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Elaboration during text comprehension.

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ELABORATION DURING TEXT COMPREHENSION

A Dissertation Presented

by

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Awarded to Jerome L. Myers

This dissertation is dedicated with much love to

my parents and sister

and to the memory of

my grandparents

for their years of faith and encouragement

and also for teaching me to cherish education

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ABSTRACT

Elaboration During Text Comprehension

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Many cognitive scientists assume that elaborations are generated during the processing of connected discourse and are stored with explicitly asserted information to form an integrated text representation. An important aspect of this hypothesis is that the generation and storage of elaborations is seen as occurring during the ongoing comprehension process. These assumptions are theoretically useful for the study of human memory because they provide a framework for interpreting several notable memory phenomena. The research documented in this dissertation was designed to evaluate the elaborative processing assumptions. Four priming experiments were conducted to study a specific type of elaboration, the inference.

Two different priming paradigms were employed. In Experiments 1 and 2, subjects read simple stories consisting of two or three sentences. Comprehension of each story required the generation of a bridging inference between the last two sentences. After reading each

each story, subjects were required to perform word recognition decisions which allowed an assessment of the activation level of concepts in memory. The results of these experiments indicated that concepts needed for inclusion in inferences were activated during the reading of the stories. The data did not, however, support the assumption that inferences are integrated during comprehension.

Experiments 3 and 4 employed a different style of story and a different task--word naming. Results from these experiments replicated the finding of inferred concept activation during reading, but they, too, failed to support the assumption of inference integration.

Discussion of these findings includes methodological considerations as well as a presentation of some alternative conceptualizations of the inference process. These alternatives may be characterized by the suggestion that the storage of inferences is either delayed or neglected altogether. Also, it is argued that readers' intentions and motivations play important roles in the inference process.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Although the information processing/computer analogy has provided researchers with a fruitful approach to the study of human cognitive abilities, there is at least one way in which it is misleading. In a computer system, memory is primarily a passive structure; data simply reside there until a user or user-invoked program accesses them. When access occurs, the user obtains only the data asked for and nothing more. In contrast, the human memory system is a dynamic structure. It supports all of our cognitive processes by providing specific input (either automatically or consciously) to cognitive operations ranging from perception to problem solving. People who study "context effects" on human information processing are usually referring to the impact of some form of memory on current processing.

This dissertation is also concerned in a general way with memory and its effects on information processing. The focus of the work presented here is on the impact of memory in the form of general world knowledge, or semantic memory, on the processing of connected discourse. The importance of this type of memory for discourse comprehension has been made explicit in the prevailing view of language processing. In this view, writers and speakers include in their communications only as much information as is necessary to provide a message framework; the comprehender can be relied on to use his or her knowledge base to embellish or fill in the gaps in the message (e.g., see Schank, 1976, or Haviland & Clark, 1974). For example, during the Vietnam War era, many a stunned eighteen year-old male was asked what was in the letter he had just received; if he replied, "Greetings from the President of the United States," usually nothing more needed to be said. Of course, miscommunications occur if a person assumes that certain information is in a comprehender's knowledge base when it is not. Thus, the example above fails if you are not familiar with the salutation from the United States Selective Service draft letter.

Cognitive psychologists refer to the process of embellishing discourse as elaboration. In the next section of this chapter, I will present an elaborative processing view of comprehension along with the theoretical motivation for such a view.

Elaboration and Text Processing

Elaborations Provide Interconnections in Memory. As noted above, the concept of elaboration provides a useful way of describing the efficiency believed to be inherent in communication acts. The interest here, however, is on considering its theoretical implications for text memory. It is commonly believed that comprehenders routinely use world knowledge to expand on the information they receive. The position that emerges from the literature is that elaborations are generated during comprehension, and they serve to unify and enrich the representation of the material that has been processed (Anderson, 1976; Anderson & Reder, 1979; Anderson & Ortony, 1975; Kintsch, 1974; Miller, 1981; Reder, (Note 1); Schank, 1976; Smith, 1981; Thorndyke, 1976). Smith (1981) presents the modal position on this point. Readers are confronted with sets of facts embedded in text. A particular set of facts can be viewed as forming an input network of propositions. Elaborations are additional facts which are added to the input network during comprehension via world knowledge. The structure that results is referred to as an "elaborated network," and it represents the combination of information from two sources--the input network, and the comprehender's knowledge base.

According to Smith, the construction of the elaborated network is what is at the heart of the comprehension process. Elaborations increase the number of interconnections between facts that are input. By adding interconnections to the network, elaboration makes for a more comprehensible and a more memorable input by virtue of the multiple retrieval routes available to any one fact. Miller (1981) has incorporated just this position in a computer simulation of sentence processing and memory.

Elaboration and Integration. Elaborative processing has come to be seen as the theoretical mechanism underlying the concept of integration. Chiesi, Spilich, and Voss (1979) and Spilich, Vesonder, Chiesi, and Voss (1979) have found that people who have extensive knowledge of a topic are better at acquiring (integrating) and using new information from within the topic domain than people with little knowledge. The explanation given for this result is that a high knowledge individual is better able to elaborate and interconnect the new material. The richer knowledge base of such an individual can support these activities to a greater extent.

There are a number of other studies that point to the importance of elaboration as an integrative process during comprehension. The basic result of these experiments is that a title, theme, or picture that disambiguates hard to comprehend passages will improve recall performance if given prior to reading the text. Such aids do not improve recall when provided after reading (Bransford & Johnson, 1972, 1973; Dooling & Lachman, 1971; Dooling & Mullet, 1973). The explanation given for this effect is that the title or theme allows the comprehender to use world knowledge to elaborate the input, and an elaborated input is a more memorable input. Apparently, with these ambiguous materials, elaboration can not occur retroactively since the themes did not improve recall when given after passages were read.

Elaboration has also been used as an explanatory mechanism in resolving the "Paradox of Interference" (Moeser, 1979; Myers, O'Brien, Balota, & Toyofuku, Note 2; Smith, 1981; Smith, Adams, & Schorr, 1978). The paradox arises from consideration of the well established finding that as the number of facts one is asked to learn about a topic increases, the ability to retrieve any one of them decreases (Anderson & Bower, 1973; Anderson, 1974; Anderson, 1976; Reder & Anderson, 1980a). This so-called "fan effect," if taken to its extreme, seems to preclude the possibility of expertise in any domain. The resolution of the paradox starts with the contention that experiments that have demonstrated fan effects have employed materials and procedures that made it difficult to form a coherent structure from the input facts. When the additional facts to be learned about a topic are easily integrated with the existing facts, fan effects tend to disappear (Myers et al., Note 2; Smith et al, 1978).

Elaboration is the key concept in understanding this resolution of the paradox. Elaborations are additional propositions, propositions that stem from our world knowledge. These are added to the memory representation and are connected with the explicitly presented material. The interconnections in the network provide more retrieval routes to each fact represented, and increasing the number of retrieval routes speeds retrieval. Thus, the degraded memory performance incurred by adding facts to a network (increasing propositional fan), is compensated for by the facilitating effect of the additional retrieval routes provided by the elaborations.

Two recent studies corroborate this position by showing that when elaborations are explicitly provided, memory performance is enhanced. Black and Bower (1979) added filler actions to simple stories that provided explicit elaborations of target actions. Subjects who studied the stories with the additional material recalled more of the target actions than did subjects who did not have additional material. In a study of probability learning, Myers, Hansen, Robson, and McCann (1983) found that subjects who studied an elaborated text solved more story problems than subjects who study less elaborate texts (story problems were word problems whose solution depended on the integration of the facts presented in the text).

One other recent study stands in apparent contradiction to those just cited. Reder and Anderson (1980b) investigated recognition accuracy for the main points of a passage when those points were either embedded in their text or extracted in the form of an unelaborated summary. Whether tested immediately or with delays of up to one year, the main points presented in summary form were remembered better. Reder and Anderson themselves suggest, however, that this unexpected finding may be due to the use of recognition accuracy as a dependent measure; this measure may not be sensitive to the benefits of the elaborated network structure. Furthermore, the materials used in the experiments were taken from college texts, and seem to have been rather dry. Subjects may simply have lacked the motivation to construct an integrated network from the texts.

Inferential Processing: A Theoretical Framework

Inference as a Special Case of Elaboration. Thus far, I have been discussing elaborative processing as an aid to comprehension, something that can enrich the understanding of discourse. It is a difficult subject for study, however. As Anderson and Reder (1979) have pointed out, elaboration is often an idiosyncratic process. The number and type of elaborations that are generated for any given text are probably affected by the motivation and intention of the comprehender. In view of this problem, the approach I have taken in attempting a study of elaboration is to write experimental materials that manipulate the process--materials that direct the comprehender along certain pre-defined elaborative paths. The way to do this is suggested by the fact that comprehenders can often fill in information when they encounter gaps in text. In fact, there are certain situations where this gap-filling process is essential for comprehension to be possible. Consider this pair of sentences used in an experiment by Haviland and Clark (1974):

We checked the picnic supplies.

The beer was warm.

Most people would not find it difficult to understand the connection between these sentences, in spite of the fact that on the surface they are not very coherent. Using Haviland and Clark's terminology, we construct a "bridging inference" in order to comprehend the sentence pair as a unit. This is a conceptual structure which links the information expressed by the first sentence with the new information given in the second. The bridging inference which is likely to be constructed from the sentences above would be something like "The picnic supplies contained some beer."

Haviland and Clark (1974) attempted to validate their concept of bridging inference. They reasoned that since the inference process makes additional demands on the comprehender, people would need more time to understand sentences which require that bridging structures be built to provide connections with previous sentences. This prediction was supported by their experiments. The sentence pair above requires inferential processing; the following pair was a control pair not requiring inferential processing:

We got some beer out of the trunk.

The beer was warm.

Compared with the control pair, subjects took almost 200 milliseconds (msec) longer to comprehend the second sentence of the inference-inducing pair. A similar result has been reported by Garnham (1981).

Types of Inference. The bridging inference can be thought of as a "necessary" elaboration. It is the tool through which we can examine the elaboration process and its role in memory representation more exactly. Before continuing with a review of the relevant literature, it is worth considering the idea of necessity in inference.

Harris and Monaco (1978) make the distinction between two basic types of inference: logical and pragmatic. A logical inference represents information that is necessarily implied by the text. For example, "Randy forced Ed to clean the fish tank" leads to the logical inference that Ed cleaned the fish tank. In contrast, a pragmatic inference represents information that is probably, but not necessarily, true given the text. Thus, "Randy asked Ed to clean the fish tank" only pragmatically implies that Ed did so.

To ascertain whether an inference is logical or whether it is pragmatic is easy. The test procedure given by Harris and Monaco consists of conjoining the implication-making sentence with the negation of its implication. If the resulting sentence does not make sense, the inference is logically implied; if it does make sense, the inference is only pragmatically implied. The sentence "Randy forced Ed to clean the fish tank, but Ed didn't do it" does not make sense; on the other hand, "Randy asked Ed to clean the fish tank, but Ed didn't do it" is sensible.

There is another type of necessity when considering inference during comprehension of connected discourse. This is the necessity exemplified by the Haviland and Clark (1974) sentence pairs presented earlier. At certain points in a text, inferences are necessary to provide connections between the current sentence and one encountered earlier. These inferences are necessary for the maintenance of coherence, but do not have to be necessary in the logical sense. Singer and Ferreira (in press) refer to these as "backward inferences," and contrast them with "forward inferences" which may be logical or pragmatic, but do not contribute to maintenance of text coherence.

One type of forward pragmatic inference, the instrument inference, has been the object of a number of studies (Corbett & Dosher, 1978; Dosher & Corbett, 1982; McKoon & Ratcliff, 1981; Paris &

Lindauer, 1976; Singer, 1979). With this type of implication, people make inferences about agents given information about certain actions. Inferring that a maid used a broom when informed only that she swept a floor is an example of instrumental inference. We will examine the content of this instrumental inference literature shortly. My main point at this time is that these inferences are not logically necessary in the Harris and Monaco (1978) sense, nor are they necessary when considering text coherence.

Because of the idiosyncracies involved in elaboration, the safest type of inference to study is the backward inference. By manipulating text characteristics, an experimenter can control the location and content of these with more reliability than could be expected with forward inferences. The key to controlling the backward inference lies in understanding the concept of text coherence. Both Thorndyke (1976) and Kintsch and van Dijk (1978) have proposed models of text processing which are based on this concept. In the next section, I will briefly review those models, emphasizing the role and character of inferential processing.

Models of Text Processing and Inference. Thorndyke (1976) has proposed a very general frame-based model for text comprehension. He claims that comprehension is governed by an overriding frame or situational context. The frame's purpose is to aid the comprehension process by facilitating the maintenance of text coherence and continuity. It does this by providing a mechanism which simultaneously stores new material and generates expectations based on that material. When a new text idea is comprehended, a set of forward inferences (elaborations) consistent with it is generated and stored in the frame along with the current text idea. The frame then provides expectations for the next input. If that input does not match any expectations, then Thorndyke claims that backward inferences are generated to establish a bridge (Haviland & Clark, 1974) from the input to a different frame. This new frame is then instantiated, and it is used to store the new input along with the backward inferences that connect it to the previous frame.

Kintsch and van Dijk provide much more detail on the basics of text processing. In particular, they address the concept of text coherence in a much more specific way. They do not describe the processes involved in accepting physical input; they start, instead, with semantic input in the form of propositions derived from the discourse. These propositions form the basis of two knowledge structures. First, the microstructure, or text base, is a network of propositions constructed from the text. Second, the macrostructure, or gist of the passage, is constructed concurrently with the microstructure from generalizations of micropropositions.

The theory is most clearly specified at the level of the microstructure. What Kintsch and van Dijk have done is to make the maintenance of semantic coherence a necessary condition in the construction of the text base. The mechanism for accomplishing this is the criterion of referential coherence, realized in the form of propositional overlap; two propositions are referentially coherent if they have at least one argument in common.

The process by which the text base is formed starts with a chunk of several propositions abstracted from the text. These are stored in a working memory and then linked to each other via shared arguments. A small number of these propositions are placed in a special buffer and kept active; selection of the active propositions is accomplished by the use of a "leading-edge" strategy which emphasizes recency and importance. (An "important" proposition is one that is connected to a large number of other propositions.) This strategy keeps active those propositions that are most likely to be related to the next chunk of propositions that are encountered; thus, the buffer serves to facilitate the construction of the microstructure by increasing the likelihood of coherence from chunk to chunk.

The processes described so far have been hypothesized to aid in the construction of a coherent text base, but obviously there will be cycles when the propositions in a chunk will not overlap with the propositions in the buffer or with each other (as is often the case when encountering a new paragraph or chapter). In these cases, Kintsch and van Dijk claim that the text base constructed to that point may be searched for a proposition that shares an argument with any of those in the current chunk. If one can be found, it is reinstated in the buffer to maintain coherence. If one cannot be found, the comprehender's world knowledge must be accessed so that a bridging inference (Haviland & Clark, 1974) can be constructed to connect one or more of the propositions in the chunk with previously processed propositions in the text base. The proposition or propositions that make up the bridging structure are then themselves added to the text base. A straightforward implication of the inference process as stated here is that it uses limited-capacity resources and should increase the time needed for comprehension of a sentence. The model's position on this point was obviously informed by Haviland and Clark's (1974) findings cited earlier.

While Kintsch and van Dijk's model places the inference process in the larger context of text processing, they do not speculate on its specifics. Consistent with Kintsch and van Dijk's position, however, is a slightly more detailed model of the inference process proposed by McKoon and Ratcliff (1980b) which consists of three stages: access, activation, and integration. During the first stage, information that is to be inferred must be accessed in memory. In the second, that information is activated, or brought into a working memory buffer. (McKoon and Ratcliff are not clear on the distinction between these first two stages; I am not sure that the distinction is even necessary.) Finally, the activated information is connected to the information in the text that caused it to be activated. The result of this process is a memory structure which consists of asserted text propositions, inferred propositions, and connections between them.

This general model of text and inference processing has come into wide acceptance. It makes two assumptions that are worth considering. First, it is assumed that inferences that are made to maintain text coherence occur in an on-line fashion; that is, they occur during the encoding of the text. Second, the inferred information is then connected with the asserted text, forming an integrated representation of the text in memory. In the next section, I will review experiments that address these assumptions.

Inferential Processing: A Review of Empirical Work

There is an abundant literature on inferential processing, the bulk of which claims to be consistent with the two assumptions stated above. Although we are interested here in experiments that address the generation of backward inferences, a number of studies have also been done on forward inference. These will be considered in this review also; one implication of this work is if evidence can be found that forward inferences are routinely generated and stored during comprehension, backward inferences must be also.

The experiments that have been reported represent a number of different paradigms. As will be argued later in this section, the choice of experimental paradigm is an important consideration for the study of inference. Thus, the articles that will be discussed here will be grouped by paradigm. My aim is to present the papers that are representative of their paradigms.

Recall/Recognition Memory. Thorndyke's (1976) model of the inference process claims that backward inferences are generated when necessary to maintain text coherence and continuity. These inferences are then stored in a newly-instantiated frame with the input that occasioned them. To test this claim, Thorndyke (1976) obtained false alarm rates for sentences which represented inferences that were likely to have been drawn. Embedded in each of the passages was a sentence (the continuation) whose comprehension sometimes depended on an inferential bridge back to an earlier sentence (the target). An example of the different types of critical sentences is given below:

Target: The hamburger chain owner was afraid his love for french fries would ruin his marriage.

Inference Continuation:

The hamburger chain owner decided to join weight-watchers in order to save his marriage.

Neutral Continuation:

The hamburger chain owner decided to see a marriage counselor in order to save his marriage.

Thorndyke wrote a set of potential inferences which would be either appropriate, neutral, or inappropriate given the continuation sentences in the stories. Examples based on the target and continuation sentences given above are:

Appropriate: The hamburger chain owner was very fat.

Neutral: The hamburger chain owner got his french fries for free.

Inappropriate: The hamburger chain owner's wife didn't like french fries.

A sample of subjects was asked to read each passage and then rate it for comprehensibility, imagery, and meaningfulness. After all of the stories had been read and rated, a surprise recognition test was given on sentences from the passages. When the neutral continuation was present in the story, false alarm rates were equally low (roughly equal to 25 percent) for the three different types of inference. When the inference-inducing continuation was present, however, false alarm rates varied from almost zero for inappropriate inferences to 58 percent for appropriate ones; thus, in the case of the inference-inducing continuation, subjects claimed that they saw sentences in the stories that they could have only inferred. It is interesting to note that the false alarm rate for neutral inferences, although significantly lower than for appropriate inferences, is still quite high--40 percent. From these results, Thorndyke concluded that both forward and backward inferences are generated and stored during text comprehension.

I have described Thorndyke's study in some detail because it is predicated on the model discussed above, and also because it is an attempt to study the backward inference. Some other studies are investigations of forward, or non-necessary inferences. Masson (1979) investigated the recall of sentences like "The container held the apples" as a function of whether they were cued at the time of recall. The cues were words like "basket" which were based on inferable information. Masson found that presenting the cue at the time of recall did not improve memory performance unless the same cue was present at encoding. Thus, subjects did not normally generate and include the inferable words in the sentence representation. In a different study, Masson (1979) devised an orienting task in order to establish an inferential context for sentence encoding. Subjects were given a pair of words for each sentence presented to them; they were asked to indicate which word was more related to the overall meaning of the sentence. For the apple container sentence, the words were "carry" and "harvest." Masson reasoned that such a task would foster the inferential processing he was looking for, and would make the inferred word cues effective at recall without their presence at encoding. He did, in fact, find that the word cues now improved sentence recall; his conclusion was that under the appropriate conditions, pragmatic inferences are made at encoding, and that explicit and inferred information is stored in an integrated memory representation.

Although Thorndyke (1976) and Masson (1979) claimed that their results support the notion of on-line generation and storage of inferences, there are serious criticisms that could be made of both studies. In Thorndyke's study, it is not clear whether the inferences are being generated during the encoding of the text, during the rating of the text for comprehensibility, imagery, and meaningfulness, or at the time of sentence recognition. Masson's experiment worked only because subjects performed the word relatedness task after encoding each sentence. This is an artificial situation contrived to induce inferential processing; conditions are too far removed from the standard reading situation to have any relevance for a model of inferential/elaborative text processing.

Corbett and Dosher (1978) have reported a series of experiments on instrument inference. Their work does not support the conclusion that this obvious sort of elaboration is generated and stored during encoding. They were able to replicate a Paris and Lindauer (1976) finding that highly likely instruments (e.g., scissors) are good recall cues for sentences that imply them (e.g., The athlete cut out an article for his friend). Contrary to what Paris and Lindauer suggested, however, Corbett and Dosher's study shows that this does not mean that the implied instrument must have been inferred and added to the sentence at encoding. They found that the highly likely instruments were also good recall cues when unlikely instruments (e.g., razorblade) were explicitly mentioned as instruments. Corbett and Dosher concluded that inferences not needed for comprehension are not generated during encoding, even though they may represent obvious implications of the asserted text.

Garnham (1982) takes it for granted that backward inferences are made during encoding. His question, like Corbett and Dosher's (1978), was whether forward inferences are also generated on line. He used passages that contained explicit and implicit references to instruments and conducted tests of both recognition and recall memory. His data did not discriminate between the on-line hypothesis and a deferred inference hypothesis which claims that forward inferences are made only when needed for answering specific questions. Garnham's data are consistent with an intermediate position, the omissions hypothesis, and he suggests that it is worth considering for the case of instrumental inference. This model holds that highly probable instruments are not stored in memory since they can be easily inferred at a later time through the use of world knowledge. When an improbable instrument is encountered in text, however, it must be stored since it cannot be reconstructed later. When no instrument is mentioned in a sentence, nothing is encoded in memory; the subject's memory performance will be the same as when highly likely instruments are explicitly mentioned.

To summarize the work presented above, the evidence that emerges from the recall and recognition memory paradigms does not provide direct support for the on-line generation and storage hypothesis for coherence-maintaining, or backward, inference. Evidence concerning the generation of forward inferences is equivocal, and it can not provide indirect support for the hypothesis.

Reading Time. Reading time for sentences has been examined in studies of both forward and backward inference. Forward inference was investigated by Singer (1979), who constructed sentence pairs similar to those used by Haviland and Clark (1974). Subjects read a first sentence which either implied or explicitly mentioned an instrument for some action. Sample first sentences are:

Direct Mention: The boy cleared the snow with a shovel.

Inference:	The boy cleared the snow from the stairs.
Control:	The boy hated working with a shovel.

Next, the subjects were asked to read a second sentence which mentioned the instrument and indicate when they had comprehended it. For the set of first sentences given above, the second sentence was "The shovel was heavy." Singer reasoned that if instrument inferences are not generated during encoding, the lack of coherence between the inference sentence and the second sentence should increase second sentence comprehension time relative to the direct mention condition. On the other hand, if subjects generate instrument inferences during the encoding of the first sentence, the concept "SHOVEL" will be included in the representation of the inference sentence. There will be no break in coherence between the inference and second sentences, and therefore the comprehension times will not differ for the two conditions. (Note that this logic is based on the assumption of on-line backward inferencing.) The results of two experiments of this type indicate that instrument inferences are not drawn during encoding; comprehension time increased by more than 100 msec when inference sentences preceded second sentences. This difference is not attributable to the mere repetition of the word "shovel" in the direct inference case; this is because the inference condition did not differ from a control condition which required a different sort of inference (the shovel mentioned in the control sentence is the same as that mentioned in the second sentence) but repeated the word "shovel."

Although Singer's (1979) experiments do not suggest the existence of an on-line forward inference process, they do replicate the results of Haviland and Clark (1974) and thus provide indirect support for a backward inference process. Haviland and Clark's (1974) reading time study of backward inference has been described in detail earlier. Garnham (1981) conducted a similar study, and consistent with the Haviland and Clark results, he found that subjects took longer to comprehend sentences which added new and non-coherent information to a text representation.

These reading/comprehension time studies indicate that processing load increases when a reader needs to make a backward inference. Unfortunately, as McKoon and Ratcliff (1980b) have argued, deciding which processes are responsible for the increase in load is problematic. There is no independent evidence that subjects are, in fact, engaged in inferential processing.

Sentence Verification. Keenan and Kintsch (reported in Kintsch, 1974, Chapter 8) asked subjects to read paragraphs that provided explicit details or implied details. After reading, the participants performed a sentence verification task; they had to decide whether test sentences were true based on either explicit or implicit information expressed by the paragraph. With immediate testing, reaction time (RT) to true sentences was faster when they had been explicitly presented than when they had been only implied. After a 20-minute delay, however, subjects were equally fast to verify either explicit or implicit information. Kintsch's interpretation is that there is no difference in our ability to retrieve explicit or implicit information except at short delays between learning and test. In this case, memory for surface features of explicit information is still available and will speed verification. Based on the equivalence of long-term memory performance for explicit and implicit propositions, Kintsch argued that implied propositions must be generated and stored during encoding; they join with the explicit material to form an integrated memory representation.

Reder (Note 1; 1979) has reported a similar result. Subjects made plausibility judgments faster for explicit information at immediate test. There was no difference, however, for judgements about explicit or implicit information at either a short (several minutes) or long (2 days) delay.

Of these two studies, Keenan and Kintsch's data is more generalizable to the normal reading situation. Reder's experiments were implemented with a question-asking procedure designed to force certain elaborations while the subjects were reading the passages. This is something that is not normally part of the comprehension process. Keenan and Kintsch's data are problematic as well, unfortunately. The finding of no difference in the time to verify explicit or implicit information is crucial to the on-line hypothesis. But it is quite possible that the inferential processing that Keenan and Kintsch claim is occurring at encoding is actually occurring sometime during the 20-minute delay interval.

Singer and Ferreira (in press) have conducted a verification experiment of backward inference that is not subject to this criticism; their test sentences always came immediately after comprehension. Subjects read stories which contained sentences like "He [a spy] quickly threw his report in the fire." This sentence allows the forward inference that the report burned. If the sentence was followed by "The ashes floated up the chimney," however, the inference is now backward and necessary for coherence. It was found that time to respond to the question "Did Bob [the spy] burn the report?" was 218 msec faster when the backward inference-inducing sentence was included in the story.

Singer and Ferreira's conclusion was that backward inferences are drawn at encoding more reliably than forward inferences; they argue that the RT advantage for the backward inference condition reflects the storage and use of backward inferences. This seems to be an unwarranted interpretation, however. The problem is that there is no independent evidence that the RT difference between the two conditions reflects a difference in inference processing. This is a problem because each story in the the backward inference condition contained an additional sentence. The additional sentence included words semantically related to concepts in the test question (e.g., ashes and chimney). It could be the existence of this asserted information that speeds the answer latencies in the backward condition, not the existence of inferred information in the text representation. Specifically, the subjects could simply be doing "plausability checks"

(Reder, Note 1; 1979; Reder & Anderson, 1980a), and the inclusion of more information consistent with the what is being asserted in the question makes the affirmative decision more plausible.

Priming. Before discussing the work of McKoon and Ratcliff (1980b), some general comments about this paradigm are in order. Priming refers to a measurable effect that the processing of one event has on the processing of a subsequent event. The facilitative priming effect is presumed to reflect an increase in the accessibility of information in memory. Memory structures that have been primed are commonly said to be "activated," and activated information is information that has been used recently in some way (Collins & Loftus, 1975). Although the priming paradigm has been used extensively as a way of specifying the nature of semantic memory structure and processing, priming effects are not limited to this domain. They have been observed also in experiments which have required retrieval of information from more recently experienced, or episodic, materials as well (McKoon & Ratcliff, 1979; 1980a; Ratcliff & McKoon, 1978; Swinney, 1979). This has been a welcome finding for cognitive researchers because it means that the priming paradigm can be used as a tool to explore complex mental processes that occur during reading or listening. Because priming reflects which memory structures have been activated, and also because activation occurs in a matter of milliseconds (Ratcliff & McKoon, 1981), we can investigate comprehension processes in an on-line fashion. The priming paradigm enables us to trace the flow of activation through memory, allowing us to observe the isolated retrieval operations that take place during complex cognitive processing. In addition to obtaining information about activation processes, priming allows us to investigate the structure of memory. The degree to which one concept primes another is an indication of their degree of connection in memory.

McKoon and Ratcliff (1980b) took advantage of the priming paradigm to study a special case of inferential processing, anaphoric reference. Anaphoric reference refers to the connection made by a comprehender between two different references to the same object. McKoon and Ratcliff constructed four-sentence paragraphs which mentioned a critical word, the referent, in the first sentence (e.g., "A BURGLAR surveyed the garage set back from the street"), and then referred to it again in the fourth sentence by either the same name or by an anaphore ("The CRIMINAL slipped away from the streetlamp"). Immediately after reading the paragraph, the subjects were shown a word and asked to indicate whether or not it had appeared in any of the four sentences. When the fourth sentence contained an anaphore, the word recognition decision to critical words was made faster relative to a fourth sentence containing only a neutral word. (For this story, the neutral word was "cat.") Furthermore, when words which were in the same proposition as the referent (e.g., garage) were tested, word recognition RT was faster when the fourth sentence contained either the referent or its anaphore, compared to the neutral word. These results indicate that anaphores not only activate their referents, but also activate concepts connected to the referents in the text representation.

Given the evidence that anaphores activate their referents and related propositions, McKoon and Ratcliff next considered whether the proposition containing the referent was then connected in memory with the proposition containing the anaphore. In terms of the example materials given above, the question is whether the reader connects "surveying the garage" and "slipping away from the steetlamp" with the same referent, the burglar, regardless of whether the referent or anaphore is presented in the fourth sentence. Evidence for the connection of concepts in memory comes from the existence of priming between them. The experimental situation was changed to accommodate the new question. Subjects read two passages at a time and then were asked to make consecutive word recognition decisions on a list of 10 words. The list contained critical prime-target word pairings to test for priming between concepts. One such pair is BURGLAR-STREETLAMP which matches the referent mentioned in the first sentence with an object mentioned in the final sentence. If there is a connection between referent and anaphore propositions, RT to STREETLAMP following BURGLAR should be the same whether the final sentence mentions BURGLAR or CRIMINAL. In the first case, BURGLAR is explicitly connected to STREETLAMP since they are both mentioned in the final sentence. In the second case, the anaphoric reference process connects the first and final sentences which separately contain the two words. RT to STREETLAMP should be slower when the final sentence only mentions the neutral word since only the minimal connection of being in the same paragraph should exist between BURGLAR and STREETLAMP in this case. These predictions were all supported by the data.

McKoon and Ratcliff have thus provided support for their model of the inference process presented earlier. They have found evidence for two of the three component processes they postulate: activation and integration. What are the implications of these results on anaphoric reference for our understanding of backward inference? I believe that the implications are limited. There seems to be a large difference in the amount of cognitive effort expended in performing these two processes. Anaphoric reference involves only a backward search through a text base to find a likely referent; this is followed by the connection of propositions which contain the referent and anaphore and that are already in the text base. In contrast, backward inference involves a search of the comprehender's entire knowledge base in an attempt to build a bridging structure. This structure is essentially a new input to the text base and must be integrated with it. Although their results on anaphoric reference are at best suggestive for my topic, I have covered McKoon and Ratcliff's experiment in detail because it provides a relevant example of the logic of the priming paradigm applied to a question about discourse processing.

Other studies have been reported recently that used the priming paradigm to investigate instrument inference. McKoon and Ratcliff (1981) conducted a series of experiments modeled almost exactly after their anaphoric reference studies, and they report evidence for the activation and integration of inferred instruments.

Dosher and Corbett (1982) employed the Stroop task as a measure of inferred instrument concept activation. In the Stroop task, subjects must name the ink color in which letter strings are printed. If the string is a word, the automatic implicit word naming response interferes with the articulation of the word's color. The more activated a concept is, the more interference is observed in the task. Thus, the Stroop task is a "negative" priming paradigm. In four separate experiments, Dosher and Corbett found that the reading of sentences which implied the use of certain instruments did not interfere with Stroop performance on those instrument words; this indicates that the implied instruments had not been activated during sentence encoding. Interestingly enough, though, in their fifth experiment, Dosher and Corbett instructed subjects to consciously generate the most likely instrument prior to the Stroop trial. In this case, the data revealed activation for implied instrument concepts. Based on these results, their conclusion was that instrument inferences are not generated automatically during encoding; this position is consistent with that taken in their earlier cued recall paper (Corbett & Dosher, 1978).

As mentioned previously, evidence that forward inferences are generated and stored during encoding indirectly supports the assertion that backward inferences must be also. Even though, then, these last two articles deal with forward instead of backward inference, the discrepancy between McKoon and Ratcliff's (1981) and Dosher and

Corbett's (1982) conclusions requires attention. I will return to this problem in the General Discussion chapter to come.

One last priming study deserves a brief mention here. Newsome (Note 3) performed a study of pragmatic inference. For example, given the sentence "The karate champion hit the cinder block," a likely pragmatic inference is that the cinder block broke. Using the lexical decision task (deciding whether a letter string is a word), Newsome found that implied verbs (e.g., "broke" for the sentence above) were activated immediately after processing the sentence. Her overall situation was very unlike reading, however. Subjects were shown single sentences like the above for up to 15 seconds and were asked to rate them for the ease with which they could visualize the scene that was being conveyed. They next saw a context frame consisting of the original sentence minus the verb (i.e., "The karate champion ______ the cinder block.") for two seconds, and then finally saw the lexical decision stimulus. This sequence of events seems likely to have caused subjects to perform mental operations that are not normally a part of the reading process.

To summarize, the priming approach to the study of inference has much to recommend it. It has the ability to monitor cognitive operations on-line, and because of this it can provide specific information about the component sub-processes involved in complex behavior. These features allow it to avoid all of the problems manifested by the other paradigms presented in this section. It was the approach of choice for the work to be presented in the coming chapters.

The priming studies that have been reviewed here have not provided any evidence relating to the generation of backward inferences. They have instead addressed the problem of forward inference. Furthermore, the data are ambiguous, given the conflicting results of McKoon and Ratcliff (1981) and Dosher and Corbett (1982), or not relevant to the reading situation (Newsome, Note 3).

General Summary

Cognitive psychologists have appealed to the notion of elaborative processing in their accounts of certain phenomena dealing with learning, memory, and comprehension. It is commonly accepted that elaborations are generated during the encoding of information, and that they are stored with the explicitly asserted information to form an integrated representation in memory. The purpose of this dissertation is to evaluate this claim.

My approach to the problem is to study the backward inference process. Inference is simply a special case of elaboration; it is a process that is more constrained than elaboration, especially in the case of the backward inference. Existing studies of inference were reviewed and shown to be inadequate at providing data that bear on the elaborative processing hypothesis. The commonly used memory paradigms are open to the criticism that they can not discriminate whether inferencing occurs at encoding, at test, or some time between.

Reading time studies have indicated that processing load increases when inferences need to be drawn, but we can only guess that the cause of the load is the inferential process. Furthermore, these studies do not provide any information about the exact nature of the processes involved in inference. I have argued that the optimal approach for the study of inference is the priming paradigm. Experiments based on this methodology will avoid the problems cited previously.

In what follows, four priming experiments will be described. In general, they are concerned with the same two stages of inferential processing that McKoon and Ratcliff (1980b) were concerned with in their study of anaphoric reference. I am looking for evidence that concepts included in bridging structures are activated during encoding, and that this information is connected with explicitly presented concepts.

CHAPTER II

EXPERIMENT 1

The elaborative processing hypothesis claims that elaborations are generated during comprehension, and that they interconnect explicitly presented facts. This experiment was designed to directly investigate the hypothesis. As mentioned earlier, there is a problem with studying elaboration in that it is an idiosyncratic process. In view of this fact, the general approach taken here was the same as Reder's (1976; 1979); the situation was designed so as to be almost certain that subjects were generating particular elaborations. Reder accomplished this by requiring her subjects periodically to answer elaboration-inducing questions while reading stories. Rather than intrude on the reader's natural processing of a text, the specific approach used in the experiments reported here was to have subjects read materials that required inferential processing in order to be comprehensible. Consider this pair of sentences:

[1] The situation was uncomfortable at the baseball game.

[2] Jane was sorry she had forgotten her umbrella.

At the semantic level, these sentences are coherent if it is inferred that the uncomfortable situation mentioned in sentence [1] is rain. According to the elaborative processing view, an inferential process establishes the relationship between two sentences via elaborated concepts (e.g., "rain at the ball game"). Elaborations are stored along with the concepts which have been derived from the sentences to form a single interconnected representation.

The important point in the development above is this: Inferential/elaborative processing adds not only concepts to a text representation but also links from those elaborations to explicitly presented concepts. If this is true, those links should serve as pathways for the activation of explicitly presented concepts by elaborated ones, or vice versa. Thus, after a reader has constructed a text representation enriched with elaborations, any use of elaborated concepts by that reader should facilitate the subsequent use of explicitly presented concepts, provided the hypothesized links are in place. This is simply a restatement of the fundamental assertion of spreading activation models of memory processing (Anderson, 1976; Collins & Loftus, 1975).

The priming approach to the investigation of the elaborative processing hypothesis was operationalized as follows. Subjects were asked to read simple three-sentence stories. The stories were written such that the last two sentences were like sentences [1] and [2], i.e., incoherent at the surface level, but comprehensible if the appropriate inferential bridges were constructed. Immediately after reading a story, subjects performed a word recognition task in a paradigm similar to that used by McKoon and Ratcliff (1980b) and Ratcliff and McKoon (1981). Six words were presented one at a time; subjects indicated as quickly as possible whether or not each word had appeared in any of the three preceding sentences. Included in the series of six words was a critical prime-target pair. The prime was a word corresponding to a concept likely to have been elaborated in an attempt to establish coherence between the second and third sentences. The target was a word from the second sentence which was likely to be connected to the prime concept in a representation of the gist of the story. For example, the prime-target pair for sentences [1] and [2] was "RAIN - GAME." If inferential processing has established a link between elaborated and explicit concepts, making a decision about "RAIN" should activate the concept "GAME" in the story's representation, thus facilitating the decision to the target word "GAME" relative to a neutral prime. So, the idea behind this experiment is to prime the recognition decision about a word in the second sentence through the use of a concept that is likely to have been elaborated. To the extent that this is possible, the elaborative processing hypothesis receives support.

METHOD

Materials.

Development. The materials used in this study were developed as follows. First, sentences like [1] and [2] above were written such that when paired, they related simple stories or actions with the help of an obvious bridging inference. Next, an additional second sentence was written which changed not only the story but also the inference required for the comprehension of the sentence pair as a story. For example, with sentences [1] and [2], the likely inference is that Jane was uncomfortable because it was raining. Consider, however, sentence [1] paired with a different version of sentence [2]:

[2'] Jane was sorry she had forgotten her cushion.

A pairing of sentences [1] and [2'] suggests instead that Jane's seat was hard. Thus, each story existed in two different versions; the reason for this will be discussed below in the Experimental Design section. An important consideration which influenced the material development was the availability of a reasonable prime-target word pair for both versions of each story. The inference that a particular story evoked had to be obvious; there had to be a focal concept that was reliably accessed by the readers like "RAIN" or "SEAT." Furthermore, the first sentence had to contain a noun which would be connected to the focal concept of the inference in a representation of the gist of the story. The focal inference concept and the noun selected from the first sentence were used as prime-target pairs: "There was RAIN at the GAME," "There were hard SEATS at the GAME." Finally, an attempt was made to insure that any pre-existing semantic association between the prime and target words was minimal, at best. Twenty-five stories were written in two versions each such that they met all of the considerations mentioned above; prime-target pairs were designated as well.

Validation. To validate the experimenter's intuitions about the obviousness of the bridging inferences required to comprehend the stories, a normative study was conducted. Twenty-six students were recruited from an undergraduate psychology course to participate in an in-class session that took about twenty minutes. Two lists of the twenty-five two-sentence stories were constructed. The first list contained a random order of one version of each story. The second list presented the other version of each story in the same order. A randomly selected half of the class received the first list while the other half received the second. The students were told that they were going to read a set of sentence pairs, each of which described some sort of situation or event. They were instructed to read the sentences carefully and then write in their own words a one or two sentence description of what the story was about. They were warned that the sentences they read would not be connected in an explicit way, but that the relation between them would be obvious in most cases; it was stressed that the experimenter was not looking for creativity. An example story and description were provided. The students worked through the lists of stories one at a time and in order.

Subjects' story descriptions were examined and scored for the presence of two things which correspond roughly to liberal and conservative acceptability criteria: 1--The gist of the intended inference, and 2--The use of the intended prime word in the description of the story. For all but three of the stories, a clear majority of the subjects (eight or more out of thirteen) described the gist of the intended inference. One of those three stories was dropped; the others were modified to make them clearer. Examination of the story descriptions for the presence of the prime word indicated that the subjects tended to use the same words to describe their understanding of the story. In just three cases the prime word did not appear in the written descriptions. In these cases, however, the subjects consistently used a synonym of the designated primes; these synonyms were adopted instead of the original primes for use in the experiment. Including these replacements, for 35 of the 48 story versions, a majority of the subjects used the prime word in their story descriptions.

The product of the development and validation procedures was a set of 24 two-sentence stories existing in two different versions. Each story reliably evoked a specified bridging inference, and the prime-target pair selected for the story tapped this inference.

An additional sentence was written to be used as an introduction for both versions of each of the twenty-four stories. These sentences were fairly neutral and uninformative with respect to the inferences to be drawn. To provide an example, the sentence used to introduce the two versions of the ballpark story given above was:

[0] Jane was not enjoying the afternoon at the ballpark.

Appendix A gives a listing of both versions of each story along with their corresponding prime-target pairs.

Word List Construction. Construction of the six-word lists to accompany each story started with the placement of the prime-target word pair in either the second and third, the third and fourth, or the fourth and fifth word positions in the list. Eight stories each were chosen at random for assignment to one of these three position conditions. The nature of the filler words for the remainder of the list was determined by consideration of how many yes ("Yes, the word did appear in the story") and no ("No, the word did not appear in the story") decisions were desired. The prime never appeared in the story, whereas the target always did; thus, there was at least one "Yes" and one "No" response required in every list of six words. Ten stories were chosen at random to contain words requiring three of each kind of response (3Y-3N), five were selected to be 4Y-2N, five others were 2Y-4N, two were 5Y-1N, and the remaining two were 1Y-5N. Care was taken to insure that the filler words chosen to occupy word list positions occurring before the prime-target pair were not associated to either of the two critical words. The word lists for the two versions of the same story differed only with respect to which word functioned as the prime.

Story List Construction. Before describing the preparation of story lists for this experiment, we must first consider the baseline RT against which facilitation was measured. The choice of baseline here was influenced heavily by the consideration that despite precautions, the primes could be somewhat semantically associated to the targets. If unaccounted for, such a condition would not permit an unambiguous interpretation of a facilitation effect as evidence for inferential processing. The facilitation observed could be a result of the operation of inferential processing alone, semantic association alone, or both at the same time. This interpretive problem was avoided quite simply; the inferred concept prime from one version of a story was used as the neutral prime for the other version of the same story. Table 1 illustrates this design with the help of the ballpark story materials. If, following version 1, "RAIN" facilitates a decision about "GAME" because of a pre-existing semantic association, then that facilitation will occur to the same extent in the neutral prime condition for version 2; thus, facilitation due to semantic association is automatically subtracted out when we look at the difference between the two prime conditions. As a result, we are free to interpret any facilitation observed in this experiment as a product of inferential processing.[1]

The process of story list construction started with the preparation of two different lists of the twenty-four stories; Version 1 contained a randomly chosen version of each story, while Version 2 contained the other versions of the stories. Each version then provided the basis for two parallel forms. Form A contained a random assignment of the stories to either the inferred prime or neutral prime conditions (twelve stories in each). Form B reversed this prime condition assignment. To provide an example of the result of this process, Table 2 shows how the ballpark story and prime-target pairs

TABLE 1

PRIMING DESIGN FOR EXPERIMENTS 1 AND 2
AS ILLUSTRATED THROUGH THE BALLPARK STORY

[0] Jane was not enjoying the afternoon at the ballpark.

[1] The situation was uncomfortable at the baseball game.

Version 1:

[2] Jane was sorry she had forgotten her umbrella.

	Inferred Prime	Neutral Prime
Prime:	RAIN	SEAT
Target:	GAME	GAME

Version 2:

[2'] Jane was sorry she had forgotten her cushion.

	Inferred Prime	Neutral Prime
Prime:	SEAT	RAIN
Target:	GAME	GAME

differed for each of the four story lists. Finally, the stories were assigned to one of four blocks in a quasi-random fashion. In each block of six stories there were three stories from the inferred prime and three from the neutral prime conditions. The three stories within a prime condition represented target positions 1, 2, and 3.

Design. Considering Subject as a random factor, this experiment took the form of a two (Version 1 vs. Version 2) by two (Form A vs. Form B) by two (inferred prime vs. neutral prime) by three (word list position 1 vs. 2 vs. 3) by 24 (subjects) factorial design. Version and Form were between-subjects variables; type of prime and word list position were manipulated within subjects. This design was used to analyze separately the RT data from both the primes and the targets. Supplementary analyses were also conducted using Item as a random factor with Subject held fixed.

Procedure. Participants were assigned at random to one of the four version-by-form list conditions, and were tested individually in sessions that lasted approximately 30 minutes. Presentation of stories and word lists and measurement of RT was controlled by a PDP 8E microcomputer interfaced with a visual display screen. Subjects sat in front of the screen with their hands positioned on a response console. Response devices consisted of triggers activated by a subject's left index finger, right index finger, and right thumb.

The series of events for each trial (i.e., a story and the

TABLE 2

ASSIGNMENT OF BALLPARK STORY PRIME-TARGET PAIRS TO VERSION AND FORM CONDITIONS

Version 1

	Form A	Form B
Prime:	RAIN (inferred)	SEAT (neutral)
Target:	GAME	GAME

Version 2

	Form A	Form B
Prime:	SEAT (inferred)	RAIN (neutral)
Target:	GAME	GAME

corresponding word list) follows. Trials were preceded by the question "READY?" on the screen. Subjects initiated the trial by pressing the thumb switch; this cleared the screen and presented the first sentence of a story. When the sentence was understood, they pressed the thumb switch again, replacing the first sentence of the story with the second. They continued in this way, pressing the switch to indicate that they had read and understood what was currently on the screen. When they finished with the third sentence of a story, the thumb switch press cleared the screen; after a 500 msec delay, the word list presentation began. The first word on the list was presented in the center of the screen; subjects were told that if the word had appeared in the story they were to pull the response lever marked "Yes" on the response console with their right index fingers. Otherwise, they were told to use their left index fingers and pull the lever marked "No." Words remained on the screen until either the subject made a decision, or until five seconds elapsed. When a decision was made about a word, the screen was cleared and there was a 150 msec delay before presentation of the next word on the list in the same screen location. If, instead, there was no response within five seconds, the screen was cleared and a 150 msec beep occurred to alert the subject that the current word trial was over; after another 150 msec interval, the next word was presented. Following completion of the word list, subjects were presented with a comprehension question on the screen for two randomly selected stories from each block. As can be seen by examining the questions (which appear along with the stories in Appendix A), correct answers depended on proper comprehension of the story, so these questions provided a check to insure that subjects were reading and understanding the stories. An intercom linked the experimenter and subject rooms, so to answer a question, subjects merely vocalized their responses. The experimenter then recorded whether the answers were correct or not. Prior to the experiment, it was decided to discard data from any subject who made errors on more than two out of eight comprehension questions. Finally, to give the participants an indication of their performance, after completing each set of six words, the average RT and number of errors appeared briefly on the screen.

The subjects were instructed to read each story sentence at their own pace, and to press the thumb switch only when they understood it. Also, it was stressed that they should understand each set of three sentences as a story. For the word recognition task, they were told to respond as quickly and as accurately as possible. A copy of instructions given to subjects appears in Appendix C.

The subjects were given a six-trial practice block of materials that were similar to the critical set. To encourage reading for comprehension from the outset, a comprehension question followed each story in the practice set. Following the practice block, subjects worked through the four critical blocks with short breaks in between. Order of block presentation was random for each subject, as was the order of story presentation within a block.

Subjects. A total of twenty-six University of Massachusetts undergraduates took part in this experiment. They had been recruited from psychology courses and received experimental credit for their participation. Data from two subjects were discarded, one persons's because of an inordinately slow and error-filled performance, and another's because of failure to meet the comprehension question criterion of no more than two incorrect answers.

RESULTS AND DISCUSSION

Analysis Procedures. Separate analyses were conducted on the prime and target data. For each subject, mean reaction times were computed for the six Position by Type of Prime condition cells, averaging over a maximum of four items in each cell. These data were submitted to the fixed-effect ANOVAs described above in the section on design. Item analyses were also performed; these differ depending on whether considering the set of 48 primes, or the set of 24 targets. The only item analysis results that will be reported in the text will be from tests of variables having theoretical interest: Type of Prime, Position, and their interaction.

Additional analyses were conducted on the proportion of correct responses for each cell. Cell proportions were calculated for each subject; since many of these were equal to one, they were replaced with:

$$Y^*_{ij} = (kY_{ij} + 3/8)/(k + 3/4)$$

where Y^*_{ij} is the adjusted proportion, Y_{ij} is the original proportion, and k is the number of scores on which the proportion is based. These adjusted scores were then transformed by taking the arc sine of the square root (Myers, 1979). The transformed scores were then submitted to fixed-effect ANOVAs. Full results of all ANOVAs and post hoc tests are tabled in Appendix D.

Findings for Prime Words. If readers are generating inferences in an on-line fashion, then inferred concepts should be activated for some period of time following the inferential processing. Given that the prime words used in this experiment represent concepts that have been activated by inferential processing, RT for those inferred (activated) prime words should differ from that for neutral primes; specifically, mean RT for the inferred prime condition will be larger. The reasoning behind this prediction is based on the fact that the correct response to a prime word encountered in the word recognition list is "No." If, in fact, the concept underlying the inferred prime has been activated, making a negative response will be difficult since the existence of activation should set up a bias to respond "Yes."

Mean RT and error rates are shown in Table 3. Results from analyses of variance performed on prime trial RT are shown in Tables 8 and 9 of Appendix D. Considering the data for primes, the results indicate that inferred primes were activated during the course of

TABLE 3

MEAN REACTION TIMES (IN MSEC) AND PERCENTAGE ERRORS (IN PARENTHESES) AS A FUNCTION OF TYPE OF PRIME AND POSITION IN EXPERIMENT 1

Primes

	Type of Prime		
	Neutral	Inferred	Mean
Position 1	858 (1.04)	916 (10.42)	887 (5.73)
Position 2	930 (2.08)	986 (12.50)	958 (7.29)
Position 3	874 (4.17)	1094 (12.50)	984 (8.33)
Mean	887 (2.43)	999 (11.81)	943 (7.12)

Targets

	Type of Prime		
	Neutral	Inferred	Mean
Position 1	818 (6.25)	818 (2.08)	818 (4.17)
Position 2	920 (9.38)	989 (4.17)	955 (6.77)
Position 3	957 (7.29)	917 (7.29)	937 (7.29)
Mean	898 (7.64)	908 (4.51)	903 (6.08)

story comprehension, providing support for the claim that the subjects were engaging in on-line inferential processing. It took the subjects an average of 112 msec more to correctly reject inferred primes than neutral primes ($F[1,20] = 8.56$, $p < .01$ by subjects; $F[1,42] = 11.87$, $p < .01$ by items). There was also a slight tendency for RT to increase with word list position ($F[2,20] = 2.77$, $.05 < p < .10$ by subjects; $F < 1$ by items), but this effect is entirely due to changes in the inferred prime condition RT. As Table 3 shows, the inferred prime RT increases from 916 to 986 msec (70 msec) from positions 1 to 2, and from 986 to 1094 (108 msec) from positions 2 to 3, while the neutral prime RT does not change systematically. Bonferroni *t*-tests (see Appendix D, Table 10) indicated that the difference between inferred primes at Positions 1 and Position 3 was significant, and there were no significant differences between the neutral primes. This interaction of Position by Prime Condition is moderately reliable: $F[2,20] = 3.85$, $p < .05$ by subjects; $F[2,40] = 1.85$, $p >$ .10 by items. The interaction can be interpreted as evidence for a decrease in the ability of the comprehender to separate inferred material from explicitly presented material (Kintsch, 1974), especially when surface information has become degraded due to intervening material, or has decayed due to time. The interaction effect was more marked for Form A than for Form B, as indicated by a significant Position by Prime Condition by Form interaction ($F[2,40] = 7.28$, $p < .05$).

Despite the relatively small number of errors, the results of an analysis of error rates (see Appendix D, Table 11) corroborate the findings of the RT analysis. Subjects made more errors to inferred primes than to neutral primes ($\underline{F}[1,20] = 20.24$, $\underline{p} < .001$), indicating again the difficulty subjects experienced when they needed to discriminate inferred from explicit material. This main effect of Prime Condition was larger for Form A than for Form B, however; a test of the Prime Condition by Form interaction yielded $\underline{F}[1,20] = 6.06$, $\underline{p} < .05$, indicating again that, by chance, the strongest or best items were in Form A. In addition to these effects, the Position by Prime Condition by Form interaction was significant ($\underline{F}[2,40] = 5.49$, $\underline{p} < .01$). As expected, the transformed error rates for the neutral prime condition do not vary reliably across Position or Form. For the inferred prime condition, however, two of the six points vary from the expected pattern of increasing error rate with Position. Given the small number of observations supporting these error analyses, it could be the case that noise is obscuring a general Position by Prime Condition interaction.

To summarize the analysis of the prime data, there is ample evidence to indicate that concepts representing inferred primes are activated during the comprehension process. When asked to make a word recognition decision for inferred prime words, subjects were slower and less accurate as compared with neutral prime words. Furthermore, the later in the word list this decision was made, the worse their performance became. This result suggests that, in addition to being activated, inferred concepts are added to a text representation soon after they are generated; a reader quickly begins to lose the ability to differentiate inferred from explicitly-presented material.

It is possible, however, to consider an alternative to the explanations offered here for the prime trial data. It would claim that subjects were not generating inferences during comprehension but rather were either generating them at the time of test, or simply performing some sort of plausibility check at the time of test. This behavior would lead to the observed RT difference between neutral and inferred primes. As a model of performance in this task it seems unlikely on logical grounds, however, since 100% of the trials in this experiment require inferential processing. Even if subjects started the experiment by deferring the processing necessary to perform the word recognition task until the test, it would certainly be in the their interest to evolve a strategy of generating inferences on-line. Since they were reading at their own rates, they could easily have done this. A more direct argument against the alternative explanation comes from the data of Experiments 3 and 4 to be presented later which support the on-line inference generation position.

Findings for Target Words. Results from the statistical analyses performed on target word RT are shown in Tables 12, 13, and 14 of Appendix D. Reviewing the prediction for these items, it was expected that RT to targets preceded by inferred words would be faster as compared with targets preceded by neutral words. The results do not support this prediction. As shown in Table 3, mean RT was actually slower (898 msec vs. 908 msec), though not significantly so, to targets primed by inferred words ($\underline{F} < 1$ by subjects and items). There were moderately reliable differences between the means for Position ($\underline{F}[2,40] = 3.90$, $\underline{p} < .05$ by subjects; $\underline{F}[2,20] = 1.68$, $\underline{p} > .10$ by items). Bonferroni $\underline{t}$-tests indicated that subjects responded the fastest to targets in Position 1; mean RTs for Positions 2 and 3 were not significantly different.

The ANOVA performed on target error rates (Appendix D, Table 15) yielded two results; there was a significant Position by Version interaction, and a marginal Position by Version by Form interaction. These effects are of little theoretical interest and will not be discussed further.

To summarize the findings for target words, contrary to expectation, there was no evidence in either the RT or error rate data to indicate that inferred concepts can be used to prime word recognition decisions to explicitly-presented words.

General Summary. Having found surprisingly strong effects of Type of Prime on prime RTs, the failure of this experiment to demonstrate a priming effect was rather puzzling. In order to give the elaborative processing hypothesis as fair a test as possible, the first attempt to understand the negative result with target words was directed at methodology. In the next chapter, an experiment will be presented which used the same materials with a change in procedure.

CHAPTER III

EXPERIMENT 2

Consider the word recognition procedure used in Experiment 1. Subjects worked through a list of six words with a 150 msec interval between a response and the presentation of the next word. Words used as primes were never used in the stories, so the correct response to them was "No." As the data from the last experiment show, in the case of inferred primes this was a difficult decision to make. If the difficulty of this decision carried over in some way beyond the response, it could adversely affect RT to the target words that followed. The suggestion here is that the 150 msec interval may not have been long enough for the subjects to completely terminate processing on the difficult inferred-prime trials. It could be the case that target words were, in fact, primed by inferred words, but that the priming effect was masked by interference from the priming trial; the processing of target words that followed inferred words may have started later than that of target words that followed neutral words.

To check this possibility, Experiment 2 used the same materials with a different procedure. Instead of using trial-to-trial priming embedded in a list of words, in this experiment the prime word was presented as a single word cue that the subjects merely had to read. Following a variable stimulus onset asynchrony (SOA), subjects performed a word recognition decision on the target word. Since no decision is made to prime words, there should be no "cognitive processing carry over" to delay target word processing in the inferred prime condition. The prediction for this experiment is the same as before: RT to targets that are cued by inferred words should be faster than that for target words cued by neutral words.

METHOD

Materials. The 24 stories used in Experiment 1 were used as critical stimuli in this experiment with one exception; one of them was replaced (noted in Appendix A). In addition, 48 more stories similar in structure to the critical ones were written to be used as filler. Prime-target word pairs were chosen for these such that 12 had old targets and 36 had new targets; thus, over the whole stimulus set of 72 stories, old and new targets were equally probable. Since only one recognition stimulus was needed for each story, there was no need to include the leading vague sentence that had served as a source of recognition stimuli for the six-word lists in the previous experiment. Only the critical sentence pair, the second and third sentence of each story, was used for this experiment. The critical stories were assigned to the same List and Form conditions reported in Experiment 1.

Design. As for Experiment 1, the between-subjects variables for this experiment were Version and Form. SOA was manipulated within each subject at two levels (250 msec vs. 750 msec). Thus, considering the Subject factor random, and averaging over items, the design is a two (Version) by two (Form) by two (Type of Prime) by two (SOA) mixed factorial ANOVA. Additional analyses were carried out with the Item factor random and with Subject held fixed.

Procedure. Participants were assigned at random to one of the four version-by-form conditions, and were tested individually in sessions that lasted approximately 30 minutes. The display equipment and response console were the same as that used in the previous experiment.

The series of events for each trial follows. The stories were presented to and read by the subjects in the same way as Experiment 1; sentences were read individually at each subject's own pace. A 500 msec delay followed the subjects' indication that the second (and last) story sentence had been read. A visual cue, a set of three X's, was then displayed for 500 msec in the center of the screen to capture the subjects' attention. Following this, the prime word replaced the cue and stayed on the screen for either 250 or 750 msec. Subjects were asked merely to read the prime silently. As soon as the prime was erased from the screen, the target word was presented in the center of the screen, one line lower than where the prime had been. Subjects then had up to five seconds to make a word recognition decision; they were asked to respond as quickly and as accurately as possible.

The materials were presented in six blocks of twelve stories each. The presentation order of the blocks and the stories within each block was random for each subject. To help insure that the materials were being read for comprehension, questions were asked after the word recognition task for four stories from each block. A copy of instructions given to subjects appears in Appendix C.

Subjects. A total of twenty University of Massachusetts undergraduates took part in this experiment. They had been recruited from psychology courses and received experimental credit for their participation. All subjects met the criterion of no more than two comprehension question errors.

RESULTS AND DISCUSSION

Analysis Procedures. For each subject, mean reaction times were computed for the four SOA by Type of Prime cells, averaging over a maximum of six items in each cell. These data were submitted to a fixed-effect ANOVA. An Item analysis was also performed, and complete ANOVA tables for both analyses are given in Tables 16 and 17 of Appendix D.

Findings. Mean RT and error rates are shown in Table 4. These data do not support the prediction of the elaborative processing hypothesis. Rather, at both SOAs, targets primed by inferred word cues were actually responded to more slowly than those primed by

TABLE 4

MEAN REACTION TIMES (IN MSEC) AND PERCENTAGE ERRORS (IN PARENTHESES) AS A FUNCTION OF TYPE OF PRIME AND SOA IN EXPERIMENT 2

		Type of Prime		
		Neutral	Inferred	Mean
SOA	250 msec	1117 (7.50)	1183 (8.33)	1150 (7.92)
	750 msec	1135 (6.67)	1154 (6.67)	1145 (6.67)
	Mean	1126 (7.08)	1169 (7.50)	1148 (7.29)

neutral cues. However, neither the main effects of Type of Prime or SOA, nor their interaction were significant (see Tables 16 and 17 in Appendix D for results of the analyses of variance). One source of variance, the Form by Version interaction, did achieve significance: Form A items were responded to more slowly when presented in Version 1 than in Version 2, while the opposite was true of Form B items ($F[1,16] = 5.33$, $p < .05$). There was also a trend for items presented at the 250 msec SOA to be responded to more slowly than those at 750 msec for Form A, while the reverse was true for Form B; this resulted in a marginally significant SOA by Form interaction ($F[1,16] = 4.17$, $.05 < p < .10$).

Inspection of the error data presented in Table 4 shows that subjects made, on the average, 1.75 errors out of the twenty-four critical trials (an error rate of 7.29 percent), and there were no systematic trends with respect to experimental conditions.

Summary. Given the results of this experiment, the "cognitive carry over" explanation does not account for the failure of Experiment 1 to show a priming effect. In the next chapter, an experiment will be described which provides a further attempt to address the question of integration of inferred and explicit material. The logic behind the next experiment remains the same, but the materials and paradigm were changed.

CHAPTER IV

EXPERIMENT 3

The results of Experiment 1 do not support the assumption that inferred propositions are added to a discourse representation during comprehension. In Experiment 2, similar results were obtained with a slightly modified experimental procedure. To check on the hypothesis further, for the next two experiments a new set of materials was developed, and a different experimental task was used.

The motivation for a change of materials came from the concern that either: 1--previous stories do not facilitate the connection of inferred and explicitly-presented propositions; or, 2--that such connections are set up, but that the prime-target pairs used in the studies did not tap them. The stories written for Experiment 3 consisted of two sentences written around a category-exemplar word pair. For example:

[3] The ship was cruising along on the calm sea.

[4] Suddenly it dived under water until only its periscope was visible.

A reader of this story would probably infer that the ship mentioned in the first sentence was a submarine. Thus, with this type of story, stories based on category-exemplar pairs, it is likely that an inference will bridge the gap between a category name mentioned in the first sentence, and the specific member alluded to in the second sentence. Thus, the prime-target word pair for this story is SHIP-SUBMARINE. Note that the order of priming for this experiment is from explicit concept to inferred concept, which is the reverse of that used in Experiments 1 and 2. Perhaps the null results obtained so far are caused by low path accessibility when using an inferred concept as a starting point for priming. If this is the case, the priming effect that has not been obtained previously may appear.

The experimental situation for this study is similar to that of Experiment 2 in that subjects read two-sentence stories and saw a single word prime, but the task was changed from target word recognition to target word naming. The naming task has been used frequently in experiments on priming of semantic memory (e.g., Lorch, Note 4; Becker & Killion, 1977; Warren, 1977) and has proven to be a useful way of detecting activation of memory structures; it has the added quality of being an error-free, low variability task. Another advantage is that no materials need to be sacrificed to provide catch trials. The major reason for the change, though, was that word recognition is more likely to be affected by conscious subject strategies since it is a forced-choice task. Subjects generally perform the naming task without realizing that they are being timed; when comprehension questions are asked after each trial (as was the case with this experiment), they perceive question answering as their primary task.

The logic of this experiment is illustrated in Table 5 which shows the priming design. There were three conditions in this experiment. In the first two conditions, subjects saw the inferred category exemplar as the target word for naming, but the prime was either "positive," (the category name), or "neutral" (the word "BLANK"). In the last condition, subjects received the intact positive prime-target pair after a story that was <u>not</u> about that pair. Although the target words were low dominant category exemplars, and thus the semantic association between them and the category names minimized, there might still be some facilitation of the naming response to them when using the category name as a prime. Therefore, facilitation relative to the neutral prime condition could represent either semantic association, inferential processing, or both. For this reason, the non-inferred positive prime condition was included in the experiment. If the naming latency to "SUBMARINE" following "SHIP" in the inferred target condition is not faster than in the non-inferred target condition, there has been no activation of the concept "SUBMARINE" due to inferential processing. If, however, the latency is smaller when the target has followed a story in which it has been implicitly included (the inferred target condition), then it has been activated through inferential processing, and the facilitation effect due to this processing is reflected via reference to the neutral prime condition.

TABLE 5

PRIMING DESIGN FOR EXPERIMENTS 3 AND 4

INFERRED TARGET CONDITION

[3] The ship was cruising along the calm sea.

[4] Suddenly it dived until only its periscope was visible.

	Positive Prime	Neutral Prime
Prime:	SHIP	BLANK
Target:	SUBMARINE	SUBMARINE

NON-INFERRED TARGET CONDITION

[5] In a fit of rage, the angry animal turned and charged.

[6] The crowd cheered as the matador deftly avoided the rush.

	Positive Prime	Neutral Prime*
Prime:	SHIP	BLANK
Target:	SUBMARINE	SUBMARINE

*Not included in Experiment 3.

METHOD

Materials.

Development. Forty-five low dominant exemplars were chosen from the Battig and Montague (1969) and Shapiro and Palermo (1970) category norms. The categories chosen were fairly common and could be labeled with a single word like "ship," "animal," or "planet." Low dominant exemplars were purposely chosen so that the pre-existing semantic association between them and their respective category names would be minimized.

For each category-exemplar pair a two-sentence story was written such that the first sentence used the category name to describe an unspecified exemplar, and the second sentence provided enough information for the reader to infer which specific exemplar was being described. The category name served as a prime while the exemplar name served as a target. Finally, a comprehension question was written for each story. To answer a question correctly, a subject would have had to make the correct inference. The stories, prime-target word pairs, and comprehension questions for the set of 45 critical trials are given in Appendix B. Seventy-five other stories, similar in sentence structure to the 45 critical stories, were written to serve as filler. The prime-target word pairs selected for the filler stories did not have category-exemplar relationships.

Story List Construction. Each of the 45 stories was randomly assigned to one of three subsets; the subsets corresponded to the three conditions in the experiment. Two more lists of stories were generated so that each subset could be represented under each condition. Thus, given the same number of subjects in each list condition, each story appeared with the three types of prime-target pairs an equal number of times.

Design. Considering Subject as a random factor, this experiment has the form of a three (Lists; between subjects) by three (Conditions; within subjects) factorial ANOVA. An ANOVA in which Item was considered random with the Subject factor fixed was also performed.

Procedure. Participants were assigned at random to one of the three list conditions, and were tested individually in sessions that lasted approximately one hour. In addition to the equipment described previously for stimulus presentation and response recording, a voice key was used to help record naming latencies. It was interfaced with the PDP 8E, and was set to react to the leading edge of the subjects' responses; naming latency, then, was defined as the time from target onset to the beginning of the articulation of a response by the subject.

The series of events for each trial was as follows. Stories were presented in the same manner as described for Experiments 1 and 2; the pair of sentences was read individually at each subject's own pace, and it was stressed that the sentence pair should be understood as a story. A 500 msec delay followed the subjects' indication that the second sentence had been read. A visual cue consisting of three X's was then displayed for 500 msec in the center of the screen to capture the subjects' attention. Following this, the prime word replaced the cue and stayed on the screen for 250 msec. Subjects were asked to read the prime silently. As soon as the prime was erased, the target word was presented in the center of the screen, one line lower than where the prime had been. The subjects were instructed to read the target out loud as quickly as possible. If the voice key registered the response correctly, the screen was cleared and then a comprehension question about the story appeared; if no response had been registered by 2.5 seconds, the words "TRIAL OVER" appeared briefly on the screen before the question was presented. Subjects were asked to answer the question out loud, and the experimenter recorded whether or not the answer was correct. A copy of instructions given to subjects appears in Appendix C.

The experimenter monitored the naming responses as a check to insure that the voice key had been activated by the subject's voice articulating the correct response. If the word was misread, or if there had been a voice key failure (premature or late activation), then the experimenter was able to delete the data from that trial before the next story was presented.

After a six-trial practice block, the materials were presented in five blocks of 24 stories each. Each block contained 15 filler and 9 critical trials distributed evenly across the three experimental conditions. The presentation order of blocks and stories within blocks was random for each subject.

Subjects. Twenty-seven University of Massachusetts undergraduates (nine per list condition) took part in this experiment. They had been recruited from psychology courses and received experimental credit for their participation.

RESULTS AND DISCUSSION

Analysis Procedures. For each subject, mean naming latencies were computed for the three condition cells, averaging over a maximum of 15 observations per cell. These data were submitted to a fixed-effect ANOVA. An Item analysis was also performed, and the results of these analyses are given in Tables 18 and 19 of Appendix D.

Findings. Mean naming latency and error rates are shown in Table 6. The error rates reflect voice key failure almost exclusively, and are quite low overall (1.23%); thus, error rate will not be discussed further. The mean Condition latencies in Table 6 are consistent with prior expectation. Target words were named faster when they represented inferred concepts. The variability between the three means was significant over Subjects ($F[2,48] = 20.47$, $p < .01$), but not over Items ($F[2,4] = 2.58$, $p > .10$). Two planned Bonferroni t-tests were conducted for pairwise comparison of conditions (see Appendix D, Table 20). These tests showed a significant difference

TABLE 6

MEAN NAMING LATENCY (IN MSEC) AND PERCENTAGE ERRORS (IN PARENTHESES) AS A FUNCTION OF CONDITION IN EXPERIMENT 3

Inferred Target		Non-Inferred Target	
Positive	Neutral	Positive	Mean
520 (0.49)	533 (1.98)	572 (1.23)	542 (1.23)

between the Inferred Target, Positive Prime (520 msec) and Non-Inferred, Positive Prime (572 msec) conditions, and also a significant difference between the Inferred, Positive Prime (520 msec) and Inferred, Neutral Prime (533 msec) conditions.

Summary. This experiment has accomplished several objectives. It has demonstrated an inference effect with a new set of materials and with the naming task, and therefore extends the generality of the finding of Experiment 1 that inferred concepts are activated during the course of comprehension. Furthermore, the difference between positively and neutrally primed targets in the inferred target condition is suggestive of a facilitation effect due to the existence of a link in memory between the category name and the inferred target. No conclusions about this effect can be drawn at this point since there is no baseline against which to judge it. The facilitation could merely reflect semantic association or it could reflect the existence of a new link (or the strengthening of the old) due to inferential processing. Experiment 4 contains an appropriate baseline and will address this issue.

The view given above takes the position that the difference between the latency to inferred and non-inferred targets reflects the activation of the inferred targets via on-line inferential processing. An alternative explanation of the current set of data takes a different view; specifically, instead of reflecting the activation of inferred targets, the difference merely reflects interference with the non-inferred targets. It might be argued that the subjects learn to develop a conscious expectation for seeing inferred concepts for naming; crossing up this expectation, as would be the case with non-inferred targets, would lead to increased naming latency (Neely, 1977). It would be hard to justify this line of reasoning for the current situation, however, because it is not likely that such a conscious expectation would develop. While it is true that 67 percent of the critical trials require the naming of inferred targets, the filler trials do not use inferred concepts as targets. Instead, they use words that have appeared in the sentences, words associated to words in the sentences, or unrelated words. Adjusting for the filler trials, then, 42 percent of all naming stimuli come from the sentences or are associates, 33 percent are unrelated words, and only 25 percent represent inferred concepts. In addition, as mentioned earlier, subjects tended not to assign any importance to the naming task in this experiment, and so were probably not engaging in any strategies for accomplishing it.

CHAPTER V

EXPERIMENT 4

Experiment 3 has demonstrated that information needed for inference building is activated during comprehension. Experiment 4 is an extension of the previous experiment aimed at determining if this activated inferred information becomes integrated with the explicit story information. In addition to the three conditions used in Experiment 3, Experiment 4 included a non-inferred target, neutral prime condition (see Table 5). The logic of this experiment follows. The 13 msec priming effect obtained in the last experiment may have been due to pre-existing semantic association only (although the target words had been chosen to minimize this association). If that was the case, then in this experiment the difference between the neutral and positive prime conditions should not differ across inference conditions; the facilitation effect will be as large when the target word represents an inferred concept as when it does not. Next, consider the elaborative processing view. This position would claim that the inferred concepts are integrated on-line with the explicit text concepts, meaning that inferred concept-explicit concept connections are formed during comprehension. These connections would allow for the priming of, for example, "SUBMARINE" from "SHIP" through some bridging inference like "The ship mentioned in the story was a submarine." The prediction based on this view, then, is that there should be facilitation for the inferred target condition, but less or no facilitation in the non-inferred target condition (there could be some facilitation due to the weak association in semantic memory).

METHOD

Materials.

Development. The materials written for Experiment 3 were used in this experiment. An additional eight stories, prime-target pairs, and comprehension questions were prepared for this study (three critical and five filler) to make a total of 48 critical trials and 80 filler trials. The three new critical stories, prime-target pairs, and questions appear at the end of Appendix B.

Story List Construction. Each of the 48 stories was randomly assigned to one of four subsets corresponding to the four conditions in the experiment. Three more lists of stories were generated so that each subset would be assigned to each condition. Thus, given the same number of subjects in each list condition, every story appeared with the four types of prime target pairs an equal number of times.

Design. Considering subject as a random factor, this experiment has the form of a four (Lists; between subjects) by two (Inference Condition; within subjects) by two (Type of Prime; within subjects) factorial ANOVA. An ANOVA with Item random and Subject fixed was also performed.

Procedure. Participants were assigned at random to one of the four list conditions, and were tested individually in sessions that lasted approximately one hour. The equipment and procedure was identical to that reported for Experiment 3. The instructions given to subjects were identical to those given for Experiment 3 (appearing in Appendix C) except for the number of trials cited.

After the practice block, the materials were presented in four blocks of 32 trials each. Each block contained 12 critical trials and 20 filler trials distributed evenly across the four experimental conditions. The presentation order of blocks and trials within blocks was random for each subject.

Subjects. Twenty University of Massachusetts undergraduates (five per list condition) took part in this experiment. They had been recruited from psychology courses and received either experimental credit or five dollars for their participation.

RESULTS AND DISCUSSION

Analysis Procedures. For each subject, mean naming latencies were computed for the four condition cells, averaging over a maximum of 12 observations per cell. These data were submitted to a fixed-effect ANOVA. An Item analysis was also performed, and results from these analyses of variance are given in Tables 21 and 22 in Appendix D.

Findings. Mean naming latencies and error rates are shown in Table 7. Once again error rate was low, averaging 1.15 percent over all critical trials in the experiment, and it will not be considered further.

Consistent with the previous experiment's data is the result that inferred targets were named considerably faster than non-inferred targets (521 msec vs. 574 msec). This 53 msec inference effect was significant by subjects ($F[1,16]=40.55$, $p < .001$), and marginally significant by items ($F[1,3]=5.83$, $.05 < p < .10$). Also consistent with the previous experiment was the existence of a difference between neutrally and positively primed targets (552 msec vs. 542 msec); although small, this 10 msec facilitation effect, represented by the main effect of Type of Prime, was significant by subjects ($F[1,16] = 4.89$, $p < .05$) but not by items ($F < 1$). It is surprising to note, however, that the facilitation effect is due mostly to the non-inferred target condition, which shows an 18 msec effect as compared with the inferred condition, which shows only a 2 msec effect. Although this apparent interaction of Inference Condition and Type of Prime was not significant ($F[1,16] = 2.13$, $p > .10$ by subjects; $F < 1$ by items), planned Bonferroni t-tests (see Appendix D, Table 23) indicated that the 18 msec facilitation effect for non-inferred targets was significant while the 2 msec effect for the inferred targets was not.

A final significant result to mention is the Type of Prime by List interaction in the subjects ANOVA ($F[3,16] = 3.80$, $p < .05$).

TABLE 7

MEAN NAMING LATENCIES (IN MSEC) AND PERCENTAGE ERRORS (IN PARENTHESES) AS A FUNCTION OF INFERENCE CONDITION AND TYPE OF PRIME IN EXPERIMENT 4

	Type of Prime		
	Positive	Neutral	Mean
Inferred Targets	520 (1.25)	522 (1.25)	521 (1.25)
Non-Inferred Targets	565 (.83)	583 (1.25)	574 (1.04)
Mean	542 (1.04)	552 (1.25)	547 (1.15)

Inspection of the data reveals the source of the interaction; for three of the four lists of materials, subjects showed an overall facilitation effect averaging about 19 msec in magnitude. For the remaining list, however, this trend was reversed by a 16 msec interference effect.

Summary. This data set fails to provide support for the claim of on-line integration of inferred and explicit information. Once again, however, the issue is clouded by uncertainties. Why was there no facilitation effect for inferred targets? This is an important question to answer since, if some aspect of the experiment's methodology artificially reduced the effect, then the study was biased against the elaborative processing hypothesis at the start. The data do not give any sure answer to the question, but the following possibility suggests itself. The smallest mean latency in both Experiments 3 and 4 was that for the positively primed inferred targets which both had a value of 520 msec. Could this value represent a performance ceiling? Perhaps inferred targets are so highly activated already (and the size of the inference effect testifies to this degree of activation) that the additional benefit of having been primed is small in comparison. While this explanation does not address the facilitation effect discrepancy between the two experiments, it does provide an account of why there is no inferred target priming effect in the current data set. Ways of dealing with the ceiling effect will be considered in the next chapter.

CHAPTER VI

GENERAL DISCUSSION

Summary of Dissertation Motivation and Findings

Cognitive scientists have attached much theoretical importance to the concept of elaboration and its role in text processing and memory. The two key aspects of the commonly accepted conceptualization of elaboration are: Elaborations are generated during the encoding of text, and they are integrated with explicitly asserted information in the text representation as part of the ongoing comprehension process. Inference, a specific type of elaboration, was the object of study for this dissertation.

Studies from within the recall/recognition memory, reading time, and sentence verification paradigms have reported evidence in support of the on-line elaborative processing hypothesis. These paradigms, however, have been shown to be inadequate for the purpose. The priming literature on inference was mostly concerned with forward, or non-necessary, inferences, and it was divided with respect to the issues of on-line generation and storage. Therefore, there is little evidence that backward inferences, those needed to maintain text coherence, are generated and stored on-line, although most researchers have reasoned on an intuitive basis that this is so. To provide data relevant to the on-line elaborative processing hypothesis, four experiments were designed and executed.

The priming data of Experiment 1 indicated that concepts which are likely to be used in the construction of an inferential bridge are activated during the comprehension process. Subjects' performances were characterized by a marked difficulty in discriminating inferred concepts from explicitly asserted ones. Interestingly, this difficulty increased as the time between comprehension and test increased; the implication is that the subjects were rapidly losing the ability to discriminate inferred and explicit material. The target data from this experiment, however, failed to support the notion that inferred concepts are integrated with the explicit material during comprehension. This failure was not caused by the peculiarities of the list priming procedure; the single word priming of Experiment 2 also failed to provide evidence for a connection between the activated inferred concepts and selected explicit concepts.

Experiments 3 and 4 demonstrated that the finding of inferred concept activation is robust; it was replicated with a different style of materials and a different task. Once again, though, the results from these two experiments do not support the hypothesis of inference integration during comprehension.

In the remainder of this chapter, I will discuss these results from two different perspectives. First, I will consider the possibility that inferences are integrated during comprehension, but that the methodology failed in its attempt to demonstrate this. Second, alternative conceptualizations of the inference process that are consistent with the data presented here will be discussed. A final section will reconsider the notion of necessity with respect to the drawing of inferences.

Methodological Issues

Development of Materials.

Prime-Target Word Pair Selection. The two basic sets of stories used in these experiments succeeded to the extent that concepts involved in inference structures were activated. Evidence for the existence of inference integration rested, however, on finding connections between those concepts and asserted ones. Data on these connections were obtained via assessments of priming effects between inferred and explicit concepts. The tenuous part of the materials development enterprise for Experiments 1 and 2 was in trying to decide on an a priori basis where the inferred material would be linked to the asserted text representation. The rule of thumb used for the first two experiments was to write stories that contained a noun which seemed likely to be connected to the inference concept in a representation of the gist of the story. For some stories, like the one about the person who wished she had an umbrella at the game, or the one about a violent disturbance at a prison, this strategy seemed appropriate: "There was RAIN at the GAME," or "There was a RIOT at the PRISON". For others, the location of a likely connection between the inference and the text was less certain (see Appendix A).

McKoon and Ratcliff's (1981) study included experiments on the connection of implied instruments and asserted concepts. The issue of concept connection is considerably easier to deal with in the limited domain of instrument inference, however. For every implied instrument there is an asserted action and object. So, for a sentence like "He swept the floor," Ratcliff and McKoon took the position that "BROOM" should be connected with (and prime) concepts in the proposition containing "FLOOR." (There is a possible problem with this situation, however, and I will return to the McKoon and Ratcliff experiments shortly.) Backward inference stories are not as easy to characterize, unfortunately. That inferences are necessary and are drawn seems certain; the manner of integration of those inferences with the text is not altogether clear. This uncertainty is indicative of our lack of information about the use of world knowledge in maintaining text coherence. Thus far we have been able to only guess about how information retrieved from semantic memory is added to a text base.

For these reasons, it seems that it is important to write stories that will require small, very well defined backward inferences. This was attempted in Experiments 3 and 4. There was a clear procedure for the writing of the materials for these studies. The first member of each sentence pair named a semantic category; the second was written in such a way as to describe a member of that category. With stories written to require only small inferential bridges, we should be more able to pinpoint the location of connections between those bridges and specific concepts in the text.

Length of Stories. For all of the studies presented here, the materials consisted of two or three-sentence stories. These are rather short considering the size of most narratives. Their use seemed justified, however, in light of the fact that many comprehensible but inferencerequiring communications are as short. Furthermore, they were understood easily in the experimental context, as evidenced by subjects' ability to answer the comprehension questions.

It must be noted, however, that stories used by other researchers have been longer. McKoon and Ratcliff's (1981) stories, for example, consisted of four sentences. In contrast, Dosher and Corbett (1982) presented only a single sentence. As Dosher and Corbett suggest, this is one possible reason for the two studies' conflicting results, and it may have been a factor in my experiments as well. There is no compelling explanation for why passage length should be important for inference processing, though. Dosher and Corbett (1982) offer the possibility that activation of sentence concepts is somehow different when subjects read full paragraphs, but they do not explain why or how this is so.

One possibility is that longer stories allow subjects to develop macrostructures or schemata which facilitate the integration of inferred material. Presumably, sentence pairs do not allow this to the same extent (Miller & Kintsch, 1980). So, although an inference may be generated, if the story is impoverished to begin with, there is very little integration possible. The text would be represented more like a set of isolated facts used in studies of propositional fan (e.g., Reder & Anderson, 1980) than an elaborated network.

Experiment Procedures.

Ceiling Effects. The activation ceiling effect problem was mentioned in the discussion of Experiment 4. The problem is that the inferred-concept targets used in the experiment may have been highly activated by inference processing before they were primed for naming. Thus, even if the explicit-concept prime was connected with the inferred concept in the text representation, priming the naming of inferred targets would not improve performance.

The usual procedure for dealing with ceiling effects is to do something to slow down the subjects' performance in the task. One way of doing this would be to degrade the video display during the naming trials, either by the introduction of "visual noise," or by reducing the screen contrast. As has been reported (Becker & Killion, 1977; Meyer, Schvanaveldt, & Ruddy, 1974), display degradation tends to enhance priming effects. Prior to running this experiment, screen contrast reduction was considered as a way of increasing the priming effects, but it was not feasible; subjects would have experienced considerable eye strain because in addition to reading naming stimuli, they were reading a large amount of text as well.

Another way to slow subjects' performance is to introduce a delay for each trial between reading the story and the naming task. This would allow time for the activation that has accrued on the inferred concept due to inferential processing to decay. Now, any activation due to priming via connections in the text representation would be noticeable. Unfortunately, this latter strategy is somewhat at odds with the overall concern of this dissertation--to assess whether connections are formed during comprehension. Employing a delay between text processing and test may only leave the question open. Perhaps, though, introducing a functional delay through the addition of an ending sentence or two would allow the overall activation level to drop while keeping the subject busy until test. This would do away with the ceiling problem without seriously compromising the claim that effects reflect integration processes at encoding. McKoon and Ratcliff (1981) used a similar approach by having subjects read two stories consecutively before encountering test stimuli. They did not explain why they used that procedure, however, so their motivation in doing so is uncertain.

Summary of Methodological Issues. Several aspects of the methods used in these experiments may have contributed to the null results with respect to inference integration. In particular, the prime-target stimulus selection, story length, and priming procedures may all have biased these studies against the integration hypothesis. In each case, an alteration with justification was offered for the purpose of removing the biases. In the next section of this chapter, I will change my perspective and consider some alternative conceptualizations of inference.

Alternative Conceptualizations

A Framework for the Alternatives. There are two related conceptualizations of inference processing that I would like to suggest. They are based on two distinctions that require consideration before the specific hypotheses can be presented.

Inference Activation/Inference Integration. This is essentially the same distinction presented by McKoon and Ratcliff (1980b; 1981) in their model of inference. Inference activation refers to the process of searching for and activating information that will be incorporated in an inferential structure. It is usually what is meant by the phrase "inference generation." As would be expected, the activation of concepts involved in the inferential structure is subject to decay after time or intervening cognitive activity.

Inference integration refers to the connection of the activated inferential structure with the text representation. When this has occurred, we generally say that the inference has been "stored."[2]

Text comprehension/Text integration. Even though the term "comprehension" usually implies the immediate construction of an integrated network representation of a text (e.g., see Smith, 1981), I would like to suggest a different view. For the hypotheses considered in this section, comprehension refers to a process that occurs during the reading of a text. Its function is to monitor and maintain text coherence on a momentary basis. Seen in this way, comprehension is concerned with only the immediately preceding and current sentences or phrases, so its text focus is quite narrow. This view of comprehension is very much like the processing assumed by Kintsch and van Dijk (1978) to occur on propositions stored in the "active buffer." It is a high priority process since the maintenance of text coherence is considered to be of primary importance.

In contrast, integration refers to the building of an integrated network which represents the text. If any backward inferences have been activated, it is presumed that these are part of the active buffer since they are needed to maintain text coherence. They function as a kind of temporary propositional "glue" to support the development of coherence. They are, therefore, candidates for inclusion in the text representation. Thus, inference integration is just a part of the overall integration process.

In contrast with the processes involved in comprehension, integration has a wide text focus; the entire text base should be available for integrative processing. Furthermore, instead of being an ongoing process, integration may take place at discrete points during the reading of a text (Just & Carpenter, 1980), so it is a "batch" rather that on-line process; because of its global nature, it should require more cognitive resources than comprehension.

Since the data I have presented suggest that inferences are activated during comprehension, the hypotheses to follow are mostly concerned with integration. If we rule out the possibility that inferences are integrated on-line, there are two hypotheses about inference integration: It could simply lag behind inference activation by some amount of time, or it could be neglected altogether.

Inference Integration Lag Hypothesis. Perhaps the integration process which has been presumed to exist for inferences requires more time for completion that was allowed by the experimental procedures. It also may be the case that if processing demands at a given point in time are high, integration may be deferred. Since it is assumed that comprehension processing has greater priority, this deferral may occur fairly often during the reading of difficult material. If inference integration is deferred for too long a period of time, the activation of the inferential structure may fade away. The inference would then have no chance of being integrated and stored with the explicitly-asserted text.

Consider again the results from Experiment 1. Word recognition decisions for inferred concepts became more difficult with delay, indicating that subjects were losing the ability to discriminate inferred and explicit material. This seems to suggest that an integration process is underway; it is not nearly complete, however, since subjects were able to perform the discrimination at even the longest delay quite well (they were still at 87 percent accuracy). Recall that the delay variable was weak, though; the longest delay between comprehension of the last sentence and presentation of the prime word for recognition was only about five seconds, and that interval was filled almost entirely with other word recognition decisions. Making the stories longer, perhaps by including one or more simple closing sentences, might allow the integration of inferred and explicitly-asserted information to be completed.

This explanation is consistent with students' common observation that lectures seem perfectly understandable while they are in progress, but understanding diminishes to a frighteningly small amount just a few hours later. The explanation for this phenomenon in terms of the lag hypothesis would be as follows. During the lecture, comprehension processes are providing checks that coherence is being maintained, with the focus on only the most recent input. Inferences are being generated to aid comprehension, but before they can be integrated with the explicitly-asserted material, new information comes in for comprehension, taking away resources from the integration processing. The student's experience at the time is that comprehension is good (a valid impression), but the unfortunate truth is that the stored representation is an impoverished unelaborated network. Later, their recall of the material is poor. (Poorer recall for unintegrated material has been demonstrated by Myers et al.; Note 2.)

Regeneration Hypothesis. This hypothesis is similar to the integration lag idea in that it assumes inferences are activated during comprehension, and that inference integration does not necessarily follow. While the integration lag hypothesis claims that inference integration occurs when it can, the regeneration hypothesis assumes instead that inferences are never integrated. Instead, inferences can be regenerated whenever necessary by using the explicitly-asserted material stored in the text representation. The notion here is that inference activation may require less effort than integrative processing, so inferences are not added to the text representation.

A problem for the regeneration hypothesis is the data of Keenan and Kintsch (Kintsch, 1974) and Reder (1976; 1979) who have shown that subjects are able to verify inferred statements as quickly as explicit ones, given a sufficient delay interval between reading and test. This result implies that the inferences have been included in the text representation. If inferences are not part of the text representation, verifying inferred statements should take longer than verifying explicit ones because they have to be regenerated at the time of test. However, subjects may be performing plausibility checks for both types of sentences to perform the verification (Reder, 1976; 1979). Thus, regeneration may not be needed to perform the task on inferred statements, and the Kintsch and Reder experiments are biased against the hypothesis.

Summary of Alternative Conceptualizations. Two hypotheses have been suggested to account for the pattern of results presented here. They both incorporate the McKoon and Ratcliff (1980b; 1981) distinction between activating inferred information and integrating it with the text. For both hypotheses, it is assumed that inferences are generated on-line; what differs is the disposition of the inference following its generation.

The integration lag hypothesis offers the suggestion that integration of inferred material will occur if given enough time and/or resources. It is easily tested with the same basic materials and procedures employed in these experiments. We should observe priming due to inference integration by introducing some neutral sentences in the stories, perhaps at the endings, to allow integration to occur. On the other hand, introducing a larger processing load just after having generated an inference should decrease the probability of integration.

The regeneration hypothesis suggests that inferences are never stored. Instead, they can be regenerated when needed from the explicitly-asserted information that is stored in memory. Such a position may be difficult to test, however. If no evidence can be found to support the integration lag hypothesis, then inference regeneration is supported by default.

One last position worth considering is that both of the hypotheses presented here are correct for different situations. This will be discussed next.

<u>A Reconsideration of Inference Necessity</u>. The work that went into this dissertation was shaped by the conventional wisdom that when coherence is broken, an inference must be generated. My results upheld this

position in that they provided evidence for the existence of inference activation. But what of forward, or non-necessary inferences? The data are inconclusive. McKoon and Ratcliff's (1981) position is that forward inferences are not only generated, but also integrated with the text. Dosher and Corbett (1982) failed to find evidence even for activation when subjects were under normal reading instructions. It is important to note, however, that when they instructed their subjects to generate inferences while they were reading, Dosher and Corbett obtained the inference activation that they were not able to find otherwise. This suggests that, like elaboration in general, the reader's motivation and intention are important factors in the inference process. For example, readers of detective stories may purposely slow their reading rate in order to generate and integrate all manner of inferences that would help them to guess the identity of a murderer.[3] The opposite situation occurs when the reader is bored and is moving mechanically through a text. In this case the person may not notice a break in coherence, or may simply not be motivated enough to generate and store the necessary inferential bridge. Needless to say, forward inferencing would not occur at all in this reading situation. The noteworthy point here is that if we base theories of text processing on the importance of maintaining text coherence, as do Kintsch and van Dijk (1978), we must realize that we are assuming the ideal situation--a motivated and interested reader.

These arguments suggest another reason for why longer passages may be needed in order to show the effects of inferential processing

--these may be inherently more interesting for the subjects to read. People who read longer stories may be more motivated to generate inferences and elaborations and integrate them with the text. A reasonable suggestion at this point is that cognitive researchers should not attempt to decide between models of inference that are either all-or-none. Instead, it would be useful to specify the text and situational variables that are important determinants of inferential processing.

Concluding Comments

These investigations of backward inference have provided evidence that backward inferences are activated during the reading of text. The data do not support the position that activated inferences are then integrated with explicitly-asserted text propositions in memory. I have considered several different ways in which the methodology may have interfered with the tests being conducted, and have offered suggestions for modifications. I have also proposed two different models of inference that are consistent with my pattern of results, and indicated that a reader's intention and motivation may play important roles in the process.

This dissertation makes two important contributions. First, the results force acknowledgment of the distinction between comprehension and integration, and furthermore they suggest that integration is not a necessary consequence of comprehension. Future models of text processing will have to take the distinction into account.

Second, the results cast doubt on the commonly accepted notion that backward inferences are integrated during text comprehension. In most cases the literature on inference is methodologically weak and can not dispel the doubt. This situation is problematic because my results are inconsistent with the on-line elaborative processing position. Recall that this position provides the theoretical underpinning of explanations of several memory phenomena. What is needed is a more complete understanding of the effects of variables like motivation, intention, and type of inference to be generated on inferential processing. By placing constraints on inference, we will gain information about elaborative processing in general, and also we will have a better understanding of the conditions under which we should expect to observe the memory phenomena in question.

FOOTNOTES

1. Note that the "neutral" primes are not neutral in the absolute sense, but are neutral in that they are presumably not incorporated in any inferences drawn by the reader.

2. It is possible that inferences could be stored in memory but not integrated with the text representation. They could simply be stored in a separate structure, an "inference list," which may be attached via a single link to the text. This is what has been proposed for atypical script actions by Graesser, Woll, Kowalski, and Smith (1980). There are two reasons why this possibility will not be considered further. First, data from most of the studies reviewed earlier argue against an independent storage structure for inferences. Second, the important question for this dissertation is not whether inferences are in memory, but rather whether they are integrated with the explicitly asserted information as is claimed by the elaborative processing hypothesis under consideration.

3. I would like to thank Jerry Myers for suggesting this example.

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APPENDIX A

CRITICAL MATERIALS FOR EXPERIMENTS 1 AND 2

1. The group of friends left for vacation.
The trip was smooth until the unfortunate incident.

Version 1: Jerry got the jack from the trunk.

Version 2: Jerry filled the two-gallon can at the station.

	Version 1	Version 2
Inferred Prime:	FLAT	GAS
Target:	TRIP	

****

2. Jim was not used to having such a difficult time.
The pair was disappointing.

Version 1: Jim had hoped his feet wouldn't hurt that much.

Version 2: Jim has hoped for three of a kind from the dealer.

	Version 1	Version 2
Inferred Prime:	SHOES	CARDS
Target:	PAIR	

Question: Why was Jim disappointed?

****

3. Jane was not enjoying the afternoon at the ballpark.
The situation was uncomfortable at the baseball game.

Version 1: Jane was sorry she had forgotten her umbrella.

Version 2: Jane was sorry she had forgotten her cushion.

	Version 1	Version 2
Inferred Prime:	RAIN	SEAT
Target:	GAME	

Question: Why was Jane uncomfortable?

4. Along with other people, Mark stood and clapped.
Everyone at the stadium was excited by the incredible event.

Version 1: Mark had never seen a better marching band performance.

Version 2: Mark had never seen a 106-yard kickoff return before.

	Version 1	Version 2
Inferred Prime:	HALFTIME	FOOTBALL
Target:	EVENT	

(This story was replaced by Story #25 for Experiment 2.)

****

5. A janitor had been called by the office worker.
The office door annoyed the secretary because of the problem.

Version 1: The janitor used oil to stop the squeaking.

Version 2: The janitor took apart the mechanism to get the key out.

	Version 1	Version 2
Inferred Prime:	HINGE	LOCK
Target:	DOOR	

****

6. Athletic competition can cause injuries.
Mike broke his leg while playing the sport.

Version 1: He tripped over his own feet while sliding into home.

Version 2: He tripped over his own skates while chasing the puck.

	Version 1	Version 2
Inferred Prime:	BASEBALL	HOCKEY
Target:	SPORT	

Question: How did Mike get hurt?

7. Frank is usually prepared when things go wrong. The storm caused a problem at home that night.

<u>Version 1</u>: Frank placed a bucket in one corner.

<u>Version 2</u>: Frank lit candles in several rooms.

	Version 1	Version 2
Inferred Prime:	LEAK	POWER
Target:	STORM	

****

8. After the check-up Pete got a lecture from the family physician. The doctor warned Pete about his bad habit.

<u>Version 1</u>: He didn't want his patient to get liver disease.

<u>Version 2</u>: He didn't want his patient to get lung cancer.

	Version 1	Version 2
Inferred Prime:	DRINKING	SMOKING
Target:	HABIT	

****

9. The senior prom was just two hours away. One part of the rented tuxedo didn't fit properly.

<u>Version 1</u>: Dave had to use a tight belt to avoid a possible embarrassment.

<u>Version 2</u>: Dave left his top button undone so his neck wouldn't hurt.

	Version 1	Version 2
Inferred Prime:	PANTS	COLLAR
Target:	TUXEDO	

10. Jeff was in his dorm room preparing for a final.
Studying for the exam became harder as the pain got worse.

Version 1: Jeff washed down the antacid with some water.

Version 2: Jeff washed down the aspirins with some water.

	Version 1	Version 2
Inferred Prime:	STOMACH	HEADACHE
Target:	PAIN	

****

11. It was going to be a long evening.
Because the equipment in the house was broken, the temperature was uncomfortable.

Version 1: The family huddled by the fireplace to keep warm.

Version 2: The family opened the windows in hope of a cool breeze.

	Version 1	Version 2
Inferred Prime:	FURNACE	AIR CONDITIONER
Target:	HOUSE	

Question: What was the problem with the house?

****

12. Randy groaned at his bad luck.
It was a calamity when the glass broke.

Version 1: Randy couldn't afford the expensive car repairs.

Version 2: Randy couldn't save the fish from dying.

	Version 1	Version 2
Inferred Prime:	WINDSHIELD	AQUARIUM
Target:	GLASS	

13. Everyone enjoyed watching the celebration.
The usual tradition was observed.

Version 1: Ellen tossed her bouquet to the group of women.

Version 2: Ellen made a wish a took a deep breath.

	Version 1	Version 2
Inferred Prime:	WEDDING	CANDLES
Target:	PARTY	

****

14. On Saturday morning Steve had to catch up on neglected housework.
He knew it had to be done, but he disliked having to do the chore.

Version 1: Steve started with a load of dark things first.

Version 2: Steve started with the pots and pans first.

	Version 1	Version 2
Inferred Prime:	LAUNDRY	DISHES
Target:	CHORE	

****

15. A large crowd gathered around and stared.
The incredible gem in the display astonished the visitors to the museum.

Version 1: It had been produced by a huge oyster.

Version 2: The clear sparkling stone had been cut by an expert.

	Version 1	Version 2
Inferred Prime:	PEARL	DIAMOND
Target:	GEM	

****

16. It was a hot summer day.

A back yard hedge was in severe need of attention.

Version 1: Cindy unraveled the garden hose.

Version 2: Cindy sharpened her garden shears.

	Version 1	Version 2
Inferred Prime:	WATER	TRIM
Target:	HEDGE	

Question: What was Cindy going to do to the hedge?

****

17. The night was dark.
Ed had driven past the sign at the intersection without seeing it.

Version 1: He had to stop at a gas station for directions.

Version 2: He had to pay a 25-dollar fine to the judge.

	Version 1	Version 2
Inferred Prime:	LOST	TICKET
Target:	SIGN	

****

18. The employee training paid off.
The young woman was not unnerved by the incident at the bank.

Version 1: She calmly handed over the money.

Version 2: She quickly ran to get an extinguisher.

	Version 1	Version 2
Inferred Prime:	ROBBERY	FIRE
Target:	BANK	

Question: What happened at the bank?

19. The state governor was upset at what had happened.
The occurrence at the prison had received much attention in the news.

Version 1: The army was called out to help put down the disturbance.

Version 2: Five crafty convicts had made it over the wall.

	Version 1	Version 2
Inferred Prime:	RIOT	ESCAPE
Target:	PRISON	

****

20. Joe looked outside his front door.
The footing on the steps was bad because or their condition.

Version 1: Joe used rock salt to take care of the problem.

Version 2: Joe shoveled off the latest storm's accumulation.

	Version 1	Version 2
Inferred Prime:	ICE	SNOW
Target:	STEPS	

Question: What was wrong with the steps?

****

21. Travelers were confused and angry.
Severe weather closed the airport.

Version 1: The runway flooded when a nearby river overflowed.

Version 2: The dense grey mist made flying dangerous.

	Version 1	Version 2
Inferred Prime:	RAIN	FOG
Target:	AIRPORT	

22. A beagle broke away from his master during a walk. The curious dog chased a wild animal in the woods.

Version 1: The pet's owner washed it several times to get rid of the terrible smell.

Version 2: The pet's owner removed the quills that were stuck in its nose.

	Version 1	Version 2
Inferred Prime:	SKUNK	PORCUPINE
Target:	DOG	

****

23. Betty was trying to finish the job in a hurry. Unfortunately, the machine was broken.

Version 1: Betty had to hang the wet clothes out on a line.

Version 2: Betty had to write out the memo by hand.

	Version 1	Version 2
Inferred Prime:	DRYER	TYPEWRITER
Target:	MACHINE	

Question: What gave Betty a problem?

****

24. The news shocked the scientific world. The scientists were surprised by the occurrence in the mountains.

Version 1: Townspeople felt strong tremors for several days.

Version 2: Townspeople were evacuated because of the lava.

	Version 1	Version 2
Inferred Prime:	EARTHQUAKE	VOLCANO
Target:	MOUNTAINS	

25. (Neutral first sentence omitted.)
Earl was having a problem using the tool properly.

Version 1: He was bending the nails he was trying to pound.

Version 2: He was splintering the wood he was trying to cut.

	Version 1	Version 2
Inferred Prime:	HAMMER	SAW
Target:	TOOL	

(This story replaced Story #4 in Experiment 2.)

APPENDIX B

CRITICAL MATERIALS FOR EXPERIMENTS 3 AND 4

1. In a fit of rage, the angry animal turned and charged. The crowd cheered as the matador deftly avoided the rush.

Prime: ANIMAL Target: BULL

Question: What Rushed?

****

2. Everyone in the stale hot room cheered when Ed brought in the appliance. Sonn the spinning blades were blowing fresh air to all the people.

Prime: APPLIANCE Target: FAN

Question: Why did everyone cheer?

****

3. Jerry wasn't aware of the bird in the tree outside of his window. When it hooted loudly, he was startled.

Prime: BIRD Target: OWL

Question: What was in the tree?

****

4. Randy couldn't believe how beautiful the city was. The view from the Eiffel tower left a big impression on him.

Prime: CITY Target: PARIS

Question: Where was Randy?

****

5. Pam went to the store to buy the type of cloth she needed. She wanted to make a pair of blue jeans for her husband.

Prime: CLOTH Target: DENIM

Question: What did Pam buy?

****

6. Although it was expensive, Paul decided to buy the article of clothing. Its pinstriped material and vest would make him look classy.

<u>Prime</u>: CLOTHING <u>Target</u>: SUIT

<u>Question</u>: What did Paul buy?

****

7. Political unrest threatened the stability of the little country. Many protestors had been arrested in Athens alone.

<u>Prime</u>: COUNTRY <u>Target</u>: GREECE

<u>Question</u>: Where was political unrest occurring?

****

8. A serious crime had been committed in the quiet little town. There was overwhelming evidence that the fire had been set on purpose.

<u>Prime</u>: CRIME <u>Target</u>: ARSON

<u>Question</u>: What crime had been committed in the town?

****

9. Ron was quite an expert at the traditional type of dance. All of the women at the Polish festival hoped to be his partner.

<u>Prime</u>: DANCE <u>Target</u>: POLKA

<u>Question</u>: What was Ron an expert at?

****

10. Ted's disease prevented him from having alcoholic drinks. He also hated giving himself insulin injections.

<u>Prime</u>: DISEASE <u>Target</u>: DIABETES

<u>Question</u>: What was Ted's medical problem?

****

11. The ache was making studying difficult, so Wendy took some of the drug.
Her headache soon disappeared.

<u>Prime</u>: DRUG <u>Target</u>: ASPIRIN

<u>Question</u>: What did Wendy do?

12. Andy was out of shape, so he picked an exercise with which to trim himself.
He spends an hour in the pool each day.

Prime: EXERCISE Target: SWIMMING

Question: What does Andy do to keep in shape

****

13. At the aquarium Tom saw a fish he had never seen close up before.
It was a great white, a deadly species with huge jaws.

Prime: FISH Target: SHARK

Question: What did Tom see?

****

14. Harry was annoyed when he saw the little yellow flowers.
He hated to see all those weeds in his lawn.

Prime: FLOWER Target: DANDELION

Question: What was the problem with Harry's lawn?

****

15. All of the children at the picnic took large slices of the fruit.
While enjoying the red juicy treat, they had a seed spitting contest.

Prime: FRUIT Target: WATERMELON

Question: What were the children eating?

****

16. The power company could not produce electricity because the fuel needed had not been delivered.
The nuclear reactors sat idle until the situation was corrected.

Prime: FUEL Target: URANIUM

Question: Why were the reactors idle?

****

17. Although it was a bit worn, the second-hand article of furniture that Barb bought would be sufficient.

All it needed was a new shade and bulb.

Prime: FURNITURE Target: LAMP

Question: What did Barb buy?

****

18. The museum visitors were astonished by the size of the gem in the display.
It had been produced by a huge oyster.

Prime: GEM Target: PEARL

Question: What astonished the visitors?

****

19. Bob was dismayed to discover an infestation of the insects in his house.
The exterminator reported that they had eaten much of his wooden staircase.

Prime: INSECT Target: TERMITE

Question: What had infested Bob's house?

****

20. Kathy sat in the orchestra pit during the song and got ready to play the instrument.
At just the right moment, she crashed the two brass discs together.

Prime: INSTRUMENT Target: CYMBALS

Question: What was Kathy playing?

****

21. Rick asked for a piece of jewelry for his birthday.
He needed to keep better track of the time since he was always late.

Prime: JEWELRY Target: WATCH

Question: What did Rick want for his birthday?

****

22. Ann worked hard to study the language.

Although it is a dead language, she enjoyed translating stories from ancient Rome into English.

Prime: LANGUAGE Target: LATIN

Question: What was Ann studying?

****

23. Many bottles of the liquor were behind the bar, waiting for the guests' arrival.
When the wedding reception started, the corks were popped and everyone enjoyed the bubbily drink.

Prime: LIQUOR Target: CHAMPAGNE

Question: What were the guests drinking?

****

24. During the traditional holiday dinner, father was in charge of carving the meat.
He also took responsibility every Thanksgiving for dishing out the stuffing.

Prime: MEAT Target: TURKEY

Question: What was father carving?

****

25. After the mishap in the lab, the science teacher warned Shelly not to touch the metal with her bare hands.
She carefully cleaned up the silvery liquid that had escaped from the broken thermometer.

Prime: METAL Target: MERCURY

Question: What wasn't Shelly supposed to touch?

****

26. Although many people thought it was dreary, Jane liked this month.
She looked forward to the Thanksgiving holiday at its end.

Prime: MONTH Target: NOVEMBER

Question: What month was it?

27. Dave couldn't understand the music his dad listened to.
He disliked the fact that the stories were told in songs whose lyrics were written in Italian.

Prime: MUSIC Target: OPERA

Question: What music did Dave's dad listen to?

****

28. Little Joan loved the pet she received as a gift for Easter.
The cute white bundle of fur had large pink ears that twitched when it hopped.

Prime: PET Target: RABBIT

Question: What type of pet did Joan receive?

****

29. Lou was excited when he focused in on the planet with his telescope.
The rings were clearly visible.

Prime: PLANET Target: SATURN

Question: What did Lou see?

****

30. James thought that he would enjoy the profession he wanted.
He loved riding tractors and plows through the fields.

Prime: PROFESSION Target: FARMER

Question: What did James want to be?

****

31. Mary called the relative that lived nearest to her.
Her sister's daughter was in the next town.

Prime: RELATIVE Target: NIECE

Question: Whom did Mary call?

****

32. The kids learned all about the reptile at the natural history museum.

They were amazed at the huge skeleton of the prehistoric creature.

Prime: REPTILE Target: DINOSAUR

Question: What did the kids learn about?

****

33. Maria hated having to take the science course.
She thought learning about rocks was terribly boring.

Prime: SCIENCE Target: GEOLOGY

Question: What class did Maria dislike?

****

34. Everyone else at the table was disgusted by the type of seafood Jack ordered.
The tentacles of the creature were visible on his plate.

Prime: SEAFOOD Target: SQUID

Question: What did Jack order?

****

35. The ship was cruising along on the calm sea.
Suddenly it dived under water until only its periscope was visible.

Prime: SHIP Target: SUBMARINE

Question: Where did the ship go?

****

36. Mike broke his leg while playing the sport.
He tripped over his own skates while chasing the puck.

Prime: SPORT Target: HOCKEY

Question: What was Mike doing when he broke his leg?

****

37. Henry was well-traveled, but he had never been to this state before.
While he was there he learned how to dance the hula.

Prime: STATE Target: HAWAII

Question: Where was Henry?

****

38. Before Doug could do the job, he needed to get the proper tool from the shed.
It took many powerful swings before the big tree was chopped down.

Prime: TOOL Target: AXE

Question: What did Doug take out of the shed?

****

39. Denise's children were fascinated by the new toy.
They liked looking at the pictures of the kings, queens, and jacks.

Prime: TOY Target: CARDS

Question: What were the kids playing with?

****

40. Luke gazed at the tree that was blooming beautifully in the back yard.
He wondered how George Washington could have chopped down one of those.

Prime: TREE Target: CHERRY

Question: What was blooming in the yard?

****

41. Nancy did everything she could think of to get little Johnny to eat the vegetable.
Johnny finally gave in when she reminded him that Popeye eats it.

Prime: VEGETABLE Target: SPINACH

Question: What wouldn't little Johnny eat?

****

42. Chuck's wife didn't like him to take the vehicle to work.
She made sure that he always wore his helmet when he rode on it.

Prime: VEHICLE Target: MOTORCYCLE

Question: What did Chuck ride to work?

43. The Indian brave reached for one of the weapons and got ready. He aimed at the deer, pulled back on the bow, and released.

Prime: WEAPON Target: ARROW

Question: What did the Indian reach for?

****

44. The bad weather closed the airport. The dense grey mist made flying dangerous.

Prime: WEATHER Target: FOG

Question: What closed the airport?

****

45. The rickety old building collapsed last week. It did serious damage to the two cars it housed.

Prime: BUILDING Target: GARAGE

Question: What collapsed?

****

Stories Added for Experiment 4

****

46. The visiting scientists were surprised by how warm the type of dwelling was. They were grateful to the Eskimo tribe for carving the ice and helping to construct it.

Prime: DWELLING Target: IGLOO

Question: What did the Eskimo tribe help the scientists construct?

****

47. While at the restaurant, Robin and Greg asked for the customary eating utensils. They never used forks when eating at a Chinese place.

Prime: UTENSILS Target: CHOPSTICKS

Question: What did Robin and Greg ask for?

****

48. The little girl ate all of her vegetables so that she could have some of her favorite dessert.
The ones with the chocolate chips and walnuts were the ones she loved.

Prime: DESSERT Target: COOKIES

Question: What did the little girl love for dessert?

APPENDIX C

INSTRUCTIONS TO SUBJECTS

Instructions for Experiment 1

In this experiment you will read simple stories presented to you on the TV screen. After you've read a story, you will be shown a number of words one after the other. Your task is to decide whether or not the words appeared somewhere in the story. Here are the details of how this experiment works.

Each story you will read consists of three sentences. They will be shown to you one at a time. Specifically, each story starts with the word "READY?" on the screen. When you are ready, simply press the thumb switch on the inside right of the console in front of you and the first story sentence will appear. It will stay on as long as you need it to. When you have read and understood this sentence, press the thumb switch again, and then the next sentence will be shown. You simply go through the stories like this, pressing the switch when you have finished with a sentence.

When you press the switch after the third (and last) sentence of a story, the word recognition task begins. A word will be presented on the screen; you should decide as quickly as possible whether that word appeared somewhere in the story just read. You indicate your response by using the Yes-No levers on the response console. If you don't respond within five seconds, you'll hear a short beep to tell you that a new word is coming on, and then the new word will appear. In all, there are six words to respond to; they are presented automatically one after the other, so all you have to do is use the yes-no levers for this task.

Occasionally you will be given a question to answer about the story after you have done the word recognition task. Being able to answer the question depends on your having understood the story. There is an intercom in the lab that picks up your voice, so when you see a question, you can just answer aloud and I'll hear you in my room next door. Finally, to give you some indication of how well you're doing, your average time to respond (in thousandths of a second) and the number of errors made for each set of six words will appear on the screen.

In all, there are 30 stories and word lists to do, with short breaks after every six. The first six stories are for practice and with these you will be asked a question after each.

These are a lot of instructions, but before we begin I'll review them with you. Let me emphasize one more thing, though. It is extremely important that you understand the sets of three sentences as a story. The sentences are sometimes a bit vague or disconnected, but they do form a comprehensible story if you think about what you are reading. You may need to fill in information so that the sentences make sense as a story; the important point is that you shouldn't push the thumb switch to bring on the words until you are sure that you understand the third sentence and the story as a whole.

Instructions for Experiment 2

In this experiment you will read simple stories presented to you on the TV screen. After you've read a story, you will be shown a single word. Your task is to decide whether or not the word shown after the story appeared somewhere in it. Here are the details of how this experiment works.

Each "story" you will read consists of two sentences. They will be shown to you one at a time. Specifically, each story starts with the word "READY?" on the screen. When you are ready, simply press the thumb switch (it's on the inside right of the console in front of you) and the first sentence of the first story will appear. It will stay on as long as you need it to. When you have read and understood this sentence, press the thumb switch again, and then the next sentence will be shown. You simply go through the stories like this, pressing the switch when you have finished with a sentence.

When you press the switch after the second (and last) sentence of a story, the word recognition task is given. You will see three X's on the screen; these serve as a fixation point, so you should look at them. Half of a second after the X's appear they are replaced for a short time (1/4 or 3/4ths of a second) by a word. This word serves as a cue for the next word which appears on the screen, the target word. It is the target word which you must decide about. If it appeared somewhere in the two sentences you just read, pull up the lever marked "yes;" if it did not appear in the sentences, pull up the lever marked "no." To summarize, the stimulus sequence is: Fixation point (look at the point), cue word presentation (read the cue--no other response is required), and target word decision (decide if the word was in the sentences). The target word stays on the screen until you make a response to it or until five seconds are up, whichever is sooner. If you don't make a response within the five seconds allowed, the target word will disappear, and the word "ERROR" will appear on the screen. "ERROR" will also show up if you've made an incorrect response to a target word.

Occasionally you will be given a question to answer about the story after you have done the word recognition task. Being able to answer the question depends on your having understood the story. There is an intercom in the lab that picks up your voice, so when you see a question, you can just answer aloud and I'll hear you in my room next door.

In all, there are 72 stories to do, with short breaks after every 12. The first six stories are for practice and with these you will be asked a question after each; afterwards questions occur randomly.

These are a lot of instructions, but before we begin I'll review them with you. Let me emphasize one more thing, though. It is extremely important that you understand the pairs sentences as a story. The sentences are sometimes a bit vague or disconnected, but they do form a comprehensible story if you think about what you are reading. You may need to fill in information so that the sentences make sense as a story; the important point is that you shouldn't push the thumb switch to bring on the word until you are sure that you understand the sentence pair as a story.

Instructions for Experiments 3 and 4

In this experiment you will read simple stories presented to you on the TV screen. After you've read a story, you will be shown a single word. Your task is to read the word aloud as fast as you can. Here are the details of how this experiment works.

Each story you will read consists of two sentences. They will be shown to you one at a time. Specifically, each story starts with the word "READY?" on the screen. When you are ready, simply press one of the two triggers on the sides of the console in front of you (use the right-hand trigger if right-handed, the left trigger if left-handed) and the first sentence of the first story will appear. It will stay on as long as you need it to. When you have read and understood this sentence, pull the trigger again, and then the next sentence will be shown. You simply go through the stories like this, pressing the switch when you have finished with a sentence.

When you press the switch after the second (and last) sentence of a story, the word pronunciation phase starts. You will see three X's on the screen; these serve as a fixation point, so you should look at them. Half of a second after the X's appear they are replaced for a short time (1/4 of a second) by a cue word. You should read the cue word to yourself, but no response to it is required. The cue word will quickly disappear and be replaced by a target word. You should read this word out loud as quickly as you can. A special microphone connected to the computer will detect the sound of your voice and erase the TV screen. Following this, you will see a question about the story you just read. Being able to answer the question will usually depend on your having understood the story. You should just answer the question out loud; I'll hear your answers in my room next door through the lab intercom.

To summarize, the stimulus sequence after reading a pair of sentences is: 1--Fixation point (look at the X's); 2--Cue word (just read the cue silently; no other response is required); and 3--Target word presentation and target pronunciation (read the target aloud). If you haven't pronounced the word before 2 1/2 seconds, it disappears from the screen and the words "TRIAL OVER" will be shown briefly. Also if you misread the word, or if the microphone fails to pick up your voice properly, the word "ERROR" will appear. Finally, 4--A question will be shown after each story (answer out loud).

In all, there are 120* stories to do, with short breaks after every 24**. There are also six stories for practice at the experiment's beginning.

These are a lot of instructions, but before we begin I'll review them with you. Let me emphasize one more thing, though. It is <u>extremely</u> important that you understand the pairs sentences as a story. The sentences are sometimes a bit vague or disconnected, but they <u>do</u> form a comprehensible story if you think about what you are reading. You may need to fill in information so that the sentences make sense as a story; the important point is that you shouldn't pull the trigger to bring on the word for pronunciation until you are sure that you understand the sentence pair as a story.

*There were 128 stories for Experiment 4.

**Block size for Experiment 4 was 32.

APPENDIX D

RESULTS OF STATISTICAL ANALYSES FOR EXPERIMENTS 1, 2, 3, AND 4

TABLE 8

RESULTS OF ANALYSIS OF VARIANCE ON PRIME TRIAL RT FOR EXPERIMENT 1: ANALYSIS OVER SUBJECTS

Source	df	MS	Contributions to EMS	F	p*
Between Subjects	23				
Version (V)	1	44263.60	S/VF + V	.15	
Form (F)	1	123766.17	S/VF + F	.43	
VF	1	105913.91	S/VF + VF	.37	
Subjects (S) /VF	20	287612.67	S/VF		
Within Subjects	120				
Position (P)	2	120849.80	SP/VF + P	2.77	.0705
PV	2	62075.26	SP/VF + PV	1.42	
PF	2	59633.59	SP/VF + PF	1.36	
PVF	2	37455.68	SP/VF + PVF	.86	
SP/VF	40	43700.56	SP/VF		
Condition (C)	1	447559.89	SC/VF + C	8.56	.0084
CV	1	9696.83	SC/VF + CV	.19	
CF	1	92348.63	SC/VF + CF	1.77	
CVF	1	732.02	SC/VF + CVF	.01	
SC/VF	20	52303.98	SC/VF		
PC	2	106635.08	SPC/VF + PC	3.85	.0295
PCV	2	13205.38	SPC/VF + PCV	.48	
PCF	2	201500.78	SPC/VF + PCF	7.28	.0020
PCVF	2	34330.81	SPC/VF + PCVF	1.24	
SPC/VF	40	27672.74	SPC/VF		

Random Effects Variable: Subjects

*For this and all ANOVA tables to follow, only those probability values less than .10 are shown. An exception occurs in item analyses where certain p-values are shown to exceed .25. The corresponding tests were carried out as preliminaries to the pooling of mean squares. Pooling occurred whenever possible for the purpose of increasing error degrees of freedom.

TABLE 9

RESULTS OF ANALYSIS OF VARIANCE ON PRIME TRIAL RT FOR EXPERIMENT 1: ANALYSIS OVER ITEMS

Source	df	MS	Contributions to EMS	F	p
Between Items	47				
Set (S)	1	71.31	I/SFP + F/S + S	.00	
Form (F) /S	2	78736.00	I/SFP + F/S	2.79	.0748
Position (P)	2	74231.00	I/SFP + FP/S + P	.91	
SP	2	17547.00	I/SFP + FP/S + SP	.22	
FP/S	4	81216.00	I/SFP + FP/S	2.88	.0364
Items (I) /SFP	36	28234.00	I/SFP		
Within Items	48				
Version (V)	1	25174.00	IV/SFP + FV/S + V	.89**	
VS (Condition)	1	335520.00	IV/SFP + FV/S + VS	11.87**	.0013
FV/S	2	24269.00	IV/SFP + FV/S	.85*	>.2500
VP	2	18365.00	IV/SFP + FPV/S + VP	.65*	
VPS (Cond. x P)	2	52685.00	IV/SFP + FPV/S + VPS	1.85*	
FPV/S	4	27119.00	IV/SFP + FPV/S	.95	>.2500
IV/SFP	36	28608.00	IV/SFP		

Random Effects Variables: Set, Form, Items

Tested against an error term consisting of a pool of $MS_{IV/SFP}$ and $MS_{FPV/S}$ to yield MS = 28459.3 on 40 df (preliminary test of FPV/S against IV/SFP resulted in non-significant alpha level > .25).

Tested against an error term consisting of a pool of MS* and $MS_{FV/S}$ to yield MS = 28259.7 on 42 df (preliminary test of FV/S against MS* resulted in non-significant alpha level > .25).

TABLE 10

BONFERRONI T-TESTS ON PRIME TRIAL RT FOR EXPERIMENT 1

Test	Mean Diff	SD_{Diff}	t	df	p*
Inferred Primes					
Position 1 vs. Position 2	69.63	200.41	1.70	23	
Position 2 vs. Position 3	108.32	324.67	1.64	23	
Position 1 vs. Position 3	177.90	398.68	2.19	23	<.0333
Neutral Primes					
Position 1 vs. Position 2	72.18	309.15	1.14	23	
Position 2 vs. Position 3	56.22	197.20	1.40	23	
Position 1 vs. Position 3	15.96	199.72	.39	23	

*Needed for significance: $p < .0333$ (family-wise error rate = .05, one-tailed).

TABLE 11

RESULTS OF ANALYSIS OF VARIANCE ON PRIME TRIAL ERROR RATES FOR EXPERIMENT 1

Source	df	MS	Contributions to EMS	F	p
Between Subjects	23				
Version (V)	1	.02552	S/VF + V	.60	
Form (F)	1	.13165	S/VF + F	3.11	.0933
VF	1	.03841	S/VF + VF	.91	
Subjects (S) /VF	20	.04239	S/VF		
Within Subjects	120				
Position (P)	2	.01153	SP/VF + P	.67	
PV	2	.01922	SP/VF + PV	1.11	
PF	2	.04241	SP/VF + PF	2.46	.0985
PVF	2	.00448	SP/VF + PVF	.26	
SP/VF	40	.01726	SP/VF		
Condition (C)	1	.33284	SC/VF + C	20.24	.0002
CV	1	.00583	SC/VF + CV	.35	
CF	1	.09962	SC/VF + CF	6.06	.0231
CVF	1	.02213	SC/VF + CVF	1.35	
SC/VF	20	.01645	SC/VF		
PC	2	.00131	SPC/VF + PC	.08	.0295
PCV	2	.01212	SPC/VF + PCV	.74	
PCF	2	.09031	SPC/VF + PCF	5.49	.0078
PCVF	2	.00438	SPC/VF + PCVF	.27	
SPC/VF	40	.01645	SPC/VF		

Random Effects Variable: Subjects

TABLE 12

RESULTS OF ANALYSIS OF VARIANCE ON TARGET TRIAL RT FOR EXPERIMENT 1: ANALYSIS OVER SUBJECTS

Source	df	MS	Contributions to EMS	F	p
Between Subjects	23				
Version (V)	1	3431.13	S/VF + V	.01	
Form (F)	1	377123.93	S/VF + F	1.46	
VF	1	799499.75	S/VF + VF	3.09	.0939
Subjects (S) /VF	20	258383.74	S/VF		
Within Subjects	120				
Position (P)	2	266300.25	SP/VF + P	3.90	.0283
PV	2	72994.94	SP/VF + PV	1.07	
PF	2	28800.79	SP/VF + PF	.42	
PVF	2	21543.06	SP/VF + PVF	.32	
SP/VF	40	68221.10	SP/VF		
Condition (C)	1	3161.72	SC/VF + C	.06	
CV	1	8101.35	SC/VF + CV	.15	
CF	1	.38	SC/VF + CF	.00	
CVF	1	224.78	SC/VF + CVF	.00	
SC/VF	20	54183.34	SC/VF		
PC	2	36508.10	SPC/VF + PC	.79	
PCV	2	50289.96	SPC/VF + PCV	1.09	
PCF	2	95174.55	SPC/VF + PCF	2.07	
PCVF	2	10412.90	SPC/VF + PCVF	.23	
SPC/VF	40	45971.32	SPC/VF		

Random Effects Variable: Subjects

TABLE 13

RESULTS OF ANALYSIS OF VARIANCE ON TARGET TRIAL RT FOR EXPERIMENT 1:
ANALYSIS OVER ITEMS

Source	df	MS	Contributions to EMS	F	p
Between Items	23				
Set (S)	1	38.43	I/SP + S	.00*	
Position (P)	2	163010.00	I/SP + SP + P	1.68*	
SP	2	60332.00	I/SP + SP	.60	>.2500
Items (I) /SP	18	101050.00	I/SP		
Within Items	72				
Version (V)	1	11824.00	IV/SP + VS + V	.30**	
VS	1	5900.70	IV/SP + VS	.13	>.2500
VP	2	48059.00	IV/SP + VPS + VP	10.15	.0897
VPS	2	4733.70	IV/SP + VPS	.10	>.2500
IV/SP	18	28608.00	IV/SP		
Condition (C)	1	5588.50	CI/SP + CS + C	.02	
CS	1	285750.00	CI/SP + CS	12.78***	.0021
CP	2	26202.00	CI/SP + CSP + CP	1.37	
CSP	2	19146.00	CI/SP + CSP	.86	>.2500
CI/SP	18	22281.00	CI/SP		
VC	1	3648.70	VCI/SP + VCS + VC	.05****	
VCS	1	613110.00	VCI/SP + VCS	8.97****	.0067
VCP	2	37629.00	VCI/SP + VCSP + VCP	2.72	
VCSP	2	13825.00	VCI/SP + VCSP	.18	>.2500
VCI/SP	18	77781.00	VCI/SP		

Random Effects Variables: Set, Items

Tested against an error term consisting of a pool of $MS_{I/SP}$ and MS_{SP} to yield MS = 96978 on 20 df (preliminary test of SP against S/SP resulted in non-significant alpha level > .25).

Tested against an error term consisting of a pool of $MS_{VI/SP}$, MS_{VSP}, and MS_{VS} to yield MS = 39484.7 on 21 df (preliminary tests of VSP and VS against IV/SP resulted in non-significant alpha levels > .25).

Tested against an error term consisting of a pool of $MS_{CI/SP}$, MS_{CSP}, and MS_{CP} to yield MS = 22352.6 on 22 df (preliminary tests of CSP against CI/SP, and their pool against CP resulted in non-significant alpha levels > .25).

****Tested against an error term consisting of a pool of $MS_{VCI/SP}$, MS_{SPVC}, and MS_{PVC} to yield MS**** = 68318.55 on 22 df (preliminary tests of SPVC against VCI/SP, and their pool against PVC resulted in non-significant alpha levels > .25).

TABLE 14

BONFERRONI T-TESTS ON TARGET TRIAL RT FOR EXPERIMENT 1

Test	Mean Diff	SD_{Diff}	t	df	p*
Marginal Means					
Position 1 vs. Position 2	136.77	259.92	2.58	23	<.0333
Position 1 vs. Position 3	119.53	230.15	2.54	23	<.0333
Position 2 vs. Position 3	17.26	271.17	.31	23	

*Needed for significance: $p < .0333$ (family-wise error rate = .05, one-tailed).

TABLE 15

RESULTS OF ANALYSIS OF VARIANCE ON TARGET TRIAL ERROR RATES FOR EXPERIMENT 1

Source	df	MS	Contributions to EMS	F	p
Between Subjects	23				
Version (V)	1	.01146	S/VF + V	.47	
Form (F)	1	.00502	S/VF + F	.20	
VF	1	.00358	S/VF + VF	.15	
Subjects (S) /VF	20	.02464	S/VF		
Within Subjects	120				
Position (P)	2	.01679	SP/VF + P	1.66	
PV	2	.03519	SP/VF + PV	3.48	.0404
PF	2	.00194	SP/VF + PF	.19	
PVF	2	.02731	SP/VF + PVF	2.70	.0794
SP/VF	40	.01011	SP/VF		
Condition (C)	1	.03628	SC/VF + C	2.18	
CV	1	.00358	SC/VF + CV	.21	
CF	1	.02731	SC/VF + CF	1.64	
CVF	1	.00670	SC/VF + CVF	.40	
SC/VF	20	.01665	SC/VF		
PC	2	.01096	SPC/VF + PC	.54	
PCV	2	.01805	SPC/VF + PCV	.89	
PCF	2	.04888	SPC/VF + PCF	2.41	
PCVF	2	.03455	SPC/VF + PCVF	1.70	
SPC/VF	40	.02028	SPC/VF		

Random Effects Variable: Subjects

TABLE 16

RESULTS OF ANALYSIS OF VARIANCE ON RT FOR EXPERIMENT 2:
ANALYSIS OVER SUBJECTS

Source	df	MS	Contributions to EMS	F	p
Between Subjects	19				
Version (V)	1	319742.74	S/VF + V	1.64	
Form (F)	1	261.26	S/VF + F	.00	
VF	1	1042639.26	S/VF + VF	5.33	.0346
Subjects (S) /VF	16	195457.01	S/VF		
Within Subjects	60				
SOA (X)	1	579.91	SX/VF + X	.02	
XV	1	109803.60	SX/VF + XV	4.17	.0581
XF	1	3086.24	SX/VF + XF	.12	
XVF	1	3659.73	SX/VF + XVF	.14	
SX/VF	16	26346.84	SX/VF		
Condition (C)	1	36597.86	SC/VF + C	1.23	
CV	1	17860.77	SC/VF + CV	.60	
CF	1	3276.16	SC/VF + CF	.11	
CVF	1	44514.80	SC/VF + CVF	1.50	
SC/VF	16	29695.11	SC/VF		
XC	1	11295.74	SXC/VF + XC	.14	
XCV	1	16797.68	SXC/VF + XCV	.21	
XCF	1	1096.90	SXC/VF + XCF	.01	
XCVF	1	119177.50	SXC/VF + XCVF	1.47	
SXC/VF	16	81200.14	SXC/VF		

Random Effects Variable: Subjects

TABLE 17

RESULTS OF ANALYSIS OF VARIANCE ON RT FOR EXPERIMENT 2:
ANALYSIS OVER ITEMS

Source	df	MS	Contributions to EMS	F	p
Between Items	23				
Set (S)	1	7228.50	I/S + S	.00	
Items (I) /S	22	58972.00	I/S		
Within Items	72				
SOA (X)	1	1657.40	XI/S + XS + X	.01*	
XS	1	102.03	XI/S + XS	.00	>.2500
XI/S	22	105750.00	XI/S		
Condition (C)	1	29651.00	CI/S + CS + C	.51**	
CS	1	5265.70	CI/S + CS	.09	>.2500
CI/S	22	60353.00	CI/S		
XC	1	9286.00	XCI/S + XCS + XC	.20***	
XCS	1	53.69	XCI/S + XCS	.00	>.2500
XCI/S	22	49351.00	XCI/S		

Random Effects Variables: Set, Items

Tested against an error term consisting of a pool of $MS_{XI/S}$ and MS_{XS} to yield MS = 202313.04 on 23 df (preliminary test of XS against XI/S resulted in non-significant alpha level > .25).

Tested against an error term consisting of a pool of $MS_{CI/S}$ and MS_{CS} to yield MS = 57959.38 on 23 df (preliminary test of CS against CI/S resulted in non-significant alpha level > .25).

Tested against an error term consisting of a pool of $MS_{XCI/S}$ and MS_{XCS} to yield MS = 47206.68 on 23 df (preliminary test of XCS against XCI/S resulted in non-significant alpha level > .25).

TABLE 18

RESULTS OF ANALYSIS OF VARIANCE ON NAMING LATENCY FOR EXPERIMENT 3: ANALYSIS OVER SUBJECTS

Source	df	MS	Contributions to EMS	F	p
Between Subjects	26				
List (L)	2	12804.48	S/L + L	.57	
Subjects (S) /L	24	22474.10	S/L		
Within Subjects	54				
Condition (C)	2	19590.91	SC/L + C	20.74	.0000
CL	4	471.44	SC/L + CL	.49	
SC/L	48	957.12	SC/L		

Random Effects Variable: Subjects

TABLE 19

RESULTS OF ANALYSIS OF VARIANCE ON NAMING LATENCY FOR EXPERIMENT 3: ANALYSIS OVER ITEMS

Source	df	MS	Contributions to EMS	F	p
Between Items	44				
Set (S)	2	161.31	I/S + S	.03	
Items (I) /S	42	5177.94	I/S		
Within Items	90				
Condition (C)	2	29815.72	CI/S + CS + C	2.58	
CS	4	11562.15	CI/S + CS	8.29	.0000
CI/S	84	1394.78	CI/S		

Random Effects Variables: Set, Items

TABLE 20

BONFERRONI T-TESTS ON NAMING LATENCY FOR EXPERIMENT 3

Test	Mean Diff	SD_{Diff}	t	df	p*
Inf./Pos. vs. Non-Inf./Pos.	51.79	51.96	5.18	26	<.0500
Inf./Pos. vs. Inf./Neut.	13.05	31.77	2.14	26	<.0500

*Needed for significance: $p < .0500$ (family-wise error rate = .05, one-tailed).

TABLE 21

RESULTS OF ANALYSIS OF VARIANCE ON NAMING LATENCY FOR EXPERIMENT 4: ANALYSIS OVER SUBJECTS

Source	df	MS	Contributions to EMS	F	p
Between Subjects	19				
List (L)	3	30077.72	S/L + L	1.56	
Subjects (S) /L	16	19327.60	S/L		
Within Subjects	60				
Condition (C)	1	56063.46	SC/L + C	40.55	.0000
CL	3	1214.89	SC/L + CL	.88	
SC/L	16	1382.65	SC/L		
Type of Prime (T)	1	2012.82	ST/L + T	4.89	.0419
TL	3	1565.65	ST/L + TL	3.80	.0312
ST/L	16	411.70	ST/L		
CT	1	1334.49	SCT/L + CT	2.13	
CTL	3	1234.99	SCT/L + CTL	1.97	
SCT/L	16	625.40	SCT/L		

Random Effects Variable: Subjects

TABLE 22

RESULTS OF ANALYSIS OF VARIANCE ON NAMING LATENCY FOR EXPERIMENT 4: ANALYSIS OVER ITEMS

Source	df	MS	Contributions to EMS	F	p
Between Items	47				
Set (S)	3	3919.30	I/S + S	.54	
Items (I) /S	44	7286.10	I/S		
Within Items	144				
Condition (C)	1	134204.70	CI/S + CS + C	5.83	.0946
CS	3	23013.20	CI/S + CS	7.71	.0003
CI/S	44	2983.00	CI/S		
Type of Prime (T)	1	5272.60	TI/S + TS + T	.42	
TS	3	12663.00	TI/S + TS	8.05	.0002
TI/S	44	1573.70	TI/S		
CT	1	3140.00	CTI/S + CTS + CT	.07	
CTS	3	42229.00	CTI/S + CTS	25.09	.0000
CTI/S	44	1683.30	CTI/S		

Random Effects Variables: Set, Items

TABLE 23

BONFERRONI T-TESTS ON NAMING LATENCY FOR EXPERIMENT 4

Test		Mean Diff	SD_{Diff}	t	df	p*
Inferred:	Pos. vs. Neut.	1.86	39.06	.21	19	
Non-Inf.:	Pos. vs. Neut.	18.20	33.25	2.45	19	$<.0500$

*Needed for significance: $p < .0500$ (family-wise error rate = .05, one-tailed).