COMPREHENSION OF COMPLEX SENTENCES CONJOINED WITH "BEFORE" AND "AFTER"

by

WENDY LYNNE DUKE

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Department of Audiology and Speech Sciences

The University of British Columbia
1956 Main Mall
Vancouver, Canada
V6T 1Y3

Date August 17th, 1982

ABSTRACT

The purpose of this investigation is to examine the effects of certain factors on adults auditory comprehension of complex sentences conjoined with *before* and *after*. The factors investigated are: conjunction choice, order of mention, clause placement, and general-knowledge constraints. The sentences used in the study fall into four syntactic categories (Before-1, Before-2, After-1, After-2) and two semantic categories (*constrained* by general knowledge and *unconstrained*). Sixteen subjects each participated in two tasks designed to elicit varying reaction times. Stimuli consisted of 160 pre-recorded sentences describing 40 sequences of two events, with corresponding slide illustrations. Reaction time to task stimuli was recorded to the nearest hundredth of a second. Square roots of the reaction times were subjected to analysis of variance. Results indicate that only the placement of the main clause produces a significant effect on subjects' responses, thus lending support to a growing body of data which suggests that the main clause holds a priveleged position in the comprehension of complex sentences. Results are discussed with respect to experimental design, previous research and theories of sentence comprehension.

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CHAPTER ONE

A REVIEW OF THE LITERATURE

Introduction

A number of studies in the past two decades have investigated the comprehension and/or production of complex sentences conjoined with *before* and *after*. The following survey will focus on comprehension data. As may be seen in Table I, four sentences with the same operational meaning can be produced by manipulating certain factors within sentences of this kind.

The three factors which are opposed within the sentences are:

1) Conjunction Choice - sentences 1 and 2 are conjoined with *before*, whereas sentences 3 and 4 are conjoined with *after*.
2) Clause Placement - sentences 1 and 3 have an initial main clause, whereas sentences 2 and 4 have a final main clause.
3) Order of Mention - for sentences 1 and 4, the order of mention of events corresponds to the order

of occurrence of events (OME=OOE). That is, the order in which the two events are stated is the same as the order in which the two events occurred. In contrast, temporal ordering of the events is not preserved in sentences 2 and 3.

Table I

Before/After Complex Sentence Types and the Factors Which Distinguish Them

Sentence Type		Factors		
	Examples	Order of Mention	Conjunction Choice	Clause Placement
		OME=OOE[a]	Before	Main Clause First
1.	She packed the suitcase before she washed the dishes.	+	+	+
2.	Before she washed the dishes, she packed the suitcase.	-	+	-
3.	She washed the dishes after she packed the suitcase.	-	-	+
4.	After she packed the suitcase, she washed the dishes.	+	-	-

[a]OME=OOE is to be read: Order of mention of events equals order of occurrence of events.

The preceding factors have been most consistently investigated as to their role in the comprehension of complex sentences conjoined with *before* and *after*. These factors are, therefore, basic to any discussion concerning comprehension studies of such sentences. A number of additional factors have also been investigated and will be elaborated upon where relevant in the ensuing survey.

Studies Using Adult Subjects

Although most of the research concerning comprehension of *before* and *after* in complex sentences have involved young children as subjects, some of the earlier investigations examined comprehension in adult subjects. Clark and Clark (1968) investigated adults' memory for such sentences. The purpose of their study was to determine whether, in recalling complex sentences, subjects were more likely to remember certain semantic distinctions or to remember transformational markers. They proposed that a semantic explanation of memory would be supported by a response bias for sentences in which the order of occurrence of events was preserved (as in sentences 1 and 4 in Table I). In contrast, a transformational complexity model of memory would be supported by a response bias for sentences in which the subordinate clause was in final position, assuming that sentences with a preposed subordinate clause are transformationally more complex than sentences beginning with a main clause.

Clark and Clark constructed 72 complex sentences for their investigation. In addition to the four sentence types given in Table I, they included sentences of the forms "S_1 and then S_2" and "S_2 but first, S_1". These stimuli were each paired with a noun cue, and were presented on IBM cards in groups of six. Subjects were permitted to study each noun cue and sentence for 10 seconds. After completing each set of six, the subjects were presented with a second set of cards, which contained only the noun cues. They were instructed to write the appropriate sentence, verbatim, beside each noun cue.

The Clarks found two response biases for verbatim recall; one, for sentences in which temporal order of events was preserved, and one for sentences beginning with a main clause. They also determined that subjects better remembered the underlying sense of sentences preserving temporal order. Clark and Clark interpreted these results as supportive of a "semantic explanation of memory as the most general explanation", (p. 130). In discussion, they account for their findings in terms of marked and unmarked semantic distinctions.

Smith and McMahon (1970) investigated adults' comprehension of such complex sentences in a variety of tasks. These experiments were all performed using a reaction time paradigm. For each experiment, sentences of the types depicted in Table I were projected on slides. Following the presentation of each slide, subjects were required to supply the appropriate

clause in answer either to the question "What happened first?" or to the question "What happened second?". The three experiments differed with respect to the temporal relation of the prompt question and the sentence stimuli. In experiment one, the prompt question ("What happened first/second?") was explicitly stated prior to the presentation of each sentence. For experiments two and three, the prompt question was presented after the stimulus sentence. An interfering task (oral reading of a three digit number) was presented between the stimuli and prompt for experiment three. In each experiment, both the error rate and response latency times for each sentence type were analyzed. For experiments two and three, mean inspection time (the time which the subjects chose to study the sentence) was also analyzed.

Smith and McMahon found no evidence that sentences in which temporal order was preserved were comprehended more easily. One measure (inspection time) was, in fact, consistently longer for these sentences. Latency time results for order of mention varied between experiments. They did find, however, that the event which was asserted to have happened first was more accessible, regardless of sentence type. As regards *before* and *after* differences, the only significant difference found was in experiments two and three, where shorter inspection times were found for *before* sentences.

Smith and McMahon found consistent significant results for main clauses versus subordinate clauses. In each experiment, it took subjects longer to supply the subordinate clause than the main clause as an answer. The error rate of

subordinate clause answers was also significantly greater. In general, Smith and McMahon's results indicate that information in the main clause is more readily available and more easily interpreted than information in the subordinate clause.

Because these results seemed to contradict those found by the Clarks (as regards order-of-mention differences), Smith and McMahon replicated the Clarks' study and found their results to be reliable. Smith and McMahon suggested that the differences they observed might be due to differences in the processes of memory versus comprehension, and proposed that "order of mention does not have much of an influence on understanding, but has an interfering effect on memory" (p. 269).

Smith and McMahon indicated that many of their results varied remarkably in relative size depending on the exact nature of the task. Discussing this with respect to implications for a theory of comprehension, they claimed that their results support Bever's (1970) theory of a single process, multiple output comprehension process. They suggested that, in terms of Bever's theory, the differences in results between different tasks can be explained "by postulating that various tasks require different levels of abstraction or ... deeper exit points in a sub-routine" (p. 271).

Bever, in 1970, published a paper in which he proposed several organizing principles which he suggested might be basic to the comprehension of complex sentence, and in which

he discussed the studies of Smith and McMahon and the Clarks. Bever summarized these principles as follows:

A. In comprehension, the assertion of a sentence is the basis; the presupposition is organized as psychologically subsidiary to it.

B. In the comprehension of ordered events we organize the relations by starting with the first event, organizing the other events as subsidiary to the first.

C. *Ceteris paribus* tenporal order preferably corresponds to the actual order of the clauses. (Bever, 1970, p. 286).

With respect to previous studies, Bever's principle A provides a semantic explanation for the primacy of the main clause, as found by Smith and McMahon. Likewise, principles B and C predict the memory results which the Clarks found. In addition, Bever pointed out that, when combined, principles A and B predict that *before* sentences will be easier to understand than *after* sentences. That is, assertion and order are confounded in the sense that "in *before* sentences, the assertion (in the main clause) also describes the first event, while in *after* sentences it is the presupposition (in the subordinate clause) that describes the first event" (p. 287).

Bever suggested that these principles may play different relative roles in memory and comprehension. That is, depending on the task, one principle may play a reduced role relative to another. If different organizing principles are dominant among different tasks, then equivalent results would not be expected from one task to another.

Studies With Children As Subjects

In 1971, Eve Clark published the results of a study in which she investigated young children's acquisition of *before* and *after* in sentences like those in Table I. Clark chose these relational terms for study for two reasons. First, in a previous study (Clark, 1969, 1970) of young Children's spontaneous use of conjunctions, she had noticed that children (age 3;0-3;6) generally described temporally related events by use of an order-of-mention strategy; they talked about ordered events in the same order as they had occurred. Clark postulated, therefore, that young children who do not understand *before* and *after* might similarly rely on an order-of-mention strategy in interpreting such sentences. Second, recent evidence had suggested that young children display an asymmetry in the acquisition of certain pairs of relational words, acquiring the positive member of such pairs prior to the negative member (Donaldson and Wales, 1970).

In order to investigate children's comprehension of *before* and *after* in complex sentences, Clark constructed 32 sentences, eight each of the four sentence types shown in Table I. Forty children, ranging in age from 3;0-5;0, particiapted in the study. They were divided into four age groups of half-yearly intervals. The children were asked to carry out instructions, based on these sentences. The examiner read a sentence (e.g. "The boy kicked the rock after he patted the dog") and the child acted out the sentence with

appropriate toys. (A second task was designed to investigate children's production of *before* and *after*. This will not be discussed in detail here as it has no direct bearing on the comprehension of these terms, nor on the methodology developed by Clark to investigate comprehension. Generally, the results of the production task were consistent with those of the comprehension task). Errors were analyzed with respect both to the child's age group and to the sentence type. Only reversal errors were analyzed as there were no omission errors.

Clark obtained several interesting results. First, as predicted, the younger children in the study, who did not seem to fully understand *before* and *after*, appeared to follow an order-of-mention strategy in interpreting these sentences. That is, they interpreted the first event mentioned in the sentence as that event which had occurred first, resulting in superior performance for Before-2 and After-1 sentences (sentence types 1 and 4 in Table I).

The children in Clark's study also appeared to go through predictable stages in their acquisition of the terms *before* and *after*, in which *before* was generally acquired at an earlier age. Clark proposed 4 stages of acquisition of these terms:

1) Children understand neither term and rely on an order-of-mention strategy.
2) Children understand *before*, but rely on an order-of-mention strategy to interpret *after*.

3) Children treat *after* as though it means *before*.

4) Children interpret both terms correctly.

Clark accounted for her results by reference to her "semantic feature" hypothesis. Briefly, this hypothesis states that children learn the meanings of words by acquiring semantic components one at a time, in a hierarchical fashion, from the superordinate features on down. Thus, at one stage, children will confuse antonyms (such as *before* and *after*) because they only know the superordinate features which are common to both words. The specific semantic feature matrices which Clark proposed for these terms are as follows:

before:	*after*:
+ Time	+ Time
- Simultaneous	- Simultaneous
+ Prior	- Prior

Clark noted that the positive member of the pair will be acquired first because it is linguistically unmarked. In this case, *before* is considered by linguists to be the positive, or unmarked member of the relational pair (Leech, 1970).

Barrie-Blackley (1973) conducted a study which also investigated children's understanding of *before* and *after*, as well as *until*, in similar complex sentences. A comprehension task similar to Clark's was used to investigate comprehension of these terms for 30 subjects, age 6 years. Unlike Clark, Barrie-Blackley found that her subjects made more reversal errors for *before* sentences than for *after* sentences (74% and 26% of the incorrect responses, respectively). Barrie-Blackley offered no explanation for this apparent contradiction, and

concluded that six year olds have not yet mastered the adjoining of clauses with temporal links. Although some subsequent studies have failed to find superior performance for *before* sentences, Barrie-Blackley's result of fewer errors for *after* sentences has not been replicated in any of the literature reviewed here, for English complex sentences.

Clark's study generated considerable research on the comprehension of these temporal terms; much discussion centred on the differences in results obtained by Clark and Amidon and Carey. In their 1972 study, Amidon and Carey investigated children's ability to perform temporally ordered commmands under a variety of conditions. The sentences used in their study were all in the imperative (e.g. "Before you move a red plane, move a blue plane"). The 50 subjects in this study, age 5;4-6;3, were somewhat older than Clarks. These subjects were divided into 5 groups, each of which performed the tasks under different training conditions. One group received feedback as to the correctness of their responses, one received intonational emphasis on the conjunction in the command, and one received both feedback and intonational emphasis. In addition, two control groups were included, neither of which received feedback or emphasis. The second control group, however, were trained with *first* and *last* instead of *before* and *after*. After the training sessions, they were given a post-test, during which they received

neither intonational emphasis nor feedback. The post-test results for the various groups were compared.

Amidon and Carey obtained several interesting results. First, the second control group demonstrated very little difficulty in performing tasks with *first* and *last*, indicating that any difficulties with *before* and *after* could not be attributed solely to difficulty performing ordered tasks. Intonational emphasis was not found to facilitate performance of the task. Feedback, however, was found to greatly reduce errors. Those children who did not receive feedback, and subsequently made more errors on the post-test, were found to commit errors which were most often omissions of the subordinate clause, regardless of sentence type. For reversal errors only, there was a nonsignificant trend towards fewer errors when the temporal order of the events was preserved in the sentence. Contrary to Clark, therefore, Amidon and Carey did not find order-of-mention to be a dominant strategy. Differences for *before* and *after* also failed to reach significance, although there was a trend towards fewer overall errors on *before* sentences.

Amidon and Carey pointed out that their results provided an interpretive difficulty for Clark's semantic feature hypothesis. Since children in their study experienced much more difficulty with *before* and *after* than with *first* and *last*, the authors suggested that the problem lies not in acquisition of semantic features, but in handling the additional syntactic

complexity of a subordinate clause. Amidon and Carey concluded that these results support Smith and McMahon's contention that information in main clauses is more salient than information in subordinate clauses. They noted that, since the children receiving feedback in their study appeared to alter their strategy of attending preferentially to the main clause, their study lent support to Bever's (1970) notion that "listener's habits of organizing relations between clauses may change with age and experimental instruction" (p. 422).

Helen Johnson, in 1975, replicated both the Clark and Amidon and Carey studies. She found the seemingly contradictory results from both studies to be reliable. As the same subjects (18 preschool children, age 4;2-5;2) participated in all of Johnson's task, this would suggest that the different results must be due to the nature of the tasks, rather than to random differences in the populations used. Johnson's study was an attempt to delineate the relative importance of order-of-mention and main-subordinate relation strategies in children's comprehension of *before* and *after*. In fact, Johnson found evidence for both strategies; in different situations it appeared that one strategy was more dominant than the other. In the task modelled after Clark's study, reversal errors predominated and an error analysis revealed that children seemed to be using an order-of-mention strategy. When the children were given imperative commands, as in the Amidon and Carey study, errors tended towards

omissions of one clause, rather than reversals. Consistent with Amidon and Carey, the subordinate clause was most often omitted. Johnson's explanation for her results was that the strategies used by children to interpret these sentences may be sentence-form specific. That is, for declarative sentence, as used by Clark, the children appeared to follow an order-of-mention strategy, whereas for imperative sentence, the children appeared to follow a strategy of attending preferentially to the main clause. Johnson did not, however, agree with Amidon and Carey that this result supports the view that information in the main clause is more easily interpreted. Rather, Johnson suggested that (for imperative sentences) children may not be aware that the subordinate clause is also part of the command. She claimed that for a sentence such as *Eat your cheese before you drink your juice*, only the main clause is a direct command. The children, therefore, may not have had difficulty understanding a subordinate clause per se, but simply failed to understand, without corrective feedback, that both clauses of an imperative sentence should be out.

Pamela Coker (1978) examined children's comprehension of *before* and *after* used both as prepositions and as subordinating conjunctions. The subjects in her study were 60 kindergartners and 60 first-graders, ranging in age from 5;3 to 7;7. The complex sentence task was similar to Clarks and utilized similar sentences. Coker's results indicated that children

acquire *before* and *after* first as prepositions and later as subordinating conjunctions. On one prepositional task, in which children were presented with a sequence of three pictures and then asked "What did I show you before/after the x?", the children demonstrated use of a strategy whereby they responded with the next-event-in-time. This strategy, which Coker felt is somewhat analagous to an order-of-mention strategy in complex sentences, resulted in superior performance for *after* questions.

For the subordinate clause task, children were found to utilize either an order-of-mention strategy or a main-clause-first strategy. Coker pointed out that this latter strategy, of directing attention toward the main clause in the sense of acting that clause out first, will result in superior performance on *before* sentences, since the main clause always expresses the first event in *before* sentences. For this reason, children using this strategy showed the same response pattern as those identified by Clark as treating *after* to mean *before*. Coker argued, however, that this response pattern is better explained as a syntactic strategy of preferentially attending to the main clause for three reasons. First, the children who responded in this manner for the subordinate clause task showed no evidence of treating *after* to mean *before* in the prepositional tasks; in fact, many of these children, i.e. those using a next-event-in-time strategy, showed superior performance with *after* used as a preposition.

Second, this explanation is compatible with the results of previous research by Amidon and Carey and Bever. Third, Coker cited evidence from a number of sources (Coker and Legum, 1975; Coots, 1976; Eilers, Oller and Ellington, 1974; and Glusksberg, Hay and Danks, 1976) in which polarity differences were not found for other polar opposite pairs, thus bringing into question Clark's contention that the positive member of a polar pair is acquired earlier.

Coker also discussed the matter of order-of-mention versus main-clause strategies. In Coker's study, both strategies were evident (order-of-mention being more common), whereas Amidon and Carey had found much more evidence of a main-clause strategy than was apparent in either Coker's or Clark's studies. In an effort to reconcile this apparent contradiction, Coker suggested, as did Johnson before her, that these strategies are task specific. Unlike Johnson, however, she did not attribute the difference to imperative versus declarative sentences, but rather to a difference in how the child is cued to attend to the test sentences. She argued that when the child is cued to pay attention to both clauses, an order-of-mention strategy will be more dominant and the main-clause strategy will surface only in terms of better performance for *before* sentences. When, however, the child is not cued to attend to both clauses (as in Amidon and Carey's non-feedback group) the main-clause strategy will dominate and will be evident in omissions of the subordinate clause.

This is a very interesting argument. Not only does it allow for an integration of those results discussed by Coker, but it also seems to provide a logical reconciliation for the differences in results found by the Clarks, as opposed to Smith and McMahon, when working with adult subjects. The Clarks' verbatim recall task, which resulted in an order-of-mention response preference, forced the subjects to attend to both clauses. Conversely, Smith and McMahon's instructions to subjects to respond to a question with the appropriate clause, may well not have forced the subject to attend to both clauses; as Coker's argument would predict, the primary role of the main clause was evident in this study.

A further problem associated with Clark's semantic feature hypothesis was suggested by Lynne Feagans (1980) Feagans investigated children's comprehension of terms related to the concepts of order, duration and simultaneity in complex sentences, as expressed by the words *before, after, since* and *until*. Feagans cited evidence from philosophical analysis (van Fraasen, 1970) which has suggested that order is a more basic concept than simultaneity or duration. Feagans also referred to Piaget's (1966) claim that children acquire a sense of temporal order prior to a sense of duration, pointing out some older language acquisition data (Ames, 1964; Stern, 1962) which tend to support this view. The problem which this notion represents for Clark's hypoyhesis relates to the specific semantic feature matrices which Clark devised in

order to account for her *before/after* data in terms of her semantic feature hypothesis. In these matrices, the feature "Simultaneous" is represented as superordinate to the feature "Prior". Since one of the principles of the semantic feature hypothesis is that general features are acquired prior to more specific ones, any evidence demonstrating that terms expressing order are acquired at an earlier age than those expressing simultaneity would call Clark's hypothesis into question.

Feagans examined this problem with 60 children, ages 3, 5 and 7 years. Similarly to the Clark study, children were asked to act out sentences presented to them by the examiner. As predicted by Feagans, the results indicated that *before* and *after* (the temporal order terms) were generally comprehended at an earlier age than *since* and *until*. Feagans found that, even at seven years of age, the children did not respond above chance level for durational and simultaneity terms. This result casts doubt on either the above principle of the semantic feature hypothesis, or, at the very least, on the specifications of how this hypothesis relates to the acquisition of *before* and *after*, as outlined by Clark, (1970).

In 1977, French and Brown published a paper investigating the role of semantic constraints on children's comprehension of *before* and *after* in complex sentences, thus adding another dimension to this problem. They contended that Clark's semantic feature hypothesis fails to account for the role

played by supportive context in language acquisition. Although this question had not previously been examined with specific reference to the acquisition of *before* and *after*, French and Brown reported research which indicates that children are better able to understand relations in active and passive sentences when contextual semantic constraints are provided (Bever, 1970; Olson and Nickerson, 1977; Sinclair-de Zwart, 1969). In addition, they pointed out that Brown (1976) found that young children's memory for ordered sequences improved when the sequences were meaningfully ordered.

In order to examine the role of contextual support in the acquisition of *before* and *after*, French and Brown constructed a number of two-event sentences in which events were meaningfully ordered; that is, events in the sentences bore a predictible temporal relationship to each other (e.g."Raggedy Ann fills the bottle before she feeds the baby"). The component clauses of these logically constrained sentences were then randomly cross-matched with each other in order to produce an equal number of sentences in which the events were arbitrarily ordered. Forty children, ranging in age from 3;5-5;1, were asked to act out these sentences, in a procedure similar to that used by Clark.

French and Brown found that performance was markedly superior for the logical sequences. They concluded that their results support the importance of context in language development in general, and, specifically that acquisition

of *before* and *after* is facilitated by situations which provide contextual support.

Other interesting results were obtained in this study. French and Brown reported a nonsignificant tendency for fewer reversal errors on sentences which preserve the order of mention of events. In an analysis of number correct, no difference was found for the *before/after* variable. An interesting pattern was noted for omission errors. For arbitrary sentences, omission errors tended to be omissions of the subordinate clause, as found by Amidon and Carey. For logical sentences, however, errors tended to be associated with the second event. French and Brown postulated that "given the semantic constraints of the logical sentences, the main clause loses its privileged position" (p.253).

Kavanaugh (1979) also investigated the role of logical constraints on children's understanding of *before* and *after* in complex sentences. In a procedure similar to French and Browns, Kavanaugh presented 30 children with sentences in which the events were either logically or arbitrarily ordered. These children were divided into two age groups, (3;6-4;2 and 4;3-5;0). Consistent with the results of French and Brown, Kavanaugh found superior performance for logically ordered sentences, when the total number of errors was analyzed. On further analysis, this finding was maintained for reversal errors, but not for omission errors. Kavanaugh suggested that this result was due to the fact that older children

commit few omission errors; these children, he felt, will be more likely to reverse a sequence of events in preference to omitting one event, when encountering difficulty.

One final point raised by Kavanaugh bears mention. Although the role of semantic constraints and nonlinguistic strategies in language acquisition was not considered when Clark originally proposed the semantic feature hypothesis (as French and Brown have pointed out), Kavanaugh claimed "that more recent formulations of semantic feature theory (Clark, 1973, 1975, 1977; Clark and Garnica, 1974) are not imcompatible with the demonstrated effects of constrained sentences" (p. 357).

Other Related Studies

On the Role of Semantic Constraints in the Comprehension of Active and Passive Sentences

As French and Brown noted, although no previous research was concerned with the role of semantic constraints on the comprehension of *before* and *after*, a number of studies examined this question with regard to acquisition of passive sentences. French and Brown referred only to studies which investigated the effects of such constraints for young children's acquisition of passive sentences. Two influential studies which examined this effect for adults' comprehension of passives should be mentioned. The following is not intended to be a comprehensive review of the literature

pertaining to reversibility in passive sentences; rather, it is offered to demonstrate findings when a question similar to the one of interest here (namely, the role of semantic constraints in the comprehension of *before* and *after*) has been investigated.

Slobin (1966) investigated comprehension of active and passive sentences in both children and adults using a picture-verification procedure. He used sentences of two semantic types - reversible and nonreversible. "Reversibility" is used to indicate whether the actor and recipient of an action could logically exchange roles within the sentence. Examples of reversible and nonreversible sentences are "The girl chased the boy" and "The girl watered the flowers", respectively. Sxiteen subjects in each of five age groups (kindergarten, grades 2, 4 and 6, and adults) took part in this experiment. These subjects were evenly divided with respect to sex. Reaction time for picture-verification, in response to an illuminated picture immediately following the verbal presentation of a sentence, was measured.

Slobin found that, (at all ages), passive sentences took more time to evaluate than did actives. The effect of non-reversibility was to decrease picture-verification time. This effect was especially facilitative for passive sentences. That is, "making sentences nonreversible largely washed out the difference in syntactic complexity between active and passive sentences", (p. 219). While valid for all age groups,

this effect was most pronounced for the younger subjects. Slobin suggested that nonreversibility is more facilitative for passive sentences because a listener does not have the difficulty of deciding which party is the subject - only one choice is possible.

Forster and Olbrei (1973) also studied listeners' responses to reversible and nonreversible active and passive sentences. The question which Forster and Olbrei asked was subtly different from that asked by Slobin. Rather than examining how long subjects took to evaluate these sentences, they were interested in determining whether "the component of sentence processing directly attributable to syntactic processing depends critically on certain semantic properties of the sentence" (p.319). They maintain that two opposing views, the "interactive" and "constancy" hypotheses, are held on this question. The "interactive" hypothesis, as they used this term, refers to the view that feedback from the semantic level of processing affects syntactic decision making. The results obtained by Slobin, they claimed, are often cited as evidence for this hypothesis. The alternative view, that "the component of total processing time directly attributable to syntactic processing remains constant despite variation in meaning", is referred to as the "constancy" hypothesis.

In order to evaluate these two opposing views experimentally, Forster and Olbrei chose a technique modified from the decision latency procedure which had been used by Rubinstein, Garfield and Millikan (1970) to examine word

recognition. Forster and Olbrei asked their adult subjects to decide whether visually presented strings of words constituted meaningful sentences. Distractors used in the experiment equalled the number of well-formed sentences and were of two types; semantically anomalous and grammatically ill-formed. Decision latency for this task was measured and analyzed. A second procedure used to study the effects of reversibility followed the rapid serial visual presentation (RSVP) technique, previously used by Forster and Ryder (1971). In this procedure, each word of a sentence or of an anomalous string, is presented individually in quick, over-lapping succession (the trace of one word does not completely fade until the following word is projected). The subject is asked, after all the words of a given string have been thus presented, to recall the sequence of words. It is assumed that "the presentation rate is slow enough to permit each word to be identified but too fast to allow each word to be separately encoded into memory" unless "the subject is able to organize the input meaningfully" (p. 339).

The results from both tasks, in the opinion of Forster and Olbrei, failed to provide support for the interaction hypothesis. Ambiguous results were obtained when reversible versus nonreversible responses were analyzed. In one experiment, there was a nonsignificant trend towards shorter response latencies for reversible sentences. In another experiment, a marginally significant result indicated performance for nonreversible sentences. The crucial result,

however, was that for each experiment, significant differences were found between responses to active and passive sentences, regardless of whether the sentences were reversible. That is, unlike Slobin, Forster and Olbrei failed to show that nonreversibility allows for passive sentences to be processed with approximately the same ease as active sentences.

Forster and Olbrei concluded that their results supported the constancy hypothesis. On the basis of their definition of this hypothesis, and if one accepts the assumptions inherent in their tasks, this may be a valid conclusion. However, it is important to bear in mind that the tasks used by Forster and Olbrei to investigate reversibility were very different from those used by Slobin. For example, they did not use verbal stimuli, and at no point did they directly evaluate their subjects' comprehension of the stimuli sentences. Although interesting, conclusions reached by Forster and Olbrei may be considered to have questionable relevance to the problem of sentence comprehension.

The preceding two studies demonstrated very different procedural approaches and theoretical biases for examining the role of reversibility in the comprehension of active and passive sentences. Although these studies do not directly relate to the comprehension of *before* and *after* in complex sentences, they provide a framework upon which to develop

a methodology for investigating the role of similar semantic constraints in the comprehension of these sentences.

Studies Using Aphasic Subjects

Recently, some research has been conducted with aphasic subjects, examining their comprehension of *before* and *after*. Although conclusions based on such studies of comprehension in a language disordered population are not directly relatable to comprehension by normal adult subjects, it is interesting to note what trends have been observed in this population.

Sasanuma and Kamio (1976) conducted a study using 57 aphasic subjects, all of whom were native speakers of Japanese. The subjects were asked to perform a series of commands involving complex sentences with *before* and *after*. (As the stimuli sentences were all in Japanese, they do not directly correspond to those outlined in Table I. They were of four similar sentence types; half of the sentences contained *before* versus *after*, and half had the subordinate clause preposed.) All of the stimuli sentences were presented verbally, and all used the verb *touch*. both reversal and item errors were analyzed.

Sasanuma and Kamio found that these subjects made far more reversal errors on *before* than *after* sentences. Item errors appeared to be distributed equally among the sentence types. Subjects made three times more errors on *before* sentences than they did on after sentences. No correlation

was found between clinical syndrome of aphasia and error pattern. In a limited follow-up study involving 9 of the 57 subjects, Sasanuma and Kamio noted that reversal errors appeared more resistant to recovery than did item errors.

Sasanuma and Kamio pointed out that, in Japanese, order-of-mention and conjunction choice are confounded in these sentences. That is, the temporal order of events is always preserved in after sentences and is always reversed in *before* sentences. For this reason, the authors felt that it was not possible to tell whether the dominant response pattern they obtained was due to subjects utilizing an order-of-mention strategy or to subjects overgeneralizing the meaning of *after*.

Ansell and Flowers (1982) investigated this question using English-speaking aphasic subjects. Their 12 subjects were all considered to have relatively preserved auditory comprehension, as indicated by testing with the *Boston Diagnostic Aphasia Examination* (Goodglass and Kaplan, 1972) and the *Shortened Version of the Taken Test* (Derenzi and Faglioni, 1978). Test sentences, written in the imperative, were varied along the same dimensions as sentences shown in Table I. Two sets of sentences were constructed. The set considered to be more complex specified the shape of the object to be manipulated. Examples of the sentences used are "Touch the yellow one before touching the green one" and

"Touch the red square after touching the green circle". The sentences were recorded with normal intonation and were presented to the subjects 11 seconds apart. Errors were analyzed along these parameters: adverb choice, adverbial clause placement, and coincidence of order of mention with order of occurrence of events.

Ansell and Flowers found that only adverb choice was significant in aphasics' comprehension of these complex sentences, and that this effect was only significant when reversal-of-order errors were analyzed. In contrast to Sasanuma and Kamio, they found significantly fewer errors on *before* sentences. Ansell and Flowers pointed out that aphasics' error patterns are not similar to those of the children studied by Clark, since no use of an order-of-mention strategy was evident. They claimed that their results do not support the regression hypothesis (Jackobson, 1968), which contends that language dissolution in aphasia reflects language acquisition in children.

Summary

Studies have been conducted to investigate comprehension of *before* and *after* in complex sentences by children, adults and aphasics. In general, studies involving adults have utilized written stimuli, whereas studies involving children and asphasics have used verbal stimuli. Many superficial contradictions are reported in the literature. Use

of an order-of-mention strategy has appeared dominant in many studies (Clark and Clark, 1968; Clark, 1971). Primacy of the main clause is indicated in other studies (Amidon and Carey, 1972; Smith and McMahon, 1970). Still others have suggested that these two strategies may not be mutually exclusive; rather, one may become more dominant than the other given a specific task (Coker, 1979; Johnson, 1975). The influence of *before/after* differences on the comprehension of the sentence types depicted in Table I show equivocable results. In those studies where a preferential response to *before* sentences has been demonstrated, it has been argued that this result may be associated with *before* as the unmarked member of the relational pair (Clark, 1971), or, contrarily, that this result is evidence of a less dominant form of a main-clause strategy for comprehension of such sentences (Coker, 1979). Although most of the research reported above has not been concerned with the role of semantic constraints in the comprehension of complex sentences of the foregoing variety, French and Brown (1977) and Kavanaugh (1979) have examined this effect with young children and have found that semantic constraints appear to facilitate acquisition of *before* and *after*.

Statement of the Problem

A number of gaps exist in our current knowledge of the comprehension of *before* and *after* in complex sentences. The

present study was undertaken to determine:

1) The auditory comprehension of sentence types shown in Table I, by adult subjects, (previous studies with adults haved used only written stimuli).
2) The role of semantic constraints in adults' comprehension of sentence types shown in Table I.

Specifically, the following four null hypotheses were posed:

1) Adults do not demonstrate different response patterns to sentences which are constrained by general knowledge versus those that are unconstrained.
2) Adults do not demonstrate different response patterns to *before* and *after* sentences.
3) Adults do not demonstrate different response patterns to sentences in which order-of-mention and order of occurrence of events correspond, versus sentences in which this order is not preserved.
4) Adults do not demonstrate different response patterns to sentences in which the subordinate clause is preposed versus those sentences which have an initial main clause.

In developing the experimental procedures and hypotheses, a long term goal was to devise a test which might later prove useful for investigating sentence comprehension strategies used by aphasic subjects.

CHAPTER TWO

METHOD

Overview

The comprehension of sentences expressing temporally related events was examined in two separate tasks; a reaction time paradigm was used for both tasks.

For the *first* task, each stimulus item consisted of two slides and one pre-recorded sentence, which were presented simultaneously. Subjects were required to press a button indicating which slide most appropriately depicted the accompanying sentence. (One slide depicted the two events in the order stated in the sentence; the other showed the two events in the reverse order). The time required for this response was measured to the nearest one-hundredth of a second.

The *second* task was similar to the first, except that only one slide was presented with each sentence. The subjects' task in this case was to decide whether or not the slide correctly depicted the accompanying sentence. (Some of these slides represented the correct order of events; others showed the reverse order). Response time was again

measured to the nearest hundredth of a second. The same subjects, slides and sentence stimuli were used for both tasks.

Preparation of Sentence Stimuli

Forty core sentences were constructed to serve as stimuli. (As each sentence had four paraphrastic variations, corresponding to the four sentence types of Table I, this resulted in a total of 160 sentence stimuli). Twenty of the forty basic sentences were classified as *constrained* by general knowledge (C sentences) and 20 were classified as *unconstrained* (U sentences).

General Control of Variables Across the Sentences

In constructing these sentences, certain variables were controlled. The actions described by the sentences had to be readily picturable, unambiguous, and common enough that it could be safely assumed that both the events and the vocabulary describing them would be known by the subjects. All clauses comprising the sentences had to be of relatively equivalent syntactic structure, thus, core sentences were of the form "She verbed (± particle) article noun".

To further ensure that unequivalent syntactic complexity of the test sentences did not confound results, the 40 clauses which comprised the 20 C sentences were cross-matched with each other to construct the 20 U sentences. This procedure ensured that less frequent vocabulary items or events evenly

distribued among the two classifications of sentences (U and C). This procedure ensured that the two groups of sentences varied only in semantic complexity.

Specific Considerations Applied to the Cross-Matching Procedure

The necessity for one actor

Although cross-matching the clauses ensured syntactic equivalence for the two sentence classifications, this procedure raised other problems which required attention. One such problem was that the same actor had to be the subject of all of the clauses comprosing the C sentences. Otherwise, when these clauses were cross-matched to construct the U sentences, these resulting U sentences would have been semantically more complex in the sense that they would have had two actors as opposed to the U sentences' one. For this reason, one young woman was depicted as the actor of all the clauses. To retain syntactic equivalence, this woman was always referred to as "she".

Rejection of certain clauses

A second problem involved the rejection of some clauses considered by the experimenter to predispose a listener to interpret such clauses as either first or second events. That is, since cross-matching dictated that all clauses had to participate not only in sentences which were constrained by general knowledge, but also in sentences which were not so

constrained, such a bias made them inappropriate. For example, the sentence *She set the alarm before she went to sleep* was considered as a possible sentence stimuli. It was rejected, however, since the author believed that the clause, "she went to sleep", could not be readily cross-matched with any other clause, without the resultant sentence biasing the listener to interpret that clause as the second event. In other words, a sentence containing the clause, *she went to sleep*, would likely be constrained by general knowledge regardless of what other clause it was matched with, since people normally sleep after they have participated in other events; a truly arbitrary or unconstrained sentence containing that clause would, therefore, be difficult to formulate.

Procedure for cross-matching

As described above, every attempt was made to take note of, and reject, any clause which intrinsically was likely to be interpreted as occurring in a particular order relative to any other clause with which it might be combined. It is possible, however, that some clauses in the C sentences had such a subtle bias in this direction that they were undetected, and hence, not rejected. In order to minimize any affect such clauses may have had on the resultant U sentences, a specific procedure was followed during cross-matching.

The forty clauses comprising the twenty C sentences were labelled as either 1 or 2, corresponding to whether they were the first or second events in the C sentences. They were then cross-matched in *four* ways to construct the U sentences:

- five U sentences were composed of 2 first event C clauses,
- five were composed of 2 second event C clauses,
- five were composed of first event C clauses followed by a second event C clause,
- five were composed of a second event C clause followed by a first event C clause.

This procedure minimized one subtle source of biasing which may have otherwise resulted in U sentences which were not wholly unconstrained.

Rejection of certain sentences

Although this cross-matching procedure was considered necessary, it limited the number of possible combinations of C clauses which could be used to generate U sentences. Nonetheless, every attempt was made to ensure that the resulting U sentences met three further constraints. The *first* is obvious; i.e., that cross-matched clauses did not, by chance, result in sentences which were constrained by general knowledge. Two such precautions against this have already been described (e.g., rejection of certain clauses and procedure for cross-matching). However, it was still possible that, had the clauses been randomly matched from this point on, that such randomly matched clauses might have resulted in constrained sentences, simply by coincidence. For example, the sentence *She took a shower before she went to work*, could have resulted from cross-matching, at this point. This sentence would have been rejected, however, since these two

events could be expected to occur in that order; the new sentence is not the unconstrained one that was aimed for, but yet another constrained sentence.

A *second* constraint concerns the reverse of the previous situation; i.e., clauses could not be randomly matched in such a way as to result in sentences which were contrary to an expected order of events. In other words, a sentence could not be one describing a highly unlikely sequence of events. For example, the sentence *She got on the bus before she packed her suitcase,* (which was a possible consequence of cross-matching), would not simply be unconstrained but would be describing events in an order reverse to expectation. As unlikely sentences are, in the author's opinion, quite different from sentences in which the temporal relation of two events is not predictable (unconstrained), such sentences would be rejected. Stated otherwise, both of these first two constraints dealt with the concept of reversibility. In order to be acceptable, the U sentences had to be judged as equally likely regardless of how their component clauses were ordered.

A *third* constraint also dealt with implausible sentences. Although the second constraint dealt with sentences which were unlikely in the sense of describing events which occur in an unexpected order, this is not, of course, the only manner in which a sentence can be considered unlikely. A sentence can be judged as implausible because it describes two events which one cannot imagine as being related, or for many other reasons. Since the purpose of this investigation

was to study how subjects react to "Unconstrained" versus "Constrained" sentences, and not "unlikely" versus "likely" sentences, a "plausibility" criteria was used.

This *plausibility* criteria was that the U sentences had to be judged as plausible sentences describing events which did not require unreasonable stretches of the listeners' imagination. This was by far the most difficult constraint to meet, since determining the plausibility of a sentence, out of context, is a very nebulous task. Although no procedure used to judge such a subjective concept as "plausibility" can be totally adequate, it was necessary to deal with this problem in some way. Therefore, *a U sentence was rejected if it was judged to be significantly less plausible, than the two C sentences from which its component clauses were drawn.* Three judges were used for the task of determining plausibility; if one of them considered the sentence to be unlikely, it was rejected. The key word here, of course, is "significant", which allowed for some difference in judged plausibility between the constrained and unconstrained sentences. This was necessary, however, since it is only reasonable that a sentence composed of two clauses so related as to be expected to occur in a particular temporal relation to each other (C sentences) would be somewhat more plausible than sentences composed of clauses which are not so related; that is, the plausibility of C sentences is obvious. Yet the uncomfortable question remains of how significant a difference judged plausibility is considered too significant.

At the very least, however, outlandish sentences have been eliminated by this judging procedure. Hopefully, those sentences which remain are indeed merely unconstrained and not implausible.

Some constraints particular to the U sentences have been discussed. A *fourth* constraint was specific to the C sentences. Although the C sentences had to be, by definition, ones in which the clauses occurred in an expected temporal relation to each other, such sentences in which the reverse order of events was totally impossible were rejected. In other words, the purpose of the C sentences was to suggest a particular order of events to the listener, not to strictly impose one. It is possible, (although the author knows of no evidence to deny or confirm this), that different processes are at play in comprehending sentences in which one interpretation is more likely than another, as opposed to sentences in which, owing to content alone and regardless of syntax, one interpretation is demanded since the other is impossible. Therefore, in order to maintain some degree of homogeneity among the C sentences, all of these sentences had to be ones that could possibly occur in the reverse order but would be unlikely to be heard in that form.

Summary of Sentence Construction Procedures

To briefly recapitulate: 20 sentences were constructed in which the temporal order of events described by them were constrained by general knowledge (C sentences). Both these sentences and the 40 clauses of which they were composed met a number of constraints which have been outlined above. The same 40 clauses were then cross-matched, using a specific procedure previously described, in order to construct 20 sentences in which the temporal order of events was not constrained by general knowledge, (U sentences). These sentences also met a number of constraints which have been discussed.

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The Resulting Sentence Stimuli

As mentioned, these forty basic sentences were all of one syntactic type (Before-2 form). Each of these Before-2 sentences were then expanded into their four syntactic variations, as shown in Table I, resulting in 160 sentences (four syntactic variations each of 40 paraphrastically different sentences). The 40 core sentences are reproduced in Table II. Two of these sentences are shown in all of their syntactic forms (Table III). As the complete set of 160 sentences can be subdivided into four syntactic classes and two semantic classes, this results in eight classifications of sentences, of which there are 20 each, in total. Table III shows an example of each of these sentence types.

Table II

Sentences Used in this Investigation[a]

	Sentence
	Constrained Sentences
1.	She ate breakfast before she went to work.
2.	She packed the suitcase before she got on the plane.
3.	She ate dinner before she washed the dishes.
4.	She ate the steak before she ate dessert.
5.	She turned on the light before she read the book.
6.	She took a shower before she dried her hair.
7.	She dialled the number before she talked on the phone,
8.	She washed her face before she put on her make-up.
9.	She bought groceries before she cooked dinner.
10.	She bought some paint before she painted the furniture.
11.	She bought the cake before she had the party.
12.	She addressed the envelope before she mailed the letter.
13.	She counted her change before she got on the bus.
14.	She stood in line before she watched the movie.
15.	She struck the match before she smoked the cigarette.
16.	She beat the eggs before she baked the cookies.
17.	She fell off the ladder before she went to the hospital.
18.	She got in the boat before she caught the fish.
19.	She robbed the bank before she hid the money.
20.	She skiied the race before she won the medal.
	Unconstrained Sentences
21.	She packed the suitcase before she washed the dishes.
22.	She bought the cake before she talked on the phone.
23.	She ate dinner before she won the medal.
24.	She got in the boat before she ate dessert.
25.	She bought groceries before she got on the bus.
26.	She smoked the cigarette before she turned on the light.
27.	She got on the plane before she ate breakfast.
28.	She went to work before she addressed the envelope.
29.	She mailed the letter before she counted her change.
30.	She had the party before she robbed the bank.
31.	She took a shower before she fell off the ladder.
32.	She skiied the race before she ate the steak.
33.	She bought some paint before she dialled the number.
34.	She beat the eggs before she washed her face.
35.	She stood in line before she struck the match.
36.	She read the book before she caught the fish.
37.	She went to the hospital before she painted the furniture.
38.	She hid the money before she watched the movie.
39.	She put on her make-up before she cooked dinner.
40.	She dried her hair before she baked the cookies.

[a]These sentences are depicted in Before-2 form.

Table III

The Eight Classifications of Sentences Under Investigation

Sentence Type	Example
Before-2	
Constrained	She ate dinner before she washed the dishes.
Unconstrained	She packed the suitcase before she washed the dishes.
Before-1	
Constrained	Before she washed the dishes, she ate dinner.
Unconstrained	Before she washed the dishes, she packed the suitcase.
After-2	
Constrained	She washed the dishes after she ate dinner.
Unconstrained	She washed the dishes after she packed the suitcase.
After-1	
Constrained	After she ate dinner, she washed the dishes.
Unconstrained	After she packed the suitcase, she washed the dishes.

Division of Sentences Into Four Testing Subsets

Each subject participated in two tasks, each involving the above described 160 sentences. In order to minimize the risk of losing listener attention during the experiments, it was necessary to divide the sentences into testing subsets. The 160 sentences, therefore, were divided into four subsets, (a, b, c, and d), which were used independently in different runs of the experiment. These four sets each consisted of 20 constrained (C) and 20 unconstrained (U) sentences. Each of the 40 core sentences was represented only once in one of its four syntactic forms, in each set; each set, therefore, contained 40 sentences each with different semantic content. The four syntactic classifications were represented by ten sentences each in the four subsets. The result was four subsets which contained 40 paraphrastically different sentences with equal representation by each of the eight sub-classifications of sentence type (i.e., five each of U/Before-1, C/Before-1, U/Before-2, C/Before-2, U/After-1, C/After-1, U/After-2, and C/After-2).

It was intended that this procedure should not only balance the sets of stimuli for sentence type, but also that it would render homogeneous the amount of visual decoding required by the subjects from subtest to subtest, as each of the 40 sequences of two events would be pictured once and only once in every subtest.

Semi-Randomization of Sentence Order Within the Subsets

Once the sentences had been subdivided into subsets a, b, c and d, as described above, they were semi-randomized as to their order within each subset. One constraint was placed on the semi-randomization of the sentence. It will be recalled that the same 40 clauses were used to construct both the U and C sentences. In each subset, therefore, a given clause would appear twice, accompanied by a different clause each time. It was possible, therefore, that subjects would hear the same clause in two consecutive sentences, perhaps resulting in some momentary confusion as to whether they were accidently hearing the same sentence twice. For this reason, the semi-randomization of the subsets was constrained such that no clause appeared in two consecutive sentences.

Assignment of Required Response Values to Sentences

Once the four subsets had been compiled and semi-randomized, the next variable was dealt with. As indicated previously, for Task 1, two slides were presented and the subject was expected to decide whether the left slide or the right slide was appropriate. Likewise, for Task 2, the subject was presented with one slide and was expected to decide whether the slide corresponded to the sentence or not (yes/no response).

Prior to testing, it was, therefore, necessary to determine for each sentence in each subtest, whether the correct slide would be presented on the left or right (for Task 1) or whether the correct slide or foil would be presented (for

Task 2). To accomplish this, each stimulus sentence was randomly assigned a number (1 or 2), with the constraint that there would be an equal occurrence of each number in each subset. For Task 1, an assignment of 1 corresponded to the correct slide appearing on the left. For Task 2, an assignment of 1 meant that the correct slide and not the foil would be presented. Thus, in each testing subsets, each of the two responses (left/right, or yes/no) would be indicated randomly and with equal frequency.

Preparation of Visual Stimuli

The events described in the sentences were illustrated by a professional artist. Each of the forty clauses were illustrated by single line drawings, to scale, and executed to the satisfaction of both the artist and the author. These were reproduced, then matched with each of the two other illustrations with which it belonged, for conversion to standard 35 mm black and white slides. Each complete slide, therefore, contained two illustrations (corresponding to the two clauses of each sentence) which depicted the events of the sentence from left to right. The total slide area was divided into half, with each illustration occupying equal areas on the slide.

Constraints Applied to the Visual Stimuli

A number of conditions and precautions were observed in preparing the illustrations. The illustrations were kept as

visually simple as possible while still providing enough contextual details to provide a clear and unambiguous interpretation; no unnecessary detail cluttered the illustrations.

It was necessary for each clause to be illustrated independently of the other clauses, but, none-the-less, in such a way as to make them visually compatible with their sentence-mate clauses. This is an important point, for recall that each clause was matched with another clause which resulted in a constrained sequence of events and one clause which resulted in a more arbitrary sequence of events. It was, therefore, not desirable to have a clause illustrated such that it could visually be tied together more with the other clause when they were matched to form constrained sentences than when it was matched with a different clause to form an unconstrained sentence. It was necessary that no bias associating the two clauses of a constrained sentence should result from the depiction; if such a bias did affect the listener, this should result from the sentential content and not from how the sentences were illustrated. This last point affected many details of the illustrations. For example, consider the clause, *she ate dessert*. This clause was matched with *she ate the steak* (to form a C sentence) and with *she got in the boat* (to form a U sentence - see Table II). Thus, the clause in question had to be depicted such that the *dessert* being eaten by the actor was one which could be eaten with equal likelihood on a boat or in a location where one was also likely to eat a steak (i.e., at a kitchen table). Also, of course, neither the boat nor the kitchen table could actually be

depicted in the illustration of *she ate dessert*, since this would cause it to be incompatible visually with one of its two matching clauses.

Virtually every illustration was held up to such scrutiny with respect to how well it depicted the clause and how compatible it would be with both of its sentence-mate clauses. For similar reasons, wherever logically possible, the actor was portrayed as wearing the same set of clothes throughout the illustrations.

The above point is not trivial. It refers back to the issue raised in a previous section, concerning the difference between sentences which are unconstrained by general knowledge versus those that are not simply unconstrained but also implausible. Just as clauses were not merely randomly matched to produce possibly implausible sentences, care was taken to ensure that the slides which illustrated these sentences resulted in equally visual sequences to accompany both the constrained and unconstrained sentences. Had the clauses not been illustrated in this "independent yet visually compatible" manner, the unconstrained sentences might have appeared to be a less likely sequences of events (visually) than the constrained sentences.

One further constraint was placed on these illustrations; it was not permissible for them to contain any linguistic content. It was considered that such an inclusion might have affected the time needed for visual processing of individual slides, thus confounding the investigation. Hence, in some

illustrations, such as those taking place in a hospital or in a store, printed signs were not considered to be an acceptable way of conveying context.

A total of 80 slides were thus prepared. Forty slides depicted a sequence of two events, shown in a left to right order which corresponded with the forty stimuli sentences. The remaining 40 slides served as foils; they showed the same 40 sequences of two events in the reverse order.

Preparation of Taped Stimuli

The 160 sentences were recorded at a normal speaking rate, at a tape recorder speed of 7½ inches per second. Stressed sections of the sentences peaked at 0 dB on the VU meter and the microphone was set at a constant distance from the speaker. The tape recorder used was a Revox, Model 77A; recordings were made on acetate audiotape (Ampex 406). These sentences were recorded on Track 1 of the audiotape; on Track 2 a constant 1000 Hz tone was recorded. The purpose of the tone, which was to trigger certain mechanisms of the reaction-time equipment, will be dealt with more fully later in this chapter.

Splicing of the Taped Stimuli

Once recorded, the sentences were spliced, then joined with leader tape to form the four testing subsets (a, b, c

and d). The purpose of splicing these sentences was not merely organizational. More importantly, the splice at the beginning of each sentence ensured that the onset of each sentence would be exactly synchronized with the onset of the 1000 Hz tone, on Track 2. It was highly undesirable, therefore, that the splice occur either prior to or after the onset of the sentence; if prior, the 1000 Hz tone would be present before the sentence began, thus triggering the equipment prematurely; if after, the onset of the sentence would be lost.

The sentences were played on an Otari tape recorder. Once the onset of each sentence had been roughly located at a speed of 7½ inches per second, the machine was turned to the edit mode. The tape was then slowly advanced and retracted over the playback head until the first glottal pulse had been located. This point was marked with a fine point pen. This procedure was repeated, by hand, two times to ascertain that the correct spot on the tape had been located. The locations was then rechecked at 7½ inches per second, to ensure that the area marked was indeed the onset of speech, and not a preceding throat-clearing or other such noise. (The end of each sentence was similarly located. Since the exact ending of the sentence was not crucial, the experimental concern here was that the entire sentence be preserved and not spliced prematurely. It was therefore, permissible, in this case, to mark the tape for splicing following the end of voice, rather than exactly at the instant the voice ended.)

The tape was then removed from the machine, cut with a razor blade vertically (to produce a sudden and not gradual onset) at the points marking the onset and end of each sentence, and spliced carefully to white leader tape. Five seconds worth of leader tape was used between each sentence.

The result of the foregoing procedure was four reels, each containing a testing subset of 40 sentences, joined by leader tape. Each set was internally arranged in the predetermined experimental order.

Equipment

A device for measuring response time was designed and built specifically for this experiment. The major function of this device was to co-ordinate the timing of the various components of the experiment and to provide an accurate means of measuring the subjects' response times to the stimuli. The experimental equipment included the device itself, plus two slide projectors, a Revox tape recorder, and a subject response box which contained two pushbuttons. Figures 1 and 2 depict the equipment and set-up schematically.

Stimulus Presentation and Subject Response

As each stimulus sentence was played, the 1000 Hz tone, recorded on Tract 2, of the audiotape, triggered the electronic switch of the device. The electronic switch, in turn, triggered both relay A and the timer of the device. (The

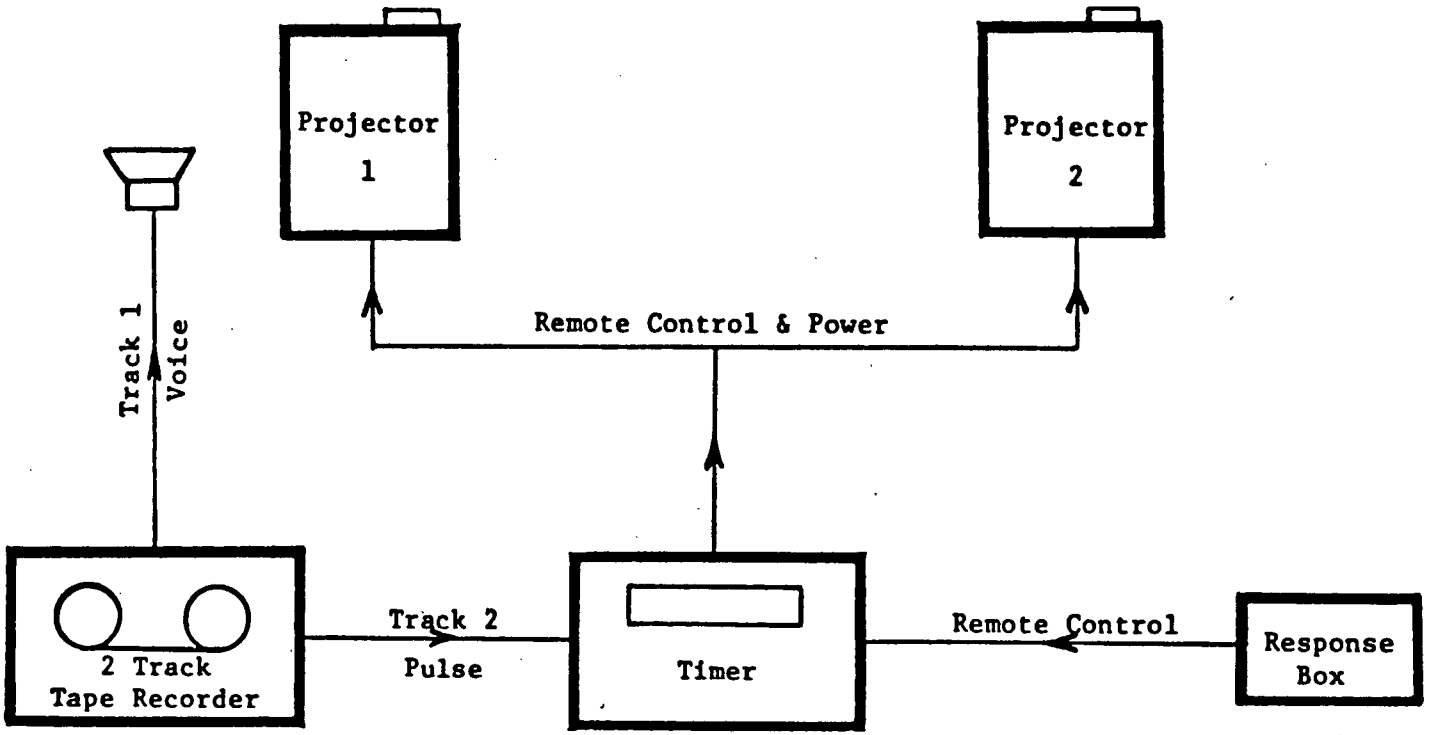

Figure 1

Block Diagram of Experimental Apparatus

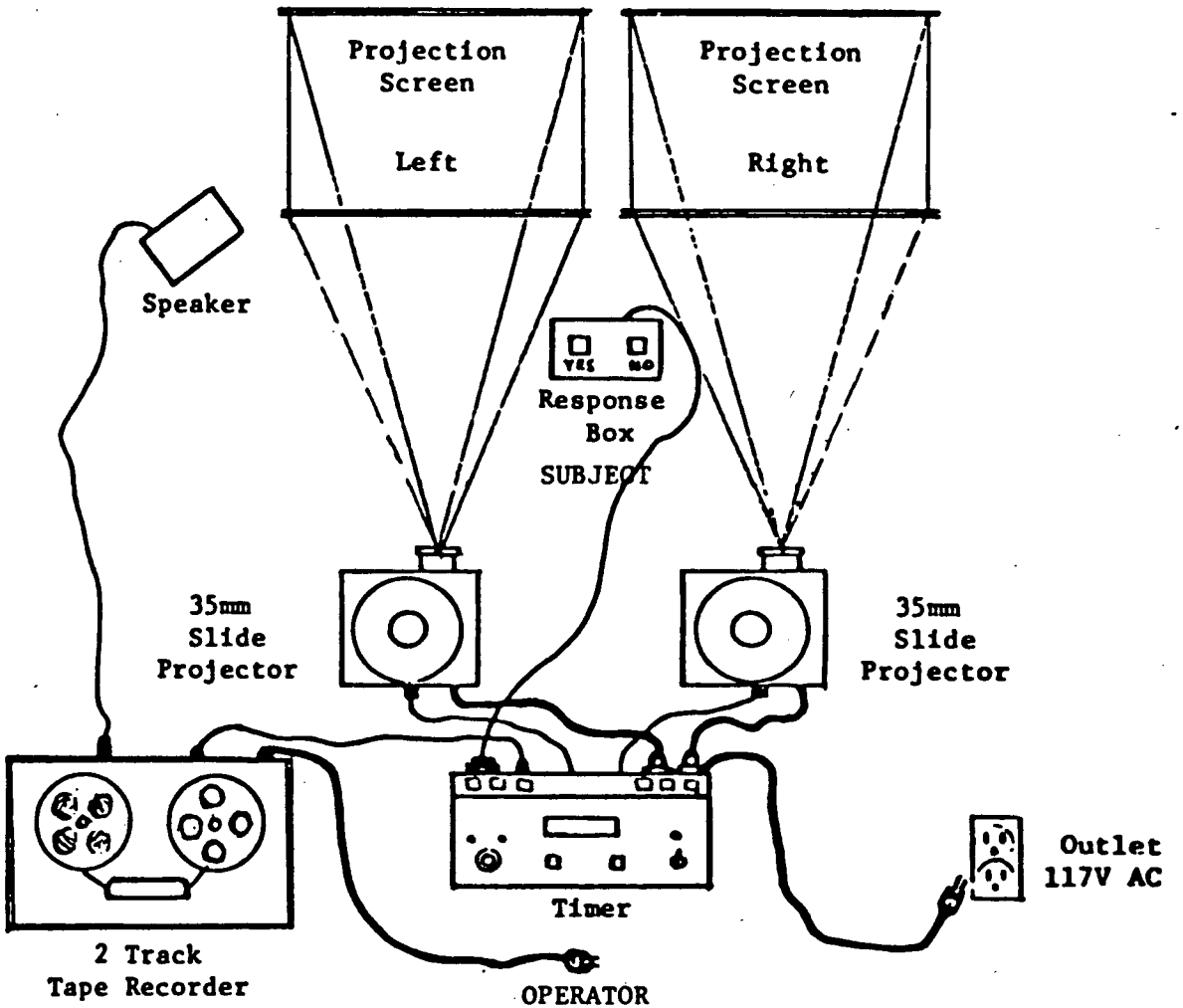

Figure 2

Physical Set-up of Experimental Apparatus

purpose of the timer was to provide a means of automatically turning off the equipment in the event of no response from the subject after an elapsed time of one minute from the presentation of the stimuus.) Relay A simultaneously activated both slide projectors, the digital stopwatch, and a delayed relay B. Thus, it was assumed that the onset of each sentence began simultaneously with the projection of the accompanying slide(s) and with the onset of the stopwatch. The stopwatch measured elapsed time between the start of the sentence and the subject's response, to the nearest one hundredth of a second.

The purpose of the delayed relay B was to interrupt the triggering signal going to the stopwatch. This interruption was necessary since three functions ("stop", "start", and "reset"), were controlled on one contact of the stopwatch. Therefore, once the stopwatch had been triggered to "start", this signal must be interrupted in order that, at a later instant, another triggering impulse could get through to trigger the stopwatch to "stop". The voltage necessary to accomplish the "stop" impulse was provided by one channel of the subject's pushbutton. The other channel of the pushbutton mechanism provided voltage to turn off the slide projectors. Therefore, once the subject had indicated his/her response by pushing the appropriate pushbutton, both the projectors and the stopwatch were turned off.

At this point, the stopwatch readout displayed the elapsed time and indicated which pushbutton had been pressed

by the subject. This display was held until the stopwatch had been manually reset by pressing the reset button provided on the device. (There was no danger of the following sentence being played prior to the subjects' response, since the Revox automatically ceased advancing when the white leader tape passed the playback head.)

Once this information had been recorded, the slide projector(s) and tape were advanced, and the reset button on the stopwatch were depressed, in preparation for presentation of the next stimulus. (This procedure, including recording response time, could be performed in approximately five seconds, which was the minimum delay between the response to one stimulus and presentation of the next.) Since only one slide projector was necessary for Task 2, the second projector was disconnected in this case.

Temporal Relation of Slide and Sentence Stimuli

It should be noted that the equipment described above provided a means of ensuring that the slide stimuli and sentence stimuli were presented simultaneously. This was one of several possible temporal relations which could have been imposed on the presentation of slide and sentence stimuli; for example, instead of being presented simultaneously, the slides could have been presented either prior to, or following. the presentation of the sentences. Each of these three possible relations was considered.

First possible relation

At least two disadvantages were moted in association with presentation of the slides prior to the onset of the sentences; first, the processing required of subjects in order to make a decision would involve the confounding influence of *visual memory;* second, in the case of slides depicting C sentences, it would be possible for the subjects to make a choice, based on probability, without reference to the following sentence.

Second possible relation

Had the slides not been presented until after auditory presentation of the sentences had been completed, then *auditory memory* would have significantly affected response time. Presenting slides after auditory presentation would, however, have eliminated the problem associated with where response time should be measured from (when dealing with sentences of unequal length); the response time could simply have been measured from the instant at which the slides were projected. (This problem will be dealt with in the following chapter). Upon further consideration, however, this argument proved specious - one would merely be trading a more obvious problem (the length of time it takes for each stimulus sentence to be uttered) for a more subtle problem (the length of time it takes for each slide stimulus to be visually processed, which, in order for the previous argument to be valid, must be assumed to be the same for each slide - a doubtful assumption).

Third possible relation

Associated with the presentation of both stimuli simultaneously, was the disadvantage of determining a suitable point in the sentence from which to measure response time. However, this solution held the attraction that it would not contaminate the task with either visual or auditory memory. This is also the temporal relation which most nearly mimicks natural language; just as in spontaneous language sentences are generally uttered with reference to a context, in this investigation the slides provide a reference for the accompanying sentences at the time of utterance. On the basis of the foregoing, simultaneous presentation of both slide and sentence stimuli appeared to be the best experimental option.

Subjects

Sixteen subjects, 8 men and 8 women, were recruited to participate in this investigation. All were young, healthy adults, in their twenties, with no known history of visual or auditory perception deficits. These subjects all reported that English was their native language; only one subject considered himself to be reasonably fluent in another language (German).

Every effort was made to draw these subjects from as wide a variety of educational and occupational backgrounds as possible. No two subjects were involved in practicing the same occupation or in studying the same discipline. The

mean amount of post-secondary education for these subjects was 2.59 years, with a range of from one year less than high school completion to 6 years of post-secondary schooling. For the male subjects, the mean educational level was 3.44 years, with a range of from zero to six years. For the female subjects, the mean educational level was 2.2 years of post-secondary education, with a range from -1 to five years. Mean age of the subjects at the time of testing was 25 years, 5.3 months, with a range from 23 years, 1 month to 29 years, 1 month. Broken down with respect to sex, the mean ages of the subjects were 25 years 11.6 months for men and 24 years, 10.9 months for women, ranging from 24 years, 2 months to 28 years 11 months, and 23 years 1 month to 29 years, 11 months, respectively.

Balancing Subjects, Tasks, and Subsets

Each of the 16 subjects participated in both Task 1 and Task 2 of the experiment. Since there were four test subsets of sentence stimuli, this required balancing these four sets, a, b, c, and d), and the two Tasks (1 and 2) with two groups of eight subjects (male and female). Half of the subjects participated in Task 1 first, and half in Task 2 first. Each test subset was given with equal frequency for Task 1 and Task 2, and with equal frequency as first or second task in which the subject participated. Using these criteria for test construction, eight groups of subsets were

formulated. Each of these pairs determined the testing content and order for one male and one female subject. These eight pairs are given in the following table:

Table 4[a]

Counterbalancing of Tasks, Subsets and Subjects

Subset	Task	Subset	Task	Number of Subjects	
				Male	Female
a	1	d	2	1	1
a	2	c	1	1	1
b	2	a	1	1	1
b	1	a	2	1	1
c	2	d	1	1	1
d	2	b	1	1	1
c	1	b	2	1	1
d	1	c	1	1	1
				Total	
				16	

[a]Presentation order is read left to right. i.e., The first row indicates that subset "a" was presented as Task 1, followed by presentation of subset "d" as Task 2.

Procedure

The experiment was conducted in a sound-proofed laboratory (Nc-22) with minimal ambient noise and a comfortable climate. Physical arrangement of the equipment was held constant for each subject. Experiments were run on subjects individually, with only the examiner and subject present. Prior to testing, the subjects were required to sign an informed consent form and to supply some biographical information. Anonyminity of the subjects was guaranteed in all cases. The consent form was composed such that the information given to the subject at that time, although accurate, was sufficiently vague that the subjects would be unaware both of which specific parameters of the sentences were of interest to the examiner and which subject behaviours were being examined. Each subject was informed that the purpose of the experiment would be explained to his/her satisfaction upon completion of the tasks.

Once these preliminaries had been accomplished, the subject was seated within easy reach of the response box. (The pushbuttons were labelled "left/yes" and "right/no" to serve as a reminder to the subject during the experiment.) Pre-recorded instructions were presented at this point (reproduced in the following section.) These instructions included a sample of speech in which the subject was asked if the volume was at a comfortable listening level; if not, it was adjusted to the subject's specifications. Two sets

of instructions were prepared; the set which the subject heard first depended on whether s/he participated in Task 1 or Task 2 first.

Following presentation of instructions, the subject was presented with three training sentences. (These sentences were syntactically different from the test sentences and were designed to ensure that the subjects had understood the instructions.) All subjects correctly responded to all three training sentences. Following presentation of training sentences, more information, regarding the nature of the testing sentences, was given. Instructions were then briefly reiterated, and testing commenced.

During testing, the experimenter and the control apparatus were placed behind the subject and out of his/her view. The only experimental apparati visible to the subject were the projector screen(s), and the pushbutton response box. Each task, with instructions, took about 20 minutes to administer. The subject then had a break. During this break, the examiner prepared for the following task. (The slide stimuli had been organized to correspond with the order of the first test subset; it was, therefore, necessary to rearrange the slides in the correct order for the second task. All slides were coded for this purpose.) The subject then returned to the laboratory, at which time s/he was re-instructed and retained for the second task. The entire experiment, including the break, took approximately one hour for each subject.

Instructions

Verbatim Instructions

Obtaining the most comfortable listening level

The following was read to each subject once, at the beginning of the experiment:

> Before we begin, I'd like to make sure the volume is at a comfortable level for you to listen to. Let me know if you would like it turned up or down? Is it at a comfortable level for you now?

Specific instructions: Task 1

The following was read to each subject, prior to Task 1:

> Now you are going to hear some sentences come over the loudspeaker, one at a time. When you hear each sentence, you will also see two slides. One slide will go with the sentence, and one slide will not. I want you to decide which slide goes with the sentence. In front of you there are two buttons. If the correct slide is on the left, I want you to press the button on the left. If the correct slide is on the right, press the button on the right. You will hear each sentence only once, so listen carefully. When you've decided which is the correct slide, push the appropriate button. A few seconds later, you'll hear the next sentence. For each sentence, indicate your choice by pushing the button on the same side as the correct slide appears. Do you have any questions? (Pause.)
>
> We are going to try some practice sentences now...

Specific instructions: Task 2

The following was read to each subject, prior to Task 2:

> Now you are going to hear some sentences come over the loudspeaker, one at a time. When you hear each sentence, you will also see a slide. The slide may or may not go with the sentence you hear. Some slides go with the sentences and some slides do not. I want you to decide whether or not the slide correctly depicts the sentence. In front of you there are two buttons. If the slide goes with the sentence, push the button on the left. If the slide does not go with the sentence, press the button on the right. You will hear each sentence only once, so listen carefully. When you've decided if the slide goes with the sentence or not, press the appropriate button - left for correct, right for incorrect. A few seconds later you'll hear the next sentence. For each sentence, indicate your decision by pressing the left button if the slide goes with the sentence, or the button on the right if it does not. Do you have any questions? (Pause.)
>
> We are going to try some practice sentences now...

General instructions Task 1 and Task 2

The following was read to each subject after presentation of the practice sentences:

> The sentences and slides which follow are somewhat different. The sentences describe a sequence of two events, which are joined by either *before* or *after*. As in a cartoon, the left picture represents the events which happened first, and the right picture represents the following event. Therefore, your task is to determine if the order of events depicted in each slide corresponds with the order of events as described by the sentence.

Reiteration of instructions: Task 1

The following was read to each subject, immediately prior to presentation of Task 1 stimuli:

> So each time, decide which of the two slides shows the two events in the same order as in the sentence, and press the button on the same side as the correct slide appears.

Reiteration of instructions : Task 2

The following was read to each subject, immediately prior to presentation of Task 2 stimuli:

> So, each time, decide whether or not the slide shows the two events in the same order as in the sentence, and press the button marked yes if it does, or the button marked no if it does'nt.

A Comment on these Instructions

One point concerning these instructions merits discussion. The wording of instructions can strongly bias a subject's responses by the amount of information they contain regarding the task under experimental scrutiny. In the present case, it was necessary to decide whether a subject should be informed that the dimension of the response being measured was speed, not accuracy. In order not to bias the subjects, instructions to "respond as quickly as possible" were omitted. Failure to include such a statement may have resulted in responses being more accurate but less rapid than they would have been had the subjects been instructed to act quickly. The rationale for this decision was to recreate as naturalistic a language environment as can be accomplished in the context of a controlled laboratory experiment. In a normal conversation, a listener generally places more emphasis on his/her understanding of the content of what is being said, than on the speed at which s/he understands the message. Thus, suggesting that subjects answer "as quickly as possible" could have caused subjects to engage a strategy for comprehension which

might be considerably different than that used in naturalistic language environments. Subjects were, therefore, not informed that the speed of their responses was the variable being investigated. In the event that subjects asked how much time they had in which to respond (as some did) they were told non-commitally that no stimuli would be presented until the previous one had received a response.

CHAPTER THREE

TREATMENT OF DATA AND RESULTS

Overview

The data from both Task 1 and Task 2 were analyzed by means of a computer-assisted analysis of variance. The raw data were transformed to square roots of the reaction times for this purpose. Two major factors were of interest; *Semantic* and *Syntactic*. It should be noted that for the purpose of analysis, the terms Syntactic and Semantic are used loosely. It is acknowledged that all of those factors described as Syntactic could also be defined semantically. The purpose of such labels in the analysis was organizational only. For this purpose, a Syntactic factor was here defined as one which has the affect of changing the surface string of the elements within a sentence while retaining the same operational meaning; a Semantic factor is one which functions to alter the operational meaning of a sentence.

In all analyses, the Semantic factor was analyzed at two levels; *Constrained* and *Unconstrained*. The Syntactic factor

was analyzed by three separate analyses, at two levels of one of the following:

1) Conjunction choice
2) Order of mention
3) Clause placement.

For Task 2 analyses, an additional factor, *Truth Value*, was investigated; this referred to whether the required response to a particular stimulus had been *yes* or *no*.

In all cases, the general null hypotheses were that there existed no significant difference between the levels of the various factors. Failure to reject the null hypothesis was evident for all null hypotheses except those concerning Clause Placement and Truth Value. Significant differences between the mean values were evident for these factors, with the mean having smaller values for main-clause-initial sentences and for *yes* responses, respectively. At no point in the analyses were any significant interaction effects evident.

Since the data from Task 1 and Task 2 were treated identically, in most respects, separate discussion of the analysis for these experiments would prove redundant. This chapter, therefore, is divided into sections dealing with treatment of all data and not into separate sections dealing with Tasks 1 and 2, except as appropriate.

Treatment of Data Prior to Analysis

Suitability of Data

Raw data was excluded from the analysis on the basis of either subject or experimenter error. Several kinds of error or mishap occurred during testing. For example, if the subject responded with an incorrect answer, the reaction time necessary to attain this incorrect response was not analyzed. These subject errors fell into two categories; those which appeared to be true miscomprehensions of the sentences and those which resulted from the subject accidentally depressing the wrong response button. (The latter were usually immediately identified by the subject.) Occasionally, the subject would attempt to engage the investigator in conversation just as the taped stimuli began, thus obscuring the first few words of the sentences.

Similarily, occasional investigator errors occurred, e.g.:

1) inserting a slide incorrectly; either in incorrect order or in an incorrect orientation,
2) a slide appearing our of focus.

In any of the above instances, or in any other case where the taped and/or visual stimuli were not consistent with each other, the particular stimulus item in question was excluded from the analysis.

It should be noted that the total number of rejected stimuli was very small. Of a possible 640 responses for each

task, 604 and 614 were recorded and analyzed for Task 1 and 2, respectively.

Measurement Procedure

Definition and measurement of reaction time posed a significant problem. As described in Chapter Two, an electronic stopwatch was used to record elapsed time between onset of each stimulus sentence and depression of the button indicating a subject's choice. Since sentences varied somewhat in length, it was inappropriate to use this recorded time as an indication of the time required for the subject to respond to each stimulus. (Obviously, a raw response time of four seconds, as measured from the onset of each sentence, would not equivalently measure response to two different sentences, one of which was two seconds in duration and the other three seconds.) It was necessary, therefore, to choose some point other than the onset of the sentence as an arbitrary zero on the time scale.

The first possibility considered was to measure response time from the end of each sentence. This seemed to be a logical point to define as "zero" time since it could be consistently applied across all sentences and since, at this point, all information necessary for sentence processing would have occurred. In the course of running the experiment, however, it was noted that a large number of responses were made prior to the completion of the sentence stimuli. This indicated that, once the task was known, it was not necessary for a subject to hear each sentence in its entirety in order

to perform the task. Clearly, a large portion of sentence processing had occurred prior to completion of the auditory signal. Given this observation, it seemed meaningless to define as "zero" a point in the sentence where much of the processing had already been accomplished; it was, therefore, necessary to define a different point as zero time.

Measurement of response time was, therefore, begun following the first clause of the sentence (plus the conjunction *before* or *after* in the case of main-clause-first sentences). In the following examples, the cut-off point is indicated:

She packed the suitcase before/she got on the plane.

Before she got on the plane/she packed the suitcase.

She got on the plane after/she packed the suitcase.

After she packed the suitcase/she got on the plane.

It was felt that, at this point, a subject would have heard all necessary and sufficient information required to respond appropriately.

Since the stopwatch had previously measured time from the beginning of each sentence, recorded time for each response now included that time which has above been defined as the reaction time, plus the time for the first clause (with *before* or *after*) to be uttered. For each recorded sentence, it was necessary, therefore, to measure the time occupied on the tape up to the cut-off point, in order that this could be subtracted from the recorded response time to obtain reaction time.

For each sentence, this time was measured using the same stopwatch used for the experiment. Each sentence segment was measured a total of five times. Some small variability in these measures was obtained; therefore, the longest and shorted measures obtained for each sentence were discarded, and the remaining three were averaged. These averaged measurements yielded a master list which contain the time, in hundredths of a second, from the onset of each sentence to its cut-off point. This list was compared to subjects' recorded response times, and, for each response, the pre-measured times were subtracted in order to obtain the subjects' reaction times. These reaction time data formed the basis for analyses.

Transformational of Data

The data were transformed, in order to attain maximum homogeneity of variance, by taking the square roots of the RTs, while maintaining their signs.

Analysis

The transformed data were analyzed by a total of six computer-assisted Analyses of Variance (ANOVAs); three dealt with data from Task 1 and three dealt with data from Task 2. It was necessary to perform three separate analyses for each task in order to separate out the three syntactic variables of interest in the sentence. Table V should make clear the

Table V

Factors Distinguishing the Eight Sentence Types

		FACTORS			
	Sentence Type	Semantic Constraints	Order of mention	Conjunction choice	Clause placement
	Examples	Constrained	OME=OOE	Before	Initial Main Clause
1.	She packed the suitcase BEFORE she washed the dishes.	-	+	+	+
2.	BEFORE she washed the dishes, she packed the suitcase.	-	-	+	-
3.	She washed the dishes AFTER she packed the suitcase.	-	-	-	+
4.	AFTER she packed the suitcase, she washed the dishes.	-	+	-	-
5.	She ate dinner BEFORE she washed the dishes.	+	+	+	+
6.	BEFORE she washed the dishes, she ate dinner.	+	-	+	-
7.	She washed the dishes AFTER she ate dinner.	+	-	-	+
8.	AFTER she ate dinner she washed the dishes.	+	+	-	-

various variables pertinent to each sentence type.

In order to analyze the data for the three syntactic variables, the data from the different sentence types had to be conflated in various ways. That is:

1) For the variable *before* versus *after*, data from sentence types 1, 2, 5 and 6 were grouped together versus data from sentence types 3, 4, 7 and 8.
2) For the syntactic variable OOE=OME versus OOE=OME, data from sentence types 1, 4, 5 and 8 were grouped versus data from sentence types 2, 3, 6 and 7.
3) For the syntactic variable Main-clause-first versus Subordinate-clause-first, data from sentence types 1, 3, 5 and 7 were grouped versus data from sentence types 2, 4, 6 and 8.
4) For the semantic variable, Constrained versus Unconstrained, data from sentences 1-4 were grouped versus data from sentences 5-8.

In each of the analyses, one of the three groupings, described previously, was defined as the "syntactic variable under consideration" for that particular computer run. This syntactic variable always had two values, plus or minus, as shown in Table V. The semantic variable was constant for all runs and had two levels also; these corresponded to "Constrained" versus "Unconstrained". For data from Task 2 only, a third variable, "Truth Value", was analyzed. "Truth Value" refers to whether a particular stimulus item had required a

positive or negative response. In all cases the 16 subjects served as blocks.

Prior to the main analyses, several preliminary analyses were conducted in order to determine whether two other variables could reliably be treated as random variables. These were *Subject Sex* and *Subject Type*. (Subject Type refers to those subjects who had participated in Task 1 first versus those subjects who had participated in Task 2 first.) Both Subject Sex and Type were found to be non-significant and were, therefore, treated as random variables for the major analyses.

The computer program by which the six following ANOVAs were accomplished also gave three frequencies, means and standard deviations for each level of each factor. No significant interaction effects were obtained. For all analyses, $p = .05$.

Task 1

Analysis 1A : Syntactic factor signifies conjunction choice

A 2 x 2 ANOVA was performed, with the Syntactic factor, in this case, referring to conjunction choice. The Syntactic factor had two levels, *Before* or *After*; the Semantic factor also had two levels, Constrained and Unconstrained; the sixteen subjects served as blocks.

The following *null hypotheses* were tested;

H_{01}: There is no significant difference between the mean values for the sixteen levels of the Subject factor.

H_{02}: There is no significant difference between the mean values for the two levels (Constrained and Unconstrained) of the Semantic factor.

H_{02}: There is no significant difference between the mean values for the two levels (Before and After) of the Syntactic factor.

Results are indicated in Table VI:

Table VI

Results of Analysis 1A : Analysis of Variance Table

Source	Sum of squares	DF	Mean square	F-ratio	Proba-bility	Test Term
SUBJ	26.001	15.	1.7334	22.009	0.00000	RESIDUAL
SEM	0.73136E-02	1.	0.73136E-02	0.92862-01	0.76068	RESIDUAL
SYN	0.34676E-01	1.	0.34676E-01	0.44029	0.50725	RESIDUAL
SEM*SYN	0.83713E-01	1.	0.83713E-01	1.0629	0.30298	RESIDUAL
Residual	46.073	585.	0.78758E-01			
Total	72.166	603.				

The *interpretation* of these statistics is as follows:

1. H_{01} is rejected; that is, a significant difference was found between the 16 levels of the Subject factor. Thus, some of the variability in the data is accounted for by inter-subject differences. (This finding was evident in each analysis.)

2. H_{02} fails to be rejected; that is, no significant difference was found between the mean values for Constrained and Unconstrained sentences. (This finding was evident in

analysis.

3. H_{03} fails to be rejected: that is, no significant difference was found between the mean values for the two levels of the Syntactic factor, *Before* and *After*.

Analysis 1B : Syntactic factor signifies Order-of-mention

A 2 x 2 ANOVA was performed, with the Syntactic factor referring to Order-of-mention. The Syntactic factor had two levels corresponding to OME=OOE and OME≠OOE; the Semantic factor had two levels, corresponding to Constrained and Unconstrained; the 16 subjects served as blocks.

The following *null hypotheses* were tested:

H_{01}: There is no significant difference between the mean values for the 16 levels of the Subject factor.

H_{02}: There is no significant difference between the mean values for the two levels (Constrained and Unconstrained) of the Semantic factor.

H_{04}: There is no significant difference between the mean values of the two levels (OME=OOE and OME≠OOE) of the Syntactic factor.

Results are indicated in Table 7.

Table VII

Results of Analysis 1B : Analysis of Variance Table

Source	Sum of squares	DF	Mean square	F-ratio	Proba-bility	Test term
SUBJ	25.863	15.	1.7242	21.924	0.00000	RESIDUAL
SEM	0.69783E-02	1.	0.69783E-02	0.88732E-01	0.76590	RESIDUAL
SYN	0.16881	1.	0.16881	2.1465	0.14343	RESIDUAL
SEM*SYN	0.15530E-01	1.	0.15530E-01	0.19747	0.65694	RESIDUAL
Residual	46.007	585.	0.78645E-01			
Total	72.166	603.				

Interpretation of these statistics is as follows:

1. H_{01} is rejected; that is, a significant difference was found between the 16 levels of the Subject factor. Thus, some of the variability of the data is accounted for by inter-subject differences.

2. H_{02} fails to be rejected; that is, no significant difference was found between the mean values for Constrained and Unconstrained sentences.

3. H_{04} fails to be rejected; that is, no significant difference was found between the mean values for the two levels, (OOE=OME and OOE≠OME) of the Syntactic factor.

Analysis 1C : Syntactic factor signifies Clause placement

A 2 x 2 ANOVA was performed. The Syntactic factor had two levels corresponding to Clause placement (Main-clause-first and Subordinate-clause-first); the Semantic factor had two levels corresponding to Constrained and Unconstrained; the 16 subjects served as blocks.

The following *hypotheses* were tested:

H_{01}: There is no significant difference between the mean values of the 16 levels of the Subject factor.

H_{02}: There is no significant difference between the mean values of the two levels (Constrained and Unconstrained of the Semantic factor.

H_{05}: There is no significant difference between the mean values for the two levels (Main-clause-first and Subordinate-clause-first) of the Syntactic factor.

Results are indicated in Table VIII:

Table VIII

Results of Analysis 1C : Analysis of Variance Table

Source	Sum of squares	DF	Mean squares	F-ratio	Probability	Test term
SUBJ	26.078	15.	1.7385	22.698	0.00000	RESIDUAL
SEM	0.10845E-01	1.	0.10845E-01	0.14159	0.70684	RESIDUAL
SYN	1.2668	1.	1.2668	16.540	0.00005	RESIDUAL
SEM*SYN	0.11746	1.	0.11746	1.5335	0.21609	RESIDUAL
Residual	44.807	585.	0.76594E-01			
Total	72.166	603.				

Interpretation of these statistics is as follows:

1. H_{01} is rejected; that is, a significant difference was found between the 16 levels of the Subjects factor. Thus, some of the variability in the data is accounted for by inter-subject differences.

2. H_{02} fails to be rejected; that is, no significant difference was found between the mean values for Constrained and Unconstrained sentences.

3. H_{05} is rejected. A significant difference was found between the mean values of the two levels (Main-clause-first and Subordinate-clause first) of the Syntactic factor. As is shown in Table IX, the mean response value for Main-clause-first sentences is smaller than the mean value for Subordinate-clause-first sentences.

Table IX

Frequencies, Means and Standard Deviations for Analysis 1C : Syntactic Factor

	Main clause first	Subordinate clause first
	302	302
O MEAN	1.2780	1.3678
P MEAN	1.2771	1.3688
O STDV	0.30147	0.38056
S ERR M	0.15930E-01	0.15930E-01

Task 2

Due to task differences between Tasks 1 and 2, it was necessary to add an extra factor to analysis of data from Task 2. This factor, called Truth Value, reflected the fact that, for this task, the subject was required to decide if a particular slide appropriately depicted the events described

by the sentence. Thus, a positive or negative response (*yes* or *no*) was demanded of the subject. Since reaction time may have been influenced by whether the correct response was *yes* or *no*, it was necessary to add this factor to the analysis. Truth Value had two levels in each of the following analyses, corresponding to *yes* or *no* as the appropriate response to each specific stimuli. In all other respects, the analyses for Task 2 are identical to the analyses for Task 1.

Analysis 2A : Syntactic factor signifies Conjunction choice

A 2 x 2 ANOVA was performed. They Syntactic factor had two levels corresponding to Conjunction choice (*Before* or *After*); the Semantic factor had two levels corresponding to Constrained and Unconstrained; Truth Value had two levels corresponding to *Yes* or *No*; and the 16 subjects served as blocks.

The following *null hypotheses* were tested:

H_{01}: There is no significant difference between the mean values for the 16 levels of the Subject factor.

H_{02}: There is no significant difference between the mean values of the two levels (Constrained and Unconstrained) of the Semantic factor.

H_{03}: There is no significant difference between the mean values for the two levels (*Before* and *After*) of the Syntactic factor.

H_{06}: There is no significant difference between the mean values for the two levels (*Yes* or *No*) of the Truth Value factor.

Results are indicated in Table X:

Table X

Results of Analysis 2A : Analysis of Variance Table

Source	Sum of squares	DF	Mean square	F-ratio	Pro-bability	Test term
SUBJ	31.638	15.	2.1092	29.320	0.00000	RESIDUAL
SEM	0.93467E-01	1.	0.93467E-01	1.2993	0.25481	RESIDUAL
SYN	0.25473	1.	0.25473	3.5410	0.06036	RESIDUAL
TRUTH	2.7551	1.	2.7551	38.299	0.00000	RESIDUAL
SEM*SYN	0.48704E-01	1.	0.48704E-01	0.67703	0.41094	RESIDUAL
SEM*TRUTH	0.97837E-02	1.	0.97837E-02	0.13600	0.71242	RESIDUAL
SYN*TRUTH	0.10709	1.	0.10709	1.4886	0.22291	RESIDUAL
SEM*SYN*TRUTH	0.64210E-01	1.	0.64210E-01	0.89257	0.34517	RESIDUAL
Residual	42.515	591.	0.71938E-01			
Total	77.414	613.				

Interpretation of these statistics is as follows:

1. H_{01} is rejected; that is, a significant difference was found between the 16 levels of the Subject factor. Thus, some of the variability in the data is accounted for by inter-subject differences.

2. H_{02} fails to be rejected; that is, no significant difference was found between the mean values for Constrained and Unconstrained sentences.

3. H_{03} fails to be rejected; that is, no significant difference was found between the mean values of the two levels of the Syntactic factor, *Before* and *After*.

H_{06} is rejected; that is, a significant difference is evident between the mean values of the two levels (*Yes* and *No*) of the Truth value factor. As is shown in Table XI, the mean values for *Yes* responses is smaller than the mean values for *No* responses.

Table XI

Frequencies, Means and Standard Deviations for Analysis 2A : Truth Value Factor

Correct response value	"Yes"	"No"
	309	305
O MEAN	1.2889	1.4222
P MEAN	1.2882	1.4230
O STDV	0.37619	0.31985
S ERR M	0.15304E-01	0.15405E-01

Analysis 2B : Syntactic factor signifies Order-of-mention

A 2 x 2 ANOVA was performed. The Syntactic factor had two levels, corresponding to Order-of-mention (OME=OOE and OME≠OOE); the Semantic factor had two levels corresponding to Constrained and Unconstrained, the Truth Value factor had two levels corresponding to *Yes* and *No*; the 16 subjects served as blocks.

The following *null hypotheses* were tested:

H_{01}: There is no significant difference between the mean values for the 16 levels of the Subject factor.

H_{02}: There is no significant difference between the mean values for the two levels (Constrained and Unconstrained) of the Semantic factor.

H_{04}: There is no significant difference between the mean values of the two levels (OME=OOE and OME≠OOE) of the Syntactic factor.

H_{06}: There is no significant difference between the mean values of the two levels (*Yes* and *No*) of the Truth Value factor.

Results are indicated in Table XII.

Table XII

Results of Analysis 2B : Analysis of Variance Table

Source	Sum of squares	DF	Mean square	F-ratio	Pro-bability	Test term
SUBJ	31.645	15.	2.1097	29.094	0.00000	RESIDUAL
SEM	0.89640E-01	1.	0.98640E-01	1.2362	0.26666	RESIDUAL
SYN	0.19132E-02	1.	0.19132E-02	0.26384E-01	0.87102	RESIDUAL
TRUTH	2.6835	1.	2.6835	37.008	0.00000	RESIDUAL
SEM*SYN	0.42408E-01	1.	0.42408E-01	0.58483	0.44473	RESIDUAL
SEM*TRUTH	0.10574E-01	1.	0.10574E-01	0.14582	0.70270	RESIDUAL
SYN*TRUTH	0.57570E-02	1.	0.57570E-02	0.79392E-01	0.77822	RESIDUAL
SEM*SYN*TRUTH	0.70152E-01	1.	0.70152E-01	0.96744	0.32572	RESIDUAL
Residual	42.855	591.	0.72513E-01			
Total	77.414	613.				

Interpretation is as follows:

1. H_{01} is rejected; that is, a significant difference was found between the 16 levels of the Subject factor. Thus, some of the variability in the data is accounted for by inter-subject differences.

2. H_{02} fails to be rejected; that is, no significant difference was found between the mean values of Constrained and Unconstrained sentences.

3. H_{04} fails to be rejected; that is, no significant difference was found between the mean values for the two levels, (OME=OOE and OME≠OOE) of the Syntactic factor.

4. H_{06} is rejected; that is, a significant difference was found between the mean values of the two levels (*Yes* and *No*) of the Truth Values factor. As is shown in Table XIII, the mean values for *Yes* responses was smaller than the mean values for *No* responses.

Table XIII

Frequencies, Means and Standard Deviations for Analysis 2B : Truth Value Factor

Correct response value	Yes	No
	309	305
O MEAN	1.2889	1.4222
P MEAN	1.2890	1.4222
O STDV	0.37619	0.31985
S ERR M	0.15372E-01	0.15473E-01

Analysis 2C : Syntactic factor signifies Clause-placement

A 2 x 2 ANOVA was performed. The Syntactic factor had two levels corresponding to Clause-placement (Main-clause-first and Subordinate-clause-first); the Semantic factor had two levels, corresponding to Constrained and Unconstrained; the Truth Values factor had two levels corresponding to *Yes*

and *No*; the 16 subjects served as blocks.

The following *null hypotheses* were tested:

H_{01}: There is no significant difference between the mean values of the 16 levels of the Subject factor.

H_{02}: There is no significant difference between the mean values fo the two levels (Constrained and Unconstrained) of the Semantic factor.

H_{05}: There is no significant difference between the mean values for the two levels (Main-clause-first and Subordinate-clause-first) of the Syntactic factor.

H_{06}: There is no significant difference between the mean values of the two levels (*Yes* and *No*) of the Truth Value factor.

Results are indicated in Table XIV.

Table XIV

Results of Analysis 2C : Analysis of Variance Table

Source	Sum of squares	DF	Mean square	F-ratio	Proba-bility	Test term
SUBJ	31.784	15.	2.1189	30.897	0.00000	RESIDUAL
SEM	0.87420E-01	1.	0.87420E-01	1.2747	0.25935	RESIDUAL
SYN	1.9637	1.	1.9637	28.633	0.00000	RESIDUAL
TRUTH	2.8452	1.	2.8452	41.486	0.00000	RESIDUAL
SEM*SYN	0.11628	1.	0.11628	1.6955	0.19338	RESIDUAL
SEM*TRUTH	0.11871E-01	1.	0.11871E-01	0.17309	0.67753	RESIDUAL
SYN*TRUTH	0.15002	1.	0.15002	2.1874	0.13968	RESIDUAL
SEM*SYN*TRUTH	0.23882	1.	0.23882	3.4823	0.06252	RESIDUAL
Residual	40.532	591.	0.68581E-01			
Total	77.414	613.				

Interpretation of the statistics is as follows:

1. H_{01} is rejected; that is, a significant difference was found between the 16 levels of the Subject factor. Thus, some of the variability in the data is accounted for by intersubject differences.

2. H_{02} fails to be rejected; that is no significant difference was found between the mean values for Constrained and Unconstrained sentences.

3. H_{05} is rejected. A significant difference was found between the mean values of the two levels (Main-clause-first and Subordinate-clause-first) of the Syntactic factor. As is shown in Table XV, the mean value for Main-clause-first sentences is smaller than the mean response value for Subordinate-clause-first sentences.

Table XV

Frequencies, Means and Standrad Deviations for Analysis 2C : Syntactic Factor

	Main-clause-first	Subordinate-clause-first
	309	305
O MEAN	1.3042	1.4066
P MEAN	1.2989	1.4122
O STDV	0.33366	0.36953
S ERR M	0.14912E-01	0.15009E-01

4. H_{06} is rejected; that is, a significant difference was found between the mean values of the two levels (*Yes* and *No*) of the Truth Value factor. As is shown in Table XVI the mean values for *Yes* responses was smaller than the mean value for

No responses.

Table XVI

Frequencies, Means and Standard Deviations for Analysis 2C : Truth Value Factor

	Yes	No
	309	305
O MEAN	1.2889	1.4222
P MEAN	1.2871	1.4241
O STDV	0.37619	0.31985
S ERR M	0.14941E-01	0.15039E-01

Summary of Results

1. In every analysis, a significant difference was found between the mean response values for the 16 subjects. Thus, some of the variance in the data is accounted for by inter-subject differences.

2. At no point in the analysis was a significant difference found between the mean values of the two levels of the Semantic factor (Constrained and Unconstrained).

3. At no point in the analysis was a significant difference found between the mean response values of the two levels of the Syntactic factor, when this factor indicated Conjunction choice, (*Before* or *After*).

4. At no point in the analysis was a significant difference found between the two levels of the Syntactic factor, when this factor indicated Order-of-mention (OME=OOE and OME≠OOE).

5. In both Task 1 and Task 2, a significant difference was found between the two levels of the Syntactic factor when this factor indicated Clause-placement. For both Tasks, this difference was in the direction of smaller mean response values for Main-clause-first sentences than for Subordinate-clause-first sentences.

6. Whenever Truth Value was a factor (i.e., in all Task 2 analyses), a significant difference was found between the two levels of this factor. In all cases, this difference was in the direction of *Yes* responses having smaller mean values than *No* responses.

7. At no point in the analysis was any significant interaction effect noted.

CHAPTER FOUR

DISCUSSION

The results of this investigation into the effects of various factors on the auditory comprehension of complex sentences conjoined with *before* and *after* are documented in the previous chapter. In the present chapter, these results are discussed with reference to experimental design, previous research and theories of sentences comprehension.

Discussion of Results

Inter-subject Differences

As noted in Chapter Three, statistically significant differences were found for the mean values of responses for different subjects. For the purpose of this investigation, individual response patterns were not analyzed. Subjects did, however, appear to adopt idiosyncratic response strategies. For example, some subjects tended to race through the task, as if speed of response represented a challenge. Other subjects appeared more concerned with making an accurate response,

resulting in a slowing of response time. It is of interest to note, however, that no noticeable difference in response accuracy distinguished these two response strategies. It is suggested that, had instructions explicitly stated that speed of response was the parameter of interest, then inter-subject response differences would have been reduced. That is, the way in which the instructions were worded allowed some freedom of interpretation with respect to speed and/or accuracy of response. It is speculated that those subjects who responded more cautiously may not have done so had the instructions stressed speed.

No statistically significant difference in mean response values was found for subjects' sex. However, there was evidence of a nonsignificant trend towards smaller response values for female subjects. Although nonsignificant, this trend is of interest since it is in accord with a result obtained by Slobin (1966). In a study investigating picture-verification for reversible and non-reversible active and passive sentences, Slobin found that, at all ages tested, female subjects gave shorter reaction times than male subjects.

True/False Differences

For Task 2, in which subjects were required to determine whether or not a single slide matched the given sentence, mean response values were smaller for stimuli requiring a "yes" response. This indicates that subjects found it easier to verify that a slide and sentence matched, than that they did

not match. Similar finding have been previously documented. Slobin (1966), found that reaction times were shorter for true active and true passive sentences, than for false active and false passive sentences (i.e., sentences which either matched or did not match an illuminated picture, respectively). Slobin suggested that "there may be a tendency to call affirmative sentences true" (p. 224). Results obtained in the present study appear to lend support to this notion. Sentences used in the present study (all affirmative) appeared easier to process when they were true with respect to the given context, in this case an accompanying slide.

Constrained/Unconstrained Differences

An important finding is that no differences were found between responses to sentences which were either constrained or unconstrained by general knowledge. In light of the results of French and Brown (1977) and Kavanaugh (1979), obtained with children, this point merits some discussion. As previously mentioned, results of these studies demonstrated childrens' performance was superior for sentences in which two events were meaningfully ordered. Two explanations for this contradiction between the present and previous results are offered.

First, as detailed in Chapter Two, unconstrained sentences in the present study were constructed in such a way as to avoid implausible sentences arising as a result of cross-matching. This caution was considered necessary since it was found that, if cross-matching were performed without this

constraint, highly questionable sentences resulted. French and Brown, however, constructed their unconstrained sentences by randomly cross-matching clauses from their constrained sentences. This procedure must have produced some unconstrained sentences which were of questionable plausibility. If this was indeed the case, then French and Brown's comprehension of plausible and implausible sentences, rather than differences in comprehension between constrained and unconstrained sentences, as they assumed.

It is also possible that the subject populations used may account for this difference in results. Perhaps the facilitation effect of logical context on the comprehension of these sentences is remarkable only for children. It is speculated that, while children are acquiring the meanings of the terms *before* and *after*, supportive context is helpful in interpreting sentences containing these words. However, as the meanings of the words become more fully understood, less support is sought from the semantic constraints of the sentence. Support for this notion comes from Slobin (1966) who noted that the influence of nonreversibility on the comprehension of passive sentences decreases with age.

One final point regarding this result requires comment. Superficially, the lack of a constrained/unconstrained difference may be considered to support the "constancy hypothesis", as outlined by Forster and Olbrei (1973). This hypothesis (discussed in Chapter One) contends that semantic

differences across sentences do not affect aspects of sentence comprehension which are attributable to syntactic processing. Although the results of the present study do not conflict with this hypothesis, neither do they lend it any direct support. No attempt was made, in the present study, to isolate the syntactic processing components of sentence processing. Rather, the procedures used were designed in the hope of attaining some more holistic indication of the subjects' understanding of the sentences. Comprehension, as such, is not a consideration in the "constancy hypothesis".

Order-of-mention Differences

No significant effect of order of mention was found in the present study; sentences in which the order-of-mention and order-of-occurrence of events correspond were responded to no differently than sentences without such a correspondence. This result is contrary to some previously reported results, especially those of Clark (1971), of children who seemed to rely strongly on an order-of-mention strategy in interpreting such sentences. It is suggested that one reason no such strategy was evident in the present study may be that an order-of-metnion strategy is one primarily used by children acquiring the meaning of *before* and *after*, and which becomes less dominant with age. Support for this notion comes from Clark's own study, in which it was noted that younger children relied more heavily on this strategy than older children.

That is, apparent use of an order-of-mention strategy decreased with increasing age and understanding of the terms *before* and *after*. One could speculate that if this trend increase with age until adulthood, then the role of this strategy for adults, if present at all, would be too reduced to be evident in many tasks.

The preceding explanation does not, however, account for the results obtained by Clark and Clark (1968) in their study of adults' memory for sentences of this kind. They noted that verbatim recall is better for sentences in which the order-of-mention preserves the order-of-occurrence of events. On the contrary, order-of-mention was not found to be a significant factor either in the present study or in the study by Smith and McMahon (1970). Smith and McMahon suggested that order-of-mention plays a different role in memory tasks than in comprehension tasks. The results reported here support their view, although it is suggested that this notion requires further experimental elaboration.

Coker (1978) suggested a more specific explanation for the difference in results regarding order-of-mention, among the different studies using children as subjects. As explained more fully in Chapter One, Coker postulated that when a subject is required to attend to both clauses (as they certainly are in the Clarks' verbatim recall task) an order-of-mention strategy predominates. When, however, the subjects' attention is not cued to both clauses, a strategy of preferentially attending to the main clause is dominant. It is suggested that the tasks used in the present investigation

did not require subjects to attend fully to both clauses. (Indeed, the fact that many responses were made prior to the completion of the sentence would appear to indicate that such an explanation is likely.) The resulting dominance of a main-clause strategy over an order-of-mention strategy could, therefore, be seen as support for Coker's postulation.

Clause Placement Differences

Sentences which begin with a main clause were found to result in smaller mean response values than sentences with an initial subordinate clause. As shown in Chapter Three, this result was highly significant in each analysis. It would appear that, for the tasks used in the present study, the main clause plays a primary role in sentence comprehension. This is in accord with previous evidence of preferential attention to the main clause, as reported by Smith and McMahon (1970), Amidon and Carey (1972), and Coker (1978).

Coker suggested that one (of two) main clause strategies used by children in her study could be described as follows:

Subjects act out only the events in the main clause and ignore the events in the subordinate clause.

A similar strategy appears to have been followed by subjects in the present study. This strategy can be paraphrased as follows:

If the main clause is heard first and supplies enough information to complete the task, respond immediately; if, however, the subordinate clause is heard first, even if it supplies enough information to complete the task, wait until hearing the main clause before responding.

Why should it be that initial main clauses are interpreted more readily than initial subordinate clauses? Townsend and Bever (1977) discussed this question in some detail. They claimed that main and subordinate clauses can be compared to visual figures and grounds, respectively. Main clauses, like visual figures, contain information that is new; this information constitutes the assertion made by the speaker. Subordinate clauses, like visual grounds, contain older information; this information is presupposed by the speaker to be known to the listener, and provides a context for the assertion of the main clause. Townsend and Bever claimed that these characteristics of main and subordinate clauses imply that the information contained in the main clause is conconsidered to be more important. The results of the present study support this view; if the listener expects the more important information to be found in the main clause, it is not surprising that s/he attends to this clause preferentially.

One final point regarding this result should be mentioned. It might be suspected that the specific measurement procedure used in this investigation may have biased the analyses of clause-placement differences. As described in Chapter Two,

the point chosen for the onset of response time measurement was within the sentence, following the first clause and the conjunction. It is acknowledged that this definition of "zero time", although the most agreeable of several alternatives, is an imperfect compromise. The problem arises because this partitioning procedure does not divide the sentences in an equivalent manner. Although the same number of words precede the partition in both types of sentence, the conjunction is heard at a relatively different position with respect to "zero time" for sentences beginning with a main clause, as opposed to sentences beginning with a subordinate clause. Consider the sentences, *She packed the suitcase before she washed the dishes* and *Before she washed the dishes, she packed the suitcase*. In the first case, the subject must wait until "zero time" (following the word *before*) until s/he has all the necessary and sufficient information required to make the response. For the second sentence, however, it is possible that the subject may have all the necessary information prior to this point. That is, upon hearing only *Before she washed*, the subject may have decided that the slide depicting *washing* must be the one describing the final event. If this is the case, the subject could possibly begin responding at a point prior to the onset of response time measurement. It is clear, however, that if such a response pattern occurred, its effect would be to reduce the response time of subordinate-clause-initial sentences, relative to those beginning with a main clause. Any suspected

bias due to the measurement procedure is, therefore, in the direction opposite to that of the observed result. If such a bias was inherent in the measurement, it would serve only to strengthen the obtained result of smaller response values for main-clause-initial sentences.

Before/After Differences

No significant difference was found between responses to sentences containing *before* and *after*. Although children's superior performance for *before* sentences was a result stressed by Clark (1971), both Smith and McMahon (1970) and Coker (1978) have pointed out that the reason underlying this result may not be that *before* is the more basic of the two terms, as Clark suggested, but that *before* and *after* are confounded with other factors in these sentences. In *before* sentences, the first event is also asserted in the main clause; thus, better performance on *before* sentences can be viewed as further evidence of preferential attention to the main clause. Coker further suggested that the response pattern of superior performance on *before* sentences is the way in which preference for the main clause is manifest when an order-of-mention strategy is dominant; otherwise, the primacy of the main clause will be evident in a more obvious manner, e.g., a subject entirely ignoring the subordinate clause.

The results of this study are consistent with Coker's speculation. Preferential attention to the main clause has been evidenced as the dominant strategy, i.e., by smaller

subject response values to sentences beginning with a main clause. The fact that it is not also evident in smaller response values to *before* sentences would be predicted by Coker, and is supported by the result of Smith and McMahon's study; in the presence of a dominant effect of response latencies being smaller for main-clause-initial sentences, no similar effect was noted for *before* sentences.

A Comment on the Relative Importance of Semantic and Syntactic Factors

It is tempting to view these results as evidence of the primacy of syntactic factors over semantic factors in the auditory comprehension of complex sentences conjoined with *before* and *after*. Such a conclusion, however, is not only premature, but also, in all probability, invalid. Labelling a factor (and subsequently a strategy) as either semantic or syntactic is by no means a totally objective decision. Such a judgement is necessarily coloured by one's theoretical bent, and ultimately, depends on linguistic analyses which may or may not be valid. It is the author's contention that such labels are useful only if they serve to communicate detail efficiently, and should be used cautiously since a label may inadvertently serve to obscure detail rather than communicate it. A case in point is the major finding of this paper, i.e., evidence for a strategy by which subjects attend preferentially

to the main clause in a sentence. Although this strategy has been described in syntactic terms, it would be highly misleading and inappropriate to label it as a "syntactic" strategy (as Coker has labelled a similar strategy). It is not at all clear that the reason subjects attend differently to main clause initial sentences is due to these sentences being syntactically simpler, as such a label implies. It is at least equally probable that semantic reasons, concerning the nature of main clause content, underly this result (Bever, 1970; Townsend and Bever, 1977). By labelling such a strategy as either semantic or syntactic, one is not only assuming more than the evidence supports, but one also runs the dangerous risk of presupposing the nature of the process.

As is indicated above, the reason underlying the result of smaller response values to main-clause-initial sentences is probably not so simple that one could describe this as either a syntactic or semantic strategy. It is suggested that this result reflects an interaction of syntactic and semantic devices utilized by the subject as an aid for sentence comprehension. More specifically, it is suggested that the surface structure phenomenon to which the subject cues has a syntactic base (namely, the absence or presence of a subordinating conjunction at the beginning of a sentence). The purpose of such focus on this syntactic term, however, is to aid organization of the semantic content of the sentence. In other words, the presence of *before* or *after* at the beginning of the sentence cues the subject to attend less to the initial clause and to await the

final clause, in order that s/he will be free to process the more important content of the main clause. Conversely, the absence of such a syntactic cue at the onset of a sentence signals the subject that s/he is free to process the first clause and, upon its completion, is free to react to the task, as the more important information of the sentence has been processed at this point.

Possible Sources of Experimental Error

Physical and Mechanical Sources of Error

Several aspects of the physical and mechanical set-up and preparation allowed room for error due to the limitations of the equipment. In all such instances, it is anticipated that any existing inaccuracy would be consistent throughout the experiment, and not a source of random, uncontrolled variation.

One such problem arises in relation to the splicing of stimulus tapes. Although this splicing was performed with every caution, it cannot be stated with certainty that every splice corresponded to the onset of each sentence to one hundredth of a second accuracy. Four aspects of this procedure may be identified as possible sources of error; locating the onset of speech for each sentence, the thickness of the razor blade used to make the cut in the tape, and the accuracy of the cut itself. Despite meticulous care to minimize these sources of inaccuracy, they still must be acknowledged.

The measurement of each sentence to the point of partitioning, (i.e., locating "zero time" for response measurement), also is problematic. As discussed in Chapter Two, variation in measurement was minimized by measuring each sentence five times, discarding the highest and lowest readings, and then averaging the remaining three readings. It is anticipated that this procedure rendered consistent any variation in measurement between sentences to an accuracy close to one hundredth of a second.

A further source of inaccuracy lies in the co-ordination of the onset of the sentence with the illumination of the slide(s). Although both operations begin at the same instant, a small period of time is required for the light of the slide projector to reach maximum illumination. Thus, full illumination of each slide would lag the onset of the sentence by a fraction of a second. As this period of time is not only very small, but also is consistent for each stimulus, this is not considered to be a major problem.

Sources of Error in Data Collection and Analysis

As a large amount of data was collected, and as each datum was subjected to a number of operations prior to computer analysis, it is possible that error may have occurred in this area. Possible sources of error include; data recording, arithmetical manipulations of data (see Chapter Three) and entering the data into the computer. As each of these steps was, at the very least, triple checked, it is doubtful that such error did occur.

A Problem with the Experimental Design

A more serious problem involves the nature of the experimental design, in particular with reference to Constrained/Unconstrained differences. If subjects had demonstrated superior performance for constrained sentences, then no conclusion could have been drawn concerning the role of this factor (general knowledge constraints) in sentence comprehension. This is because one could not reliably eliminate the possibility that the subjects had bypassed the processing of the constrained sentences and had, instead, responded to context as represented by the slides. If this had been the case, the predicted result would have been superior performance for constrained sentences. It would be impossible, therefore, to determine the cause of any observed difference between responses to constrained and unconstrained sentences.

Since, however, no significant difference was noted between responses to constrained and unconstrained sentences, and since a subject must process at least part of the sentence in order to perform the task for constrained sentences, it is reasonable to conclude that subjects also processed some part of the constrained sentences and were not merely responding to the pictured context.

This problem (namely, the impossibility of determining whether subjects would have been responding to the pictured context of the content of the sentences, in the event of superior performance for constrained sentences having been evident) is interesting for a number of reasons. First, it

underscores the necessity for keeping experiments "clean", in the sence of requiring all stimuli to be presented in one modality in order to avoid contamination factors. The present study, for example, would have been redesigned so as to eliminate the need for visual cues, had this fault in the design been noted in advance.

Secondly, an interesting question is raised regarding what one hopes to discover when attempting to examine the role of extra-linguistic information on sentence comprehension. Ultimately, the goal must be to elaborate those factors operating in the comprehension of natural language, and how such factors aid or inhibit the understanding of language outside of the laboratory. Unfortunately, in order to keep experiments methodologically clean, most contextual factors, including many which would be interesting to investigate, must be eliminated. Resolution of this problem is not immediately apparent; hopefully, further research and discussion will lead to methods of investigation which can reliably examine the influence of more than one modality on the active process of sentence comprehension.

CHAPTER FIVE

CONCLUSIONS

The purpose of this investigation has been to determine the effects of certain factors on adult subjects' comprehension of complex sentences conjoined with *before* and *after*. The following factors were investigated:

1) general knowledge constraints
2) conjunction choice
3) order of mention
4) clauses placement

The tasks were designed in an effort to elicit varying reaction times. These tasks involved matching and verifying the correspondence between slide and sentence stimuli. Major results of this investigation are as follows:

1. Subjects demonstrated superior performance for sentences requiring a "true" response.

2. Subjects demonstrated superior performance for sentences beginning with a main clause.

3. No significant difference was noted between subjects' responses for *before* and *after* sentences.

4. Subjects did not demonstrate use of an order-of-mention strategy in interpreting these sentences.

5. Extra-linguistic information, in the form of general knowledge constraints on the sentences, did not affect subjects' responses to these sentences.

The results of the present study lend support to a growing body of data which suggests that the main clause enjoys a priveleged position in the comprehension of complex sentences (Amidon and Carey, 1972; Bever, 1970; Coker, 1978; Smith and McMahon, 1970; Townsend and Bever, 1977). Preference for the main clause, in the present study, is manifest by smaller response values to sentences beginning with a main clause. Whether preferential attention to main clauses stems from some added syntactic difficulty of processing subordinate clauses, (Amidon and Carey, 1972; Smith and McMahon, 1970), or from characteristics of the semantic content of main clauses (Bever, 1970; Townsend and Bever, 1977) has not been determined in the present study, but remains a theoretically interesting point. It is suggested, however, that the results of the present study are compatible with a view that a solely semantic or syntactic explanation for this phenomenon is too simplistic. Rather, subjects may focus on a syntactic cue in the surface structure in order to help them organize the semantic content of complex sentences.

When the results of the present study are considered in conjunction with those of previous studies, one is struck by the variation in response patterns observed across studies,

depending on the task requirements. A comment by Coker (1978) provides some framework in which to note consistencies in these divergent response patterns. Coker suggested that, in the comprehension of these sentences, a preference for main clauses is demonstrated by one of two response patterns; superior performance on *before* sentences (in which the main clause expresses the first event) or attendance only to the main clause, in the sense of ignoring the subordinate. She further outlined situations in which each of these patterns could be expected. When the subject is cued to attend to both clauses, main clause performance will be manifest as superior performance for *before* sentences. When the tasks requirements do not demand full attention to both clauses (as in the present study) main clause dominance will be manifest in a more obvious way. Coker also suggested that, in the former situation, an order-of-mention strategy will dominate over the main-clause strategy, whereas in the latter situation, a strategy reflecting main clause preference will dominate. Although Coker specifically addressed the variations in results obtained for children, these comments seem largely consistent with the results found in the previously reviewed research involving adults, and with the results of the present study. Whereas Coker's suggestions have accomplished much in terms of resolving and organizing the apparent inconsistencies found in the literature, they merely organize the various response patterns while failing to supply any adequate explanation as to why different tasks requirements trigger such divergent response patterns and strategies.

An interesting comment on the variation in response patterns between tasks has been made by Smith and McMahon (1970). It underscores the importance of this phenomenon to the development of any theory of sentence comprehension:

> "...we are struck by the impression that we are viewing an object (the process of comprehension) through windows made of different types of distorting glass; each window corresponds to a different procedure. The image is, of course, blurred by the inherent variability of our measurements. The question which is central to the enterprise of understanding the comprehension process is whether we are viewing the same process through windows which show first one component process and then another, or whether we are viewing entirely different processes through each window." (p. 266)

In conclusion, many problems remain which require further investigation before our understanding of comprehension of these complex sentences can approach completion. First, how does one elaborate a theory of sentence comprehension which will not only account for, but also explain, the observed variations in response patterns and apparent strategies used in sentence comprehension? Second, what is the effect of varying instructions on a subject's performance of these and similar tasks? Third, how can we best examine comprehension in a natural language setting, without compromising experimental rigour?

Finally, it is hoped that the methodology developed here can provide a framework within which to develop tools for examining sentence comprehension strategies used by language disordered subjects.

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