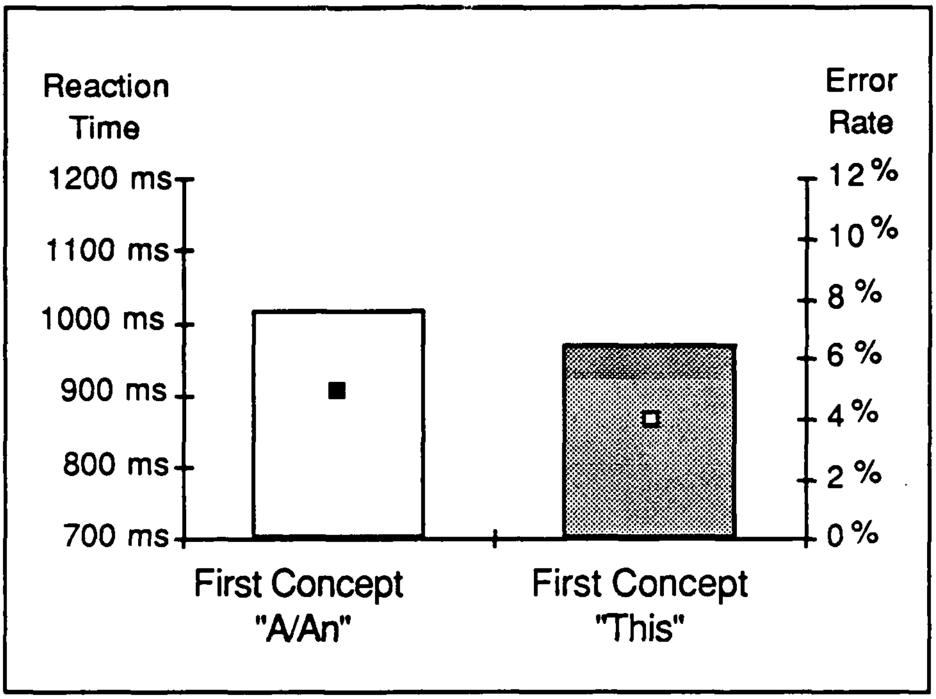

Reaction Time
1200 ms
1100 ms
1000 ms
900 ms
800 ms
700 ms
Error Rate
12 %
10 %
8 %
6 %
4 %
2 %
0 %
First Concept "A/An"
First Concept "This"

FIGURE 14

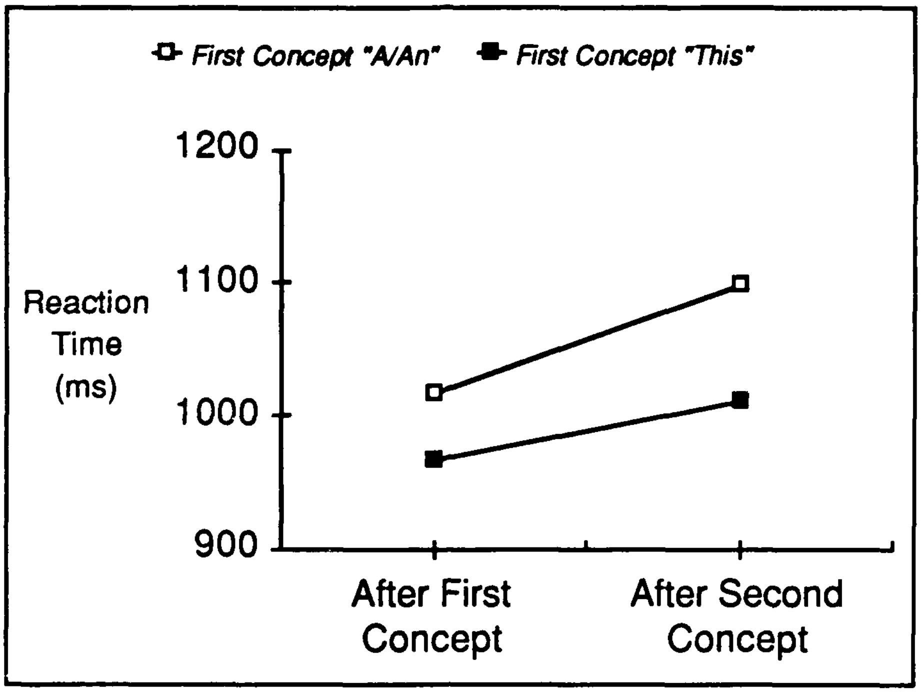

First Concept "A/An"
First Concept "This"
1200
1100
1000
900
Reaction Time (ms)
After First Concept
After Second Concept

FIGURE 15

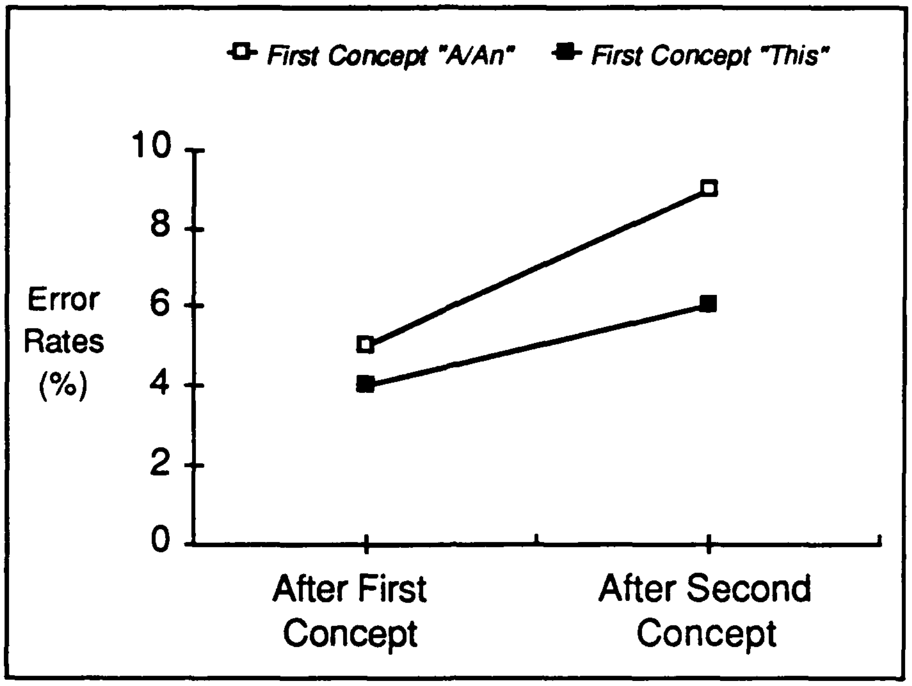

First Concept "A/An"
First Concept "This"
Error Rates (%)
10
8
6
4
2
0
After First Concept
After Second Concept

FIGURE 16
(From Gernsbacher et al., 1990)

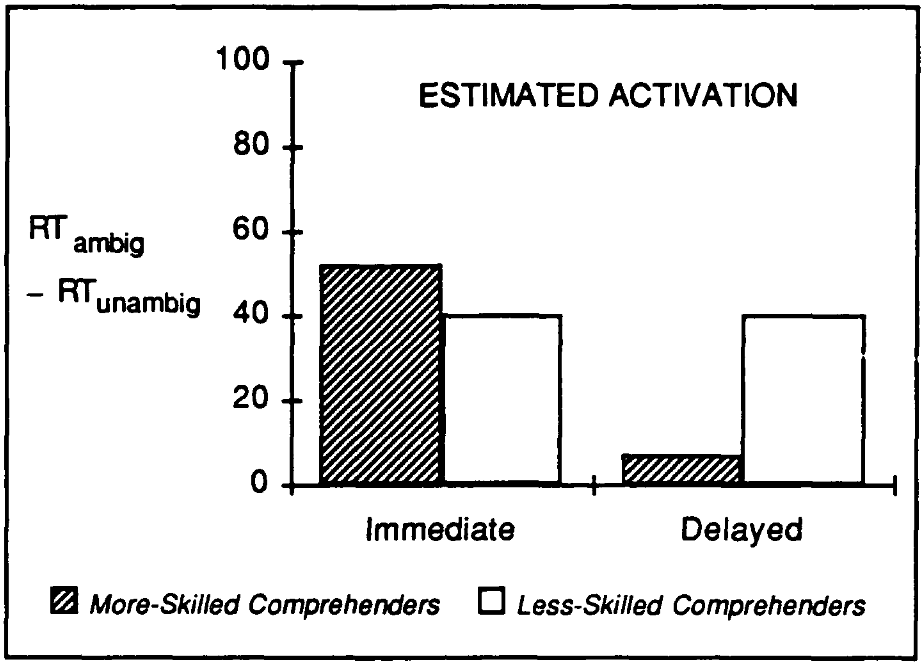


FIGURE 17

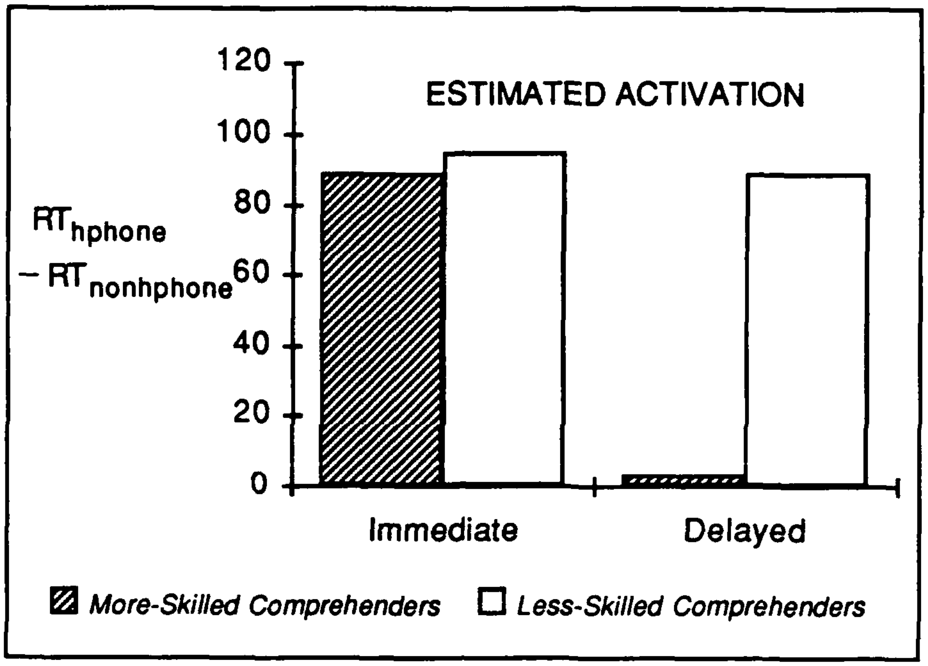

ESTIMATED ACTIVATION
120
100
80
60
40
20
0
RT hphone
− RT nonhphone
Immediate
Delayed
More-Skilled Comprehenders
Less-Skilled Comprehenders

FIGURE 18

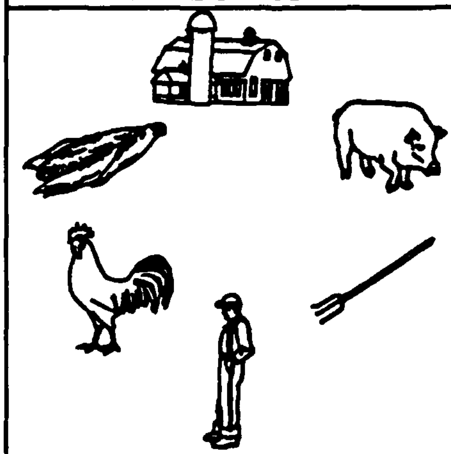
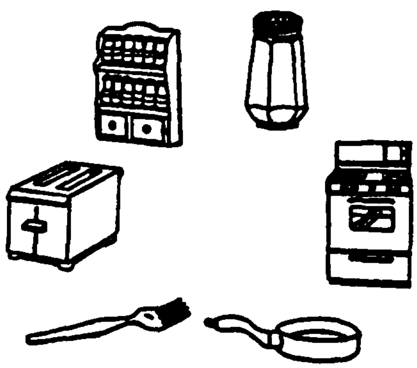
TYPICAL SCENIC ARRAY	TEST OBJECT
	**TRACTOR**
ATYPICAL SCENIC ARRAY	TEST OBJECT
	**TRACTOR**

FIGURE 19

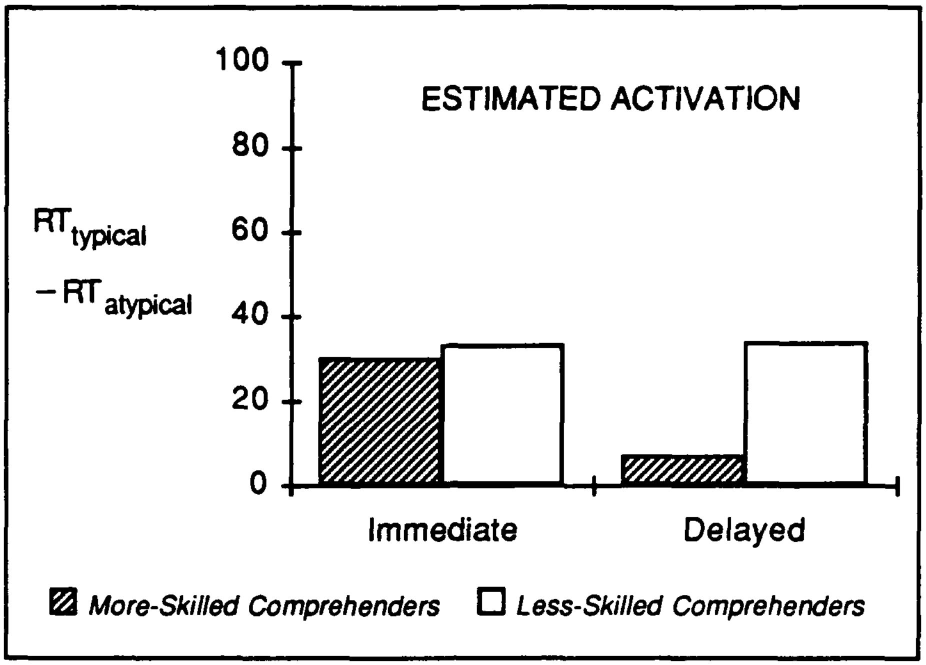

ESTIMATED ACTIVATION
100
80
60
40
20
0
RT typical
− RT atypical
Immediate
Delayed
More-Skilled Comprehenders
Less-Skilled Comprehenders

FIGURE 20

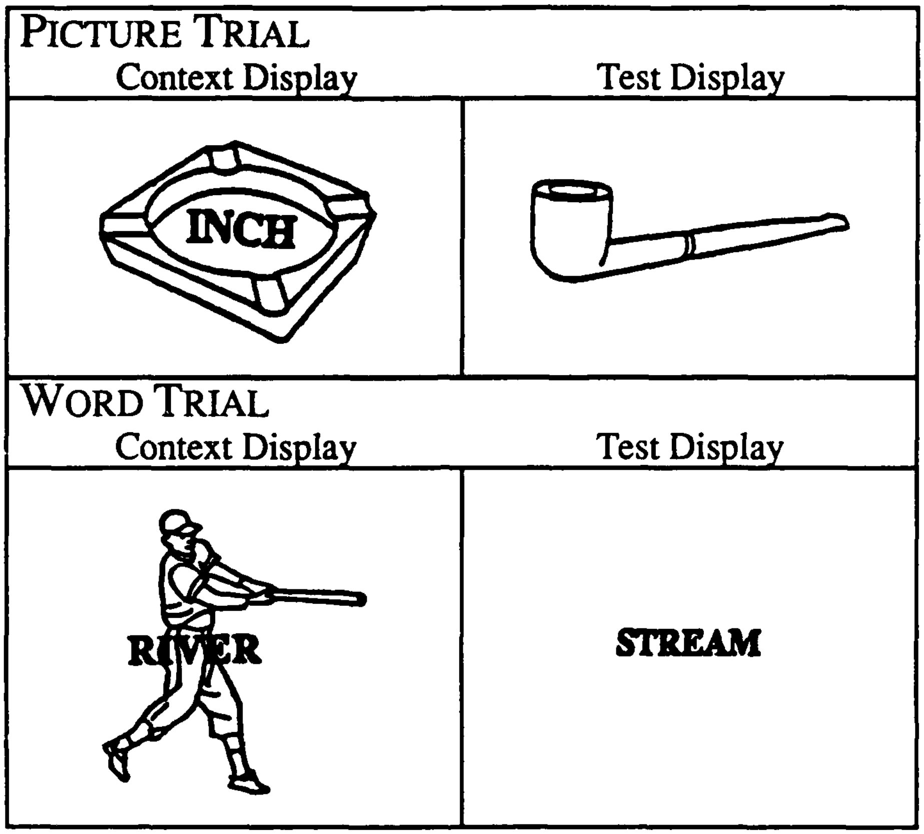

PICTURE TRIAL
Context Display
Test Display
INCH
WORD TRIAL
Context Display
Test Display
RIVER
STREAM

FIGURE 21

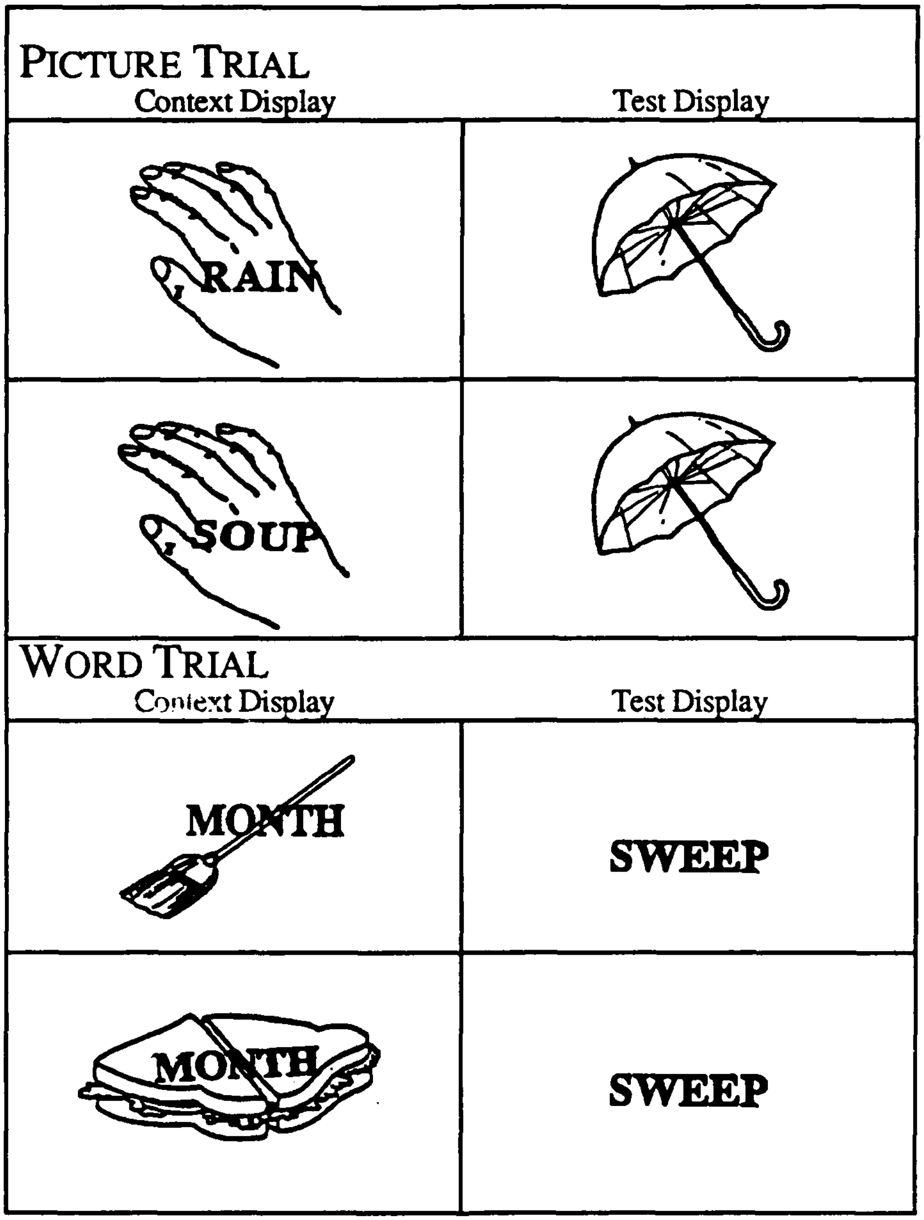

PICTURE TRIAL
Context Display
Test Display
RAIN
SOUP
WORD TRIAL
Context Display
Test Display
MONTH
SWEEP
MONTH
SWEEP

FIGURE 22

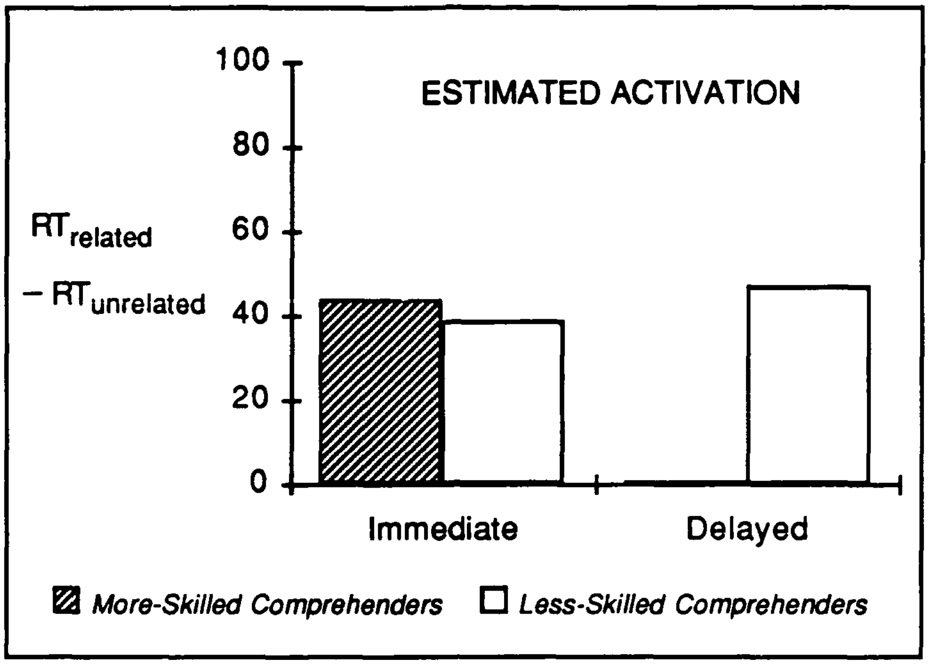

ESTIMATED ACTIVATION
100
80
60
40
20
0
RT related
− RT unrelated
Immediate
Delayed
More-Skilled Comprehenders
Less-Skilled Comprehenders

FIGURE 23
(After Perfetti & Roth, 1981, Experiment 2)

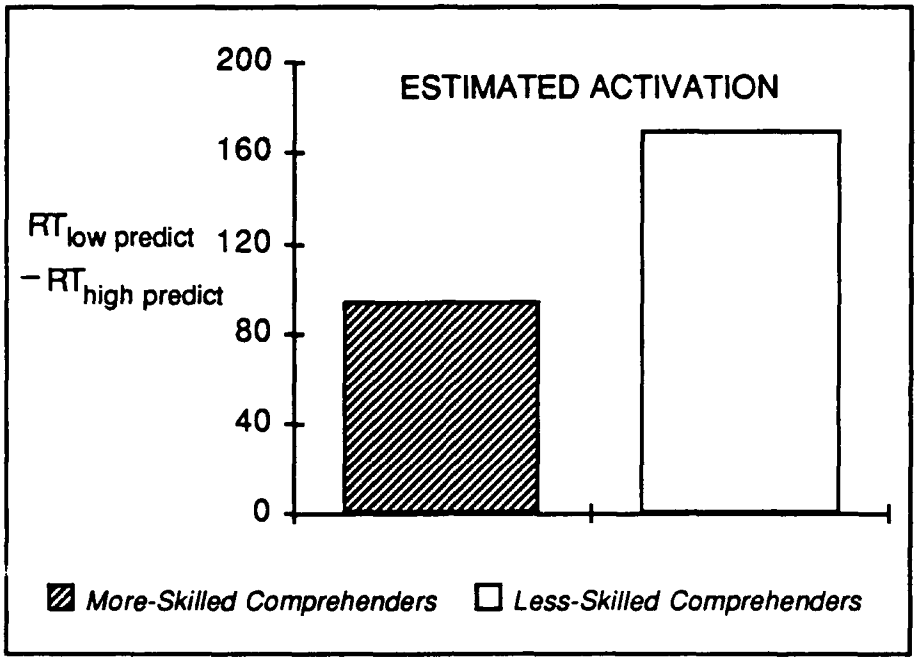


FIGURE 24

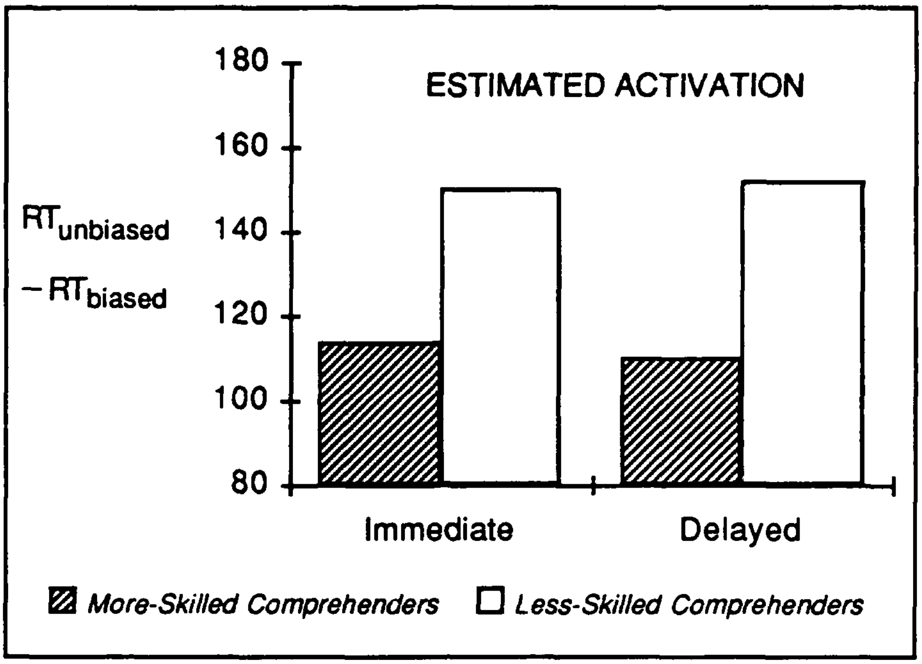

ESTIMATED ACTIVATION
$RT_{unbiased}$
$- RT_{biased}$
180
160
140
120
100
80
Immediate
Delayed
More-Skilled Comprehenders
Less-Skilled Comprehenders

FIGURE 25

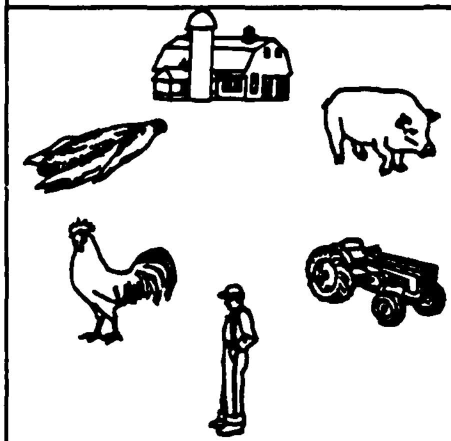
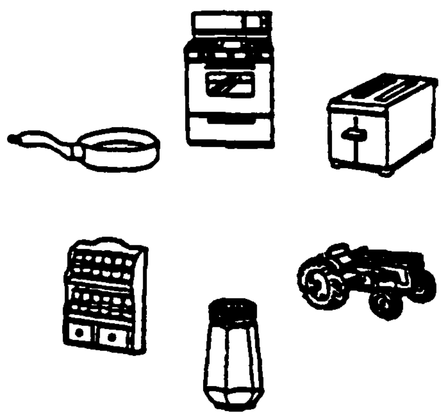
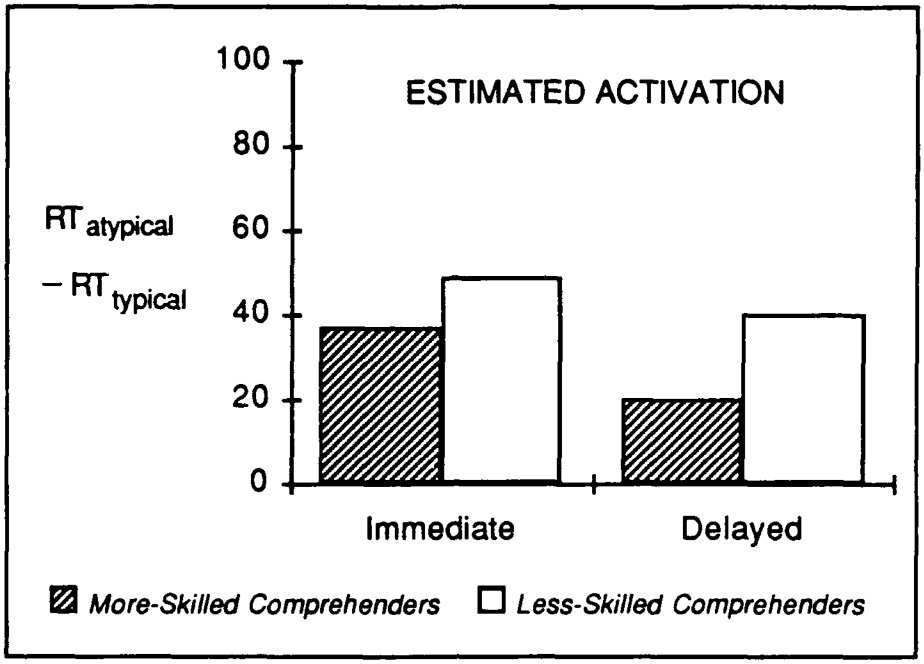
TYPICAL SCENIC ARRAY	TEST OBJECT
	**TRACTOR**
ATYPICAL SCENIC ARRAY	TEST OBJECT
	**TRACTOR**

FIGURE 26


ESTIMATED ACTIVATION
RT atypical
− RT typical
100
80
60
40
20
0
Immediate
Delayed
More-Skilled Comprehenders
Less-Skilled Comprehenders

REFERENCES

Anderson, J. R. (1983). *The architecture of cognition*. Cambridge, MA: Harvard University Press.

Arbuthnot, M. H. (1976). *The Arbuthnot anthology of children's literature*. New York: Lothrop, Lee, & Shephard.

Barrett, J., & Barrett, R. (1969). *Old MacDonald had an apartment house*. New York: Atheneum.

Becker, C. A. (1976). Semantic context and word frequency effects in visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, **2**, 556-566.

Biederman, I. (1981). On the semantics of a glance at a scene. In M. Kubovy, & J. R. Pomerantz (Ed.), *Perceptual organization* (pp. 213-252). Hillsdale, NJ: Erlbaum.

Biederman, I., Bickle, T. W., Teitelbaum, R. C., & Klatsky, G. J. (1988). Object search in nonscene displays. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **14**, 456-467.

Biederman, I., Glass, A. L., & Stacy, E. W., Jr. (1973). Searching for objects in real world scenes. *Journal of Experimental Psychology*, **97**, 22-27.

Biederman, I., Mezzanotte, R. J., & Rabinowitz, J. C. (1982). Scene perception: Detecting and judging objects undergoing relational violations. *Cognitive Psychology*, **14**, 143-177.

Biederman, I., Teitelbaum, R. C., & Mezzanotte, R. J. (1983). Scene perception: A failure to find a benefit of prior expectancy or familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **9**, 411-429.

Blutner, R., & Sommer, R. (1988). Sentence processing and lexical access: The influence of the focus-identifying task. *Journal of Memory and Language*, **27**, 359-367.

Bock, K. J., & Mazzella, J. R. (1983). Intonational marking of given and new information: Some consequences for comprehension. *Memory & Cognition*, **11**, 64-76.

Bolinger, D. L. (1972). Accent is predictable (if you're a mind-reader). *Language*, **48**, 633-644.

Brown, G. (1983). Prosodic structure and the given/new distinction. In A. Cutler, & D. R. Ladd (Ed.), *Prosody: Models and measurements* (pp. 67-77). New York: Springer-Verlag.

Burgess, C., Tanenhaus, M. K., & Seidenberg, M. S. (1989). Context and lexical access: Implications of nonword interference for lexical ambiguity resolution. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **15**, 620-632.

Calmenson, S. (1972). *Hiram's red shirt*. New York: Golden Press.

Chapman, L., & Chapman, J. (1973). *Disordered thought in schizophrenia*. New York: Appleton-Century-Crofts.

Clark, H. H., & Schaefer, E. F. (1987). Collaborating on contributions to conversation. *Language and Cognitive Processes*, **2**, 19-41.

Clark, H. H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition*, **22**, 1-39.

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and Performance VI* (pp. 535-555). New York: Academic Press.

Coltheart, M., Davelaar, E., Jonasson, J. T., & Besner, D. (1977). Access to the internal lexicon. In S. Dornic (Ed.), *Attention and Performance VI* (pp. 535-555). New York: Academic Press.

Coltheart, V., Laxon, V., Rickard, M., & Elton, C. (1988). Phonological recoding in reading for meaning by adults and children. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 387-397.

Coltheart, V., Laxon, V., Rickard, M., & Elton, C. (1988). Phonological recoding in reading for meaning by adults and children. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 387-397.

Conrad, C. (1974). Context effects in sentence comprehension: A study of the subjective lexicon. *Memory & Cognition*, **2**, 130-138.

Corbett, A. T., & Chang, F. R. (1983). Pronoun disambiguation: Accessing potential antecedents. *Memory & Cognition*, **11**, 283-294.

Cramer, P. (1970). *A study of homographs*. New York: Academic Press.

Cramer, P. (1970). *A study of homographs*. New York: Academic Press.

Cruttenden, A. (1986). *Intonation*. Cambridge: Cambridge University Press.

Cutler, A. (1976). Phoneme-monitoring reaction time as a function of preceding intonation contour. *Perception & Psychophysics*, **20**, 55-60.

Cutler, A., & Fodor, J. A. (1979). Semantic focus and sentence comprehension. *Cognition*, **7**, 49-59.

Dell, G. S., McKoon, G., & Ratcliff, R. (1983). The activation of antecedent information during the processing of anaphoric reference in reading. *Journal of Verbal Learning and Verbal Behavior*, **22**, 121-132.

Doctor, E. A., & Coltheart, M. (1980). Children's use of phonological encoding when reading for meaning. *Memory & Cognition*, **8**, 195-209.

Doctor, E. A., & Coltheart, M. (1980). Children's use of phonological encoding when reading for meaning. *Memory & Cognition*, **8**, 195-209.

Fowler, C. A., & Housum, J. (1987). Talkers' signaling of "new" and "old" words in speech and listeners' perception and use of the distinction. *Journal of Memory and Language*, **26**, 489-504.

Friedman, A. (1979). Framing pictures: The role of knowledge in automatized encoding and memory for gist. *Journal of Experimental Psychology: General*, **108**, 316-355.

Fry, D. B. (1955). Duration and intensity as physical correlates of linguistic stress. *Journal of the Acoustic Society of America*, **27**, 765-769.

Gay, T. (1978). Physiological and acoustic correlates of perceived stress. *Language and Speech*, **21**, 347-353.

Gernsbacher, M. A. (1989). Mechanisms that improve referential access. *Cognition*, **32**, 99-156.

Gernsbacher, M. A. (1989). Mechanisms that improve referential access. *Cognition*, **32**, 99-156.

Gernsbacher, M. A. (in press-a). Cognitive processes and mechanisms in language comprehension: The structure building framework. In G. H. Bower (Ed.), *The psychology of learning and motivation*. New York: Academic Press.

Gernsbacher, M. A. (in press-a). Cognitive processes and mechanisms in language comprehension: The structure building framework. In G. H. Bower (Ed.), *The psychology of learning and motivation*. New York: Academic Press.

Gernsbacher, M. A. (in press-b). *Language comprehension as structure building*. Hillsdale, NJ: Erlbaum.

Gernsbacher, M. A. (in press-b). *Language comprehension as structure building*. Hillsdale, NJ: Erlbaum.

Gernsbacher, M. A., & Faust, M. (in press). Fine tuning the activation of lexical representations during comprehension. In G. B. Simpson (Ed.), *Comprehending word and sentence* . Amsterdam: North Holland.

Gernsbacher, M. A., & Hargreaves, D. (1988). Accessing sentence participants: The advantage of first mention. *Journal of Memory and Language*, **27**, 699-717.

Gernsbacher, M. A., & Jescheniak, J. D. (1990). *Cataphoric devices in spoken discourse*. Manuscript submitted for publication.

Gernsbacher, M. A., & Shroyer, S. (1989). The cataphoric use of the indefinite *this* in spoken narratives. *Memory & Cognition*, **17**, 536-540.

Gernsbacher, M. A., & Shroyer, S. (1989). The cataphoric use of the indefinite *this* in spoken narratives. *Memory & Cognition*, **17**, 536-540.

Gernsbacher, M. A., & Varner, K. R. (1988). *The multi-media comprehension battery* (No. 88-04). Institute of Cognitive and Decision Sciences, University of Oregon, Eugene, OR.

Gernsbacher, M. A., & Varner, K. R. (1988). *The multi-media comprehension battery* (No. 88-04). Institute of Cognitive and Decision Sciences, University of Oregon, Eugene, OR.

Gernsbacher, M. A., Hargreaves, D., & Beeman, M. (1989). Building and accessing clausal representations: The advantage of first mention versus the advantage of clause recency. *Journal of Memory and Language*, **28**, 735-755.

Gernsbacher, M. A., Varner, K. R., & Faust, M. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**, 430-445.

Gernsbacher, M. A., Varner, K. R., & Faust, M. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**, 430-445.

Gernsbacher, M. A., Varner, K. R., & Faust, M. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **16**, 430-445.

Glucksberg, S., Krueuz, R. J., & Rho, S. H. (1986). Context can constrain lexical access: Implications for models of language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **12**, 323-335.

Glucksberg, S., Krueuz, R. J., & Rho, S. H. (1986). Context can constrain lexical access: Implications for models of language comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **12**, 323-335.

Gough, P. B. (1971). (Almost a decade of) Experimental psycholinguistics. In W. O. Dingwall (Ed.), *A survey of linguistic science* . College Park, MA:

Hasher, L., Rympa, B., Stoltzfus, E. R., & Zacks, R. (1989, November). *Age deficits in inhibitory mechanisms: Data and theory.* 30th annual meeting of the Psychonomic Society, Atlanta, GA.

Kausler, D. H., & Kollasch, S. F. (1970). Word associations to homographs. *Journal of Verbal Learning and Verbal Behavior*, **9**, 444-449.

Kausler, D. H., & Kollasch, S. F. (1970). Word associations to homographs. *Journal of Verbal Learning and Verbal Behavior*, **9**, 444-449.

Keele, S. W., & Neill, W. T. (1978). Mechanisms of Attention. In E. C. Carterette, & M. P. Friedman (Ed.), *Handbook of Perception* (pp. 3-47). New York: Academic Press.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review*, **95**, 163-182.

Kintsch, W., & Mross, E. F. (1985). Context effects in word identification. *Journal of Memory and Language*, **24**, 336-349.

Kruez, R. J. (1987). The subjective familiarity of English homophones. *Memory & Cognition*, **15**, 154-168.

Levelt, W. J. M. (1989). *Speaking. From intention to articulation*. Cambridge, MA: MIT Press.

Lieberman, P. (1960). Some acoustic correlates of word stress in American English. *Journal of the Acoustic Society of America*, **32**, 451-454.

Lieberman, P. (1984). *The biology and evolution of language*. Cambridge, MA: Harvard University Press.

Lucas, M. (1987). Frequency effects on the processing of ambiguous words in sentence context. *Language and Speech*, **30**, 25-46.

MacWhinney, B., & Bates, E. (1978). Sentential devices for conveying givenness and newness: A cross-cultural developmental study. *Journal of Verbal Learning and Verbal Behavior*, **17**, 539-558.

Mandler, J. M., & Johnson, N. (1976). Some of the thousand words a picture is worth. *Journal of Experimental Psychology: Human Learning and Memory*, **2**, 529-540.

Marslen-Wilson, W., Tyler, L. K., & Seidenberg, M. (1978). Sentence processing and the clause boundary. In W. J. M. Levelt, & G. B. Flores d'Arcais (Ed.), *Studies in the perception of language* (pp. 219-246). London: Wiley.

McClelland, J. L., & Kawamoto, A. H. (1986). Mechanisms of sentence processing: Assigning roles to constituents of sentences. In J. L. McClelland, & D. E. Rumelhart (Ed.), *Parallel distributed processing: Explorations in the microstructure of cognition* . Cambridge, MA: MIT Press.

Nelson, D., McEvoy, C. L., Walling, J. R., & Wheeler, J. W. (1980). The University of South Florida homograph norms. *Behavior Research Methods & Instrumentation*, **12**, 16-37.

Nelson, D., McEvoy, C. L., Walling, J. R., & Wheeler, J. W. (1980). The University of South Florida homograph norms. *Behavior Research Methods & Instrumentation*, **12**, 16-37.

Norris, D. (1986). Word recognition: Context effects without priming. *Cognition*, **22**, 93-136.

Palmer, S. E. (1975). The effects of contextual scenes on the perception of objects. *Memory & Cognition*, **3**, 519-526.

Perfetti, C. A., & Roth, S. (1981). Some of the interactive processes in reading and their role in reading skill. In A. M. Lesgold, & C. A. Perfetti (Ed.), *Interactive processes in reading* (pp. 269-297). Hillsdale, NJ: Lawrence Erlbaum Associates.

Perfetti, C. A., & Roth, S. (1981). Some of the interactive processes in reading and their role in reading skill. In A. M. Lesgold, & C. A. Perfetti (Ed.), *Interactive processes in reading* (pp. 269-297). Hillsdale, NJ: Lawrence Erlbaum Associates.

Posner, M. I. (1978). *Chronometric explorations of mind.* Hillsdale, NJ: Erlbaum.

Posner, M. I., & Snyder, C. R. R. (1975). Facilitation and inhibition in the processing of signals. In P. M. A. Rabbitt, & S. Dornic (Ed.), *Attention and Performance V* (pp. 669-682). New York: Academic Press.

Prince, E. F. (1981). On inferencing of the indefinite-this NPs. In A. Joshi, B. Webber, & I. Sag (Ed.), *Elements of discourse understanding* (pp. 231-250). Cambridge: Cambridge University Press.

Ratcliff, R., Hockley, W. E., & McKoon, G. (1985). Components of activation: Repetition and priming effects in lexical decision and recognition. *Journal of Experimental Psychology: General*, **114**, 435-450.

Rosson, M. B. (1985). The interaction of pronunciation rules and lexical representations in reading aloud. *Memory & Cognition*, **13**, 90-99.

Rosson, M. B. (1985). The interaction of pronunciation rules and lexical representations in reading aloud. *Memory & Cognition*, **13**, 90-99.

Sachs, J. S. (1967). Recognition memory for syntactic and semantic aspects of connected discourse. *Perception & Psychophysics*, **2**, 437-442.

Schober, M. F., & Clark, H. H. (1989). Understanding by addressees and overhearers. *Cognitive Psychology*, **21**, 211-232.

Seidenberg, M. S., Tanenhaus, M. K., Leiman, J. M., & Bienkowski, M. (1982). Automatic access of the meanings of ambiguous words in context: Some limitations of knowledge-based processing. *Cognitive Psychology*, **14**, 489-537.

Smith, M. C., & McGee, L. E. (1980). Tracing the time course of picture-word processing. *Journal of Experimental Psychology: General*, **109**, 373-392.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, **6**, 174-215.

Swinney, D. A. (1979). Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior*, **18**, 645-659.

Tabossi, P. (1988). Accessing lexical ambiguity in different types of sentential contexts. *Journal of Memory and Language*, **27**, 324-340.

Tabossi, P., Colombo, L., & Job, R. (1987). Accessing lexical ambiguity: Effects of context and dominance. *Psycholgical Research*, **49**, 161-167.

Tanenhaus, M. K., Leiman, J. M., & Seidenberg, M. S. (1979). Evidence for multiple stages in the processing of ambiguous words in syntactic contexts. *Journal of Verbal Learning and Verbal Behavior*, **18**, 427-440.

Terkel, S. (1974). *Working*. New York: Avon.

Terken, J., & Nooteboom, S. G. (1987). Opposite effects of accentuation and deaccentuation on verification latencies for given and new information. *Language and Cognitive Proceses*, **2**, 145-163.

Till, R. E., Mross, E. F., & Kintsch, W. (1988). Time course of priming for associate and inference words in a discourse context. *Memory & Cognition*, **16**, 283-299.

Tipper, S. P., & Driver, J. (1988). Negative priming between pictures and words in a selective attention task: Evidence for semantic processing of ignored stimuli. *Memory & Cognition*, **16**, 64-70.

Tipper, S. P., & Driver, J. (1988). Negative priming between pictures and words in a selective attention task: Evidence for semantic processing of ignored stimuli. *Memory & Cognition*, **16**, 64-70.

van Orden, G. C. (1987). A rows is a rose: Spelling, sound, and reading. *Memory & Cognition*, **15**, 181-198.

van Orden, G. C. (1987). A rows is a rose: Spelling, sound, and reading. *Memory & Cognition*, **15**, 181-198.

van Orden, G. C., Johnston, J. C., & Hale, B. L. (1988). Word identification in reading proceeds from spelling to sound to meaning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 371-386.

van Orden, G. C., Johnston, J. C., & Hale, B. L. (1988). Word identification in reading proceeds from spelling to sound to meaning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **14**, 371-386.

van Petten, C., & Kutas, M. (1987). Ambiguous words in context: An event-related potential analysis of the time course of meaning activation. *Journal of Memory and Language*, **26**, 188-208.

van Petten, C., & Kutas, M. (1987). Ambiguous words in context: An event-related potential analysis of the time course of meaning activation. *Journal of Memory and Language*, **26**, 188-208.

Wald, B. (1983). Referents and topics within and across discourse units: Observations from current vernacular English. In S. Klen-Andrew (Ed.), *Discourse perspectives on syntax* (pp. 91-116). New York: Academic Press.

Waltz, D. L., & Pollack, J. B. (1985). Massively parallel parsing: A strongly interactive model of natural language interpretation. *Cognitive Science*, **9**, 51-74.

Williams, J. N. (1988). Constraints upon semantic activation during sentence comprehension. *Language and Cognitive Processes*, **3**, 165-206.

Wright, S., & Givón, T. (1987). The pragmatics of indefinite reference: Quantified text-based studies. *Studies in Language*, **11**, 1-33.

APPENDIX 1

ADMINISTRATION OF THE MULTI-MEDIA COMPREHENSION BATTERY

The Multi-Media Comprehension Battery (Gernsbacher & Varner, 1988) comprises six stimulus stories. Two are presented by written sentences, two are presented by spoken sentences, and two are presented by nonverbal pictures. After subjects comprehend each story, they answer 12 short-answer comprehension questions.

The two written and the two auditory stories were modified from four international children's stories (Arbuthnot, 1976). We modified the stories by shortening them and replacing all colloquial expressions and low frequency words with familiar terms. The two picture stories were modified from the illustrations in two juvenile books (Barrett, 1969; Calmenson, 1972). Each illustration has been photographed and reproduced as a 35 mm color slide.

The two written stories were presented first, followed by the two auditory stories, and then the two picture stories. Groups of 33 subjects were assembled in a classroom. The written stories were presented by an IBM-AT computer which was projected via a LCD viewer placed on top of a standard overhead transparency projector. The written stories were projected onto a standard-sized projection screen located at the front of the classroom. The written stories were presented line-by-line, one paragraph per screen. The two auditory stories were previously recorded by a male speaker at a natural speaking rate and were played to subjects over speakers via a tape recorder and amplifier. The two picture stories were projected by a Kodak slide projector, yoked to a computer. The slides were projected onto a standard-size projection screen located at the front of the classroom.

The two written stories are each 636 and 585 words long, and both were presented at a rate of 185 words per minute; the two auditory stories are each 958 and 901 words long and were presented at a rate of 215 words per minute; and the two picture stories are each 31 and 32 pictures long and were presented at a rate of one slide per 7.75 seconds, including the time required by the slide projector to change slides. Each story, therefore, lasted between 3 and 4.5 minutes.

Each story was followed by 12 short-answer questions. Some of the questions measured explicit information (e.g., "What was Ike's last name?"), whereas others measured implicit information (e.g., "Why did the store attendant get so frustrated with Hiram?"). Subjects were allowed 20 seconds to write their answers to each question.

We scored each question on a 3-point scale according to the scoring criteria presented in Gernsbacher and Varner (1988). In our earlier work, we found that the scoring criteria led to highly reliable data. For instance, in Gernsbacher et al. (1990), 270 subjects' scores were assigned by twelve judges. Each subject was scored by at least two judges. Although the two judges who scored the same subject were unaware of each other's scores, their resulting scores agreed highly: The average correlation between pairs of judges was .993, and all pairs correlated .986 and above. For the rare disagreements, the average of the two judges' scores was assigned. Actually, only 240 of the 270 subjects were scored by two judges; the remaining 30 randomly selected subjects were scored by all 12 judges. Cronbach's alpha for this common set of 30 subjects' was .987, also demonstrating high inter-judge agreement.

APPENDIX 2

SCHOLARLY WRITING COMPLETED DURING THE FIRST YEAR OF SUPPORT:

Book

GERNSBACHER, M.A. (1990). *Language comprehension as structure building*. Hillsdale, NJ: Erlbaum.

Published Journal Articles

GERNSBACHER, M.A., HARGREAVES, D., & BEEMAN, M. (1989). Building and accessing clausal representations: The advantage of first mention versus the advantage of clause recency. *Journal of Memory and Language*, **28**, 735-755.

GERNSBACHER, M.A., VARNER, K.R., & FAUST, M. (1990). Investigating differences in general comprehension skill. *Journal of Experimental Psychology: Learning, Memory & Cognition*, **16**, 430-445.

In Press Journal Articles and Chapters

GERNSBACHER, M.A. (1990). Comprehending conceptual anaphora. *Language and Cognitive Processes*, in press.

GERNSBACHER, M.A., & HARGREAVES, D. (1990). The privilege of initial mention: A structure building account. *Typological studies in language*, in press.

HARGREAVES, D., & GERNSBACHER, M.A. (1990). Review of S.N. Sridhar's, "Cognition and Sentence Production." *American Journal of Psychology*, in press.

GERNSBACHER, M.A. (in press). Cognitive processes and mechanisms in language comprehension: The structure building framework. In G.H. Bower (Ed.), *The psychology of learning and motivation*. New York: Academic Press.

GERNSBACHER, M.A., & FAUST, M. (in press). Fine tuning the activation of lexical representations during comprehension. In G.B. Simpson (Ed.), *Comprehending word and sentence*. Amsterdam: North Holland.

Journal Articles Submitted for Review

GERNSBACHER, M.A, & JESCHENIAK, J.D. Cataphoric devices in spoken discourse. (submitted to *Cognition)*.

GERNSBACHER, M.A, & FAUST, M.E. The mechanism of suppression: A component of general comprehension skill. (submitted to *Journal of Experimental Psychology: Learning, Memory, and Cognition)*.

APPENDIX 3

PERSONNEL SUPPPORTED DURING THE FIRST YEAR OF SUPPORT:

Rachel R.W. Robertson,
BS, Psychology, Director of the Language Comprehension Lab
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MS, Psychology, Graduate Student Research Assistant
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Undergraduate Student Research Assistants:
Kevin Kono
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Suzanne Shroyer
Beth Travis