THE INFLUENCE OF CLAUSE STRUCTURE ON THE PERCEPTUAL ANALYSIS OF SENTENCES

by

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B.A., The University of Chicago
1969

SUBMITTED IN

PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

AT THE

 MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February, 1974

Signature of Author
Department of Linguistics, February 5, 1974

Certified by
Thesis Supervisor

Accepted by
Chairman, Departmental Committee on Graduate Students
ABSTRACT

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Judith R. Kornfeld

Submitted to the Department of Linguistics on February 5, 1974, in partial fulfillment of the requirement for the degree of Doctor of Philosophy.

The experimental studies in this dissertation represent an approach to one of the most pressing problems in psycholinguistic research: the relationship between the form of a grammar and the analysis of sentences by the listener. The particular issue addressed in this thesis is the question of whether the syntactic relations between clauses have specific effects on the initial perception of sentences.

In the Preface, a performance model is presented that takes account of both grammatical and psychological variables. This model provides a theoretical basis for dealing with the question of whether syntactic properties are relevant to early processing events. An experimental method is then outlined to study the potential effects of tree structure geometry on the immediate segmentation of sentences.

Chapter I reports the results of several studies which bear on this problem. Although most of this research shows that the positions of phrase and clause boundaries affect the way listeners break down sentences, it is not clear that boundary location is the factor which is solely responsible for the reported results. A number of recent studies suggest that dominance relations between clauses are also relevant to early perceptual analysis. A
probe-latency experiment (EXP. I.) was designed to test out the latter hypothesis, and to explore how syntactic factors interact with psychological variables like memory size. The outcome of this study is summarized at the end of Chapter I. The results of EXP. I confirm the existence of a clause boundary effect, but they are equivocal with respect to the effects of dominance properties.

Because of the uncertainty about the role of dominance, another experiment (EXP. II) was conducted, and is discussed in Chapter II. The evidence from this study argues that boundary location and dominance each have specific effects on processing, but the interaction between these factors is quite complex. A third study (EXP. III) was undertaken to clear up the question of the interaction, and to see whether the type of subordinate clause in a sentence also exerts effects on performance. Chapter III presents evidence from this experiment that argues for the independence of the boundary factor. Effects of clause type are also treated in detail.

At the end of Chapter III, the results from all three studies are reviewed and evaluated in terms of the performance theory outlined in the Preface. The experimental findings themselves are rationalized with respect to specific properties of structural descriptions in the grammar. Finally, in the Epilogue (Chapter IV), the research is brought to bear on cases of perceptually complex sentences. A variety of examples are examined to show how information about performance factors helps explain the source of some problematic constraints on deletion and movement rules.

Thesis Supervisor: Merrill F. Garrett

Title: Associate Professor of Psychology
Dedication

To my father, Samuel Kornfeld
(1900–1969)
ACKNOWLEDGEMENTS

I wish to thank first the faculty from the departments of linguistics and psychology who helped me in designing and carrying out the research. Special appreciation goes to Merrill Garrett and Ed Walker, for their advice in both technical and theoretical matters. Their encouragement and personal counsel during the experiments were invaluable aids. Morris Halle and Noam Chomsky made important suggestions about the work at several points, and their comments have turned out to be extremely useful in the final stages of the research.

The graduate students in linguistic and psychology must also be thanked for their discussion and companionship. Avery Andrews, Gary Milsark, Wales Brown, William M. Wilson, Susan Martin, Sarah Bell, and Dan Kahn all provided helpful criticisms along the way.

Lastly, a very special tribute must be extended to Diane Rice, a woman whose stories and smiles made it possible to bear even the most disastrous equipment failures.
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PREFACE

1. The problem of perceptual analysis

How do listeners perceive sentences in their native language? This is one of the most pressing problems facing current psycholinguistic research. The results of several studies have suggested that certain aspects of syntactic structure influence the way sentences are analyzed perceptually—but many details of the analysis are as yet unknown. In particular, it is unclear exactly which syntactic properties are relevant to perception. Or, even when the relevant properties are identified, it is not obvious how information about these features is made available to the listener.

What is needed to resolve these issues is a sentence processing model of a special kind: viz., one that describes the relationship between psychological processes and syntactic variables. The construction of such a model is not an easy task. It requires several steps: we must first isolate syntactic properties that are potentially crucial from the listener's standpoint; then find an experimental paradigm which is sensitive to the variables in question; devise sentences that differ minimally by these features;
and, finally, conduct one or more studies to find out whether the presence of a given property has specific effects on performance.

The research that has been done along these lines has revealed the importance of clause boundaries for the immediate segmentation of sentences. Yet the position of the boundary is not the only aspect of clause structure which could affect early perceptual analysis. Hierarchical relations among clauses ("dominance" relations) might also be crucial variables. In this thesis, several experiments are discussed that test whether dominance factors do, in fact, have specific effects on processing. However, before giving details about these tests and their implications for a performance theory, we will first consider the relationship between linguistic descriptions and processing models, and then review the results of some earlier studies that argue for such a relationship. This discussion will thus provide a perspective with which to view the dominance experiments.

2. **Performance models and linguistic theory**

An adequate theory of language behavior must describe the following: 1) the linguistic knowledge of language users; 2) the cognitive processes for using this knowledge to perceive and produce speech; and 3) the psychological factors, such as memory limits, that constrain
the processes. These three aspects can be viewed as components of a performance model, as illustrated below.

1. Linguistic Knowledge
2. Cognitive Processes
3. Psychological Factors - memory size, beliefs

Fig. I-1. Components of a performance model

If the model is to function properly, each component cannot be an isolated or arbitrary system. Consider just the knowledge component (1). It must contain linguistic information in a form that can be made readily available to the language user, via the processes in (2). This constraint serves to narrow the set of possible descriptions of linguistic knowledge. For example, random lists of facts would be excluded, but an ordered and indexible system of rules would be favored. Hence, a generative grammar would be a system which satisfied these constraints. In other words, if a grammar is conceived as an internalization of linguistic rules, it can be viewed as a plausible description of the linguistic knowledge of the language user. Certain aspects, or properties of a
particular grammar should then be reflected in the cognitive processes which are used for speech processing. This must be the case if the performance model includes a component like (2).

The relation between properties of a particular grammar and psychological processes will become clearer if we compare two different levels of syntactic representation. Assume for the moment that the description in component (1) resembles that of a phrase structure grammar. There should be an associated process or set of processes in component (2) that segment(s) speech into surface phrases. Note that this model would not be adequate to the listener's task of assigning a unique meaning to a given string, since there are some sentences with the same surface representation that still differ in meaning. For instance, (1) below:

(1) The federal agent asked the vice squad to stop gambling after 1 A.M. This sentence can mean either that the men in the vice squad should put a stop to their own gambling, or to someone else's. The interpretations of the next sentence are similar:

(2) The coach told the lifeguards to continue swimming in the smaller pool.

Just as in (1), sentence (2) can refer to the lifeguards themselves swimming, or to the availability of the smaller
pool for public swimming.

The different senses of each of these sentences can, however, be distinguished by separate underlying configurations. A more adequate model of perception should therefore include a level of grammatical representation like deep structure, which could capture the different semantic relations in the examples above. A grammar with a deep structure level such as the one presented in *Aspects* (Chomsky, 1965) would meet this criterion. Thus, it is a logical candidate for component (1).

How plausible, then, is an *Aspects*-type grammar as a description of the linguistic knowledge (that is used by the cognitive processes in component (2))? An answer to this question for the level of deep structure, as for any linguistic construct, can be found by examining evidence from both linguistic theory and psycholinguistic experiments. Linguistic theory, in this case, provides the more straightforward answer. That is, the syntactic arguments for deep structure properties have been fairly well-established (Chomsky, 1965; 1970). On the other hand, the evidence from experimental studies is more problematic. Structural descriptions of test material may be questionable, or there may be unintentional effects of non-linguistic variables in the experiments themselves.

Though these factors may make it difficult to relate behavioral findings to linguistic theory, it is still
possible to do so, especially if one assumes the following:

Ceteris paribus, a given structural feature (or set of features) should have a constant behavioral consequence; two sentences with different structural features should have consistently different consequences—i.e., they should affect different psychological processes.

According to this approach, grammatical properties are interpreted in two ways: a given feature, or property, figures both as a primitive in a formal system (a grammar), and as a unit or concept in a cognitive model of sentence processing. This framework therefore enables us to base a performance theory on the same units that a generative grammar specifies.

The approach is a plausible one, particularly since many formal aspects of the grammar correspond to intuitive concepts of language users. For example, there are a number of intuitively compelling notions that can be represented as properties of structural descriptions; e.g., ambiguity, constituency, and dominance. "Ambiguity" can be reflected by multiple structural descriptions in the grammar. "Constituency" may be defined on syntactic phrase markers; i.e., surface constituents are of the same syntactic type (NP, VP, coordinate-S. . . .) if they are dominated by a node with the same label (NP, VP, S[ . . . ]S) in deep structure. 1 Further, if the node dominating a clause in the underlying phrase marker is the topmost-S, this clause
would correspond to our intuitions of a "main clause"; if
the S-node is embedded under another clause in the tree
hierarchy, the lower clause would be identified as "subor-
dinate," etc.

In brief, there is an intuitive sense to the formal
property of "dominance." Figure I-2, below, illustrates
the relations between these kinds of grammatical intuitions
and the formalism.

<table>
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<th>DEFINITION</th>
<th>FORMALISM</th>
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<tbody>
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<td>SYNTACTIC PROPERTIES</td>
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<td></td>
</tr>
<tr>
<td>&quot;Main clause&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Subordinate clause&quot;</td>
<td>Material dominated by an S-node which is not topmost in the tree structure. (Sₙ₋₁ below).</td>
<td></td>
</tr>
<tr>
<td>&quot;Dominance&quot;--the grammatical property describing the relation of a main clause to a subordinate.</td>
<td>The vertical arrangement of S-nodes in the tree hierarchy represents the grammatical property of dominance</td>
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Fig. I-2. Correspondences between grammatical intuitions and structural formalism
Once notions like dominance are spelled out in structural terms, as above, it becomes possible to answer questions about the role these properties play in sentence processing. One can make hypotheses about specific effects of structural variables on performance, and test these claims experimentally. If the tests are successful, the results can be used to formulate rules of processes that listeners might employ to decode speech.

**Summary**

In this section, we have first outlined some prerequisites for an adequate performance theory, and then discussed the relationships among components in the model. Next, we described an experimental approach for studying the correspondences between structural properties and psychological processes. To recapitulate, the method consists of the following steps:

1. Look at aspects of linguistic formalism and corresponding grammatical properties;
2. Interpret these properties as concepts;
3. Predict the ways one or more of these properties should influence language perception (and/or production and memory); and
4. Test the claims experimentally, by developing techniques that are sensitive to the grammatical variables in question.
This approach has proven itself as a useful way of studying sentence perception. In fact, there is a growing body of experimental evidence which bears on the question of what syntactic structures are computed on-line by the listener—i.e., as he hears a sentence. These computed structures seem to reflect an initial analysis of speech into units, which are not arbitrary but correspond instead to syntactic constituents, like phrases and clauses in the grammar. This result is exactly what one would predict, given a performance model in which structural variables affect processing mechanisms.

However, it is a difficult matter to determine the structural variables which are crucial for initial sentence analysis. The research has actually just begun, and most of the findings have a variety of loose ends and alternative explanations. For example, early work with several paradigms indicated that surface phrase structure boundaries define the units of sentence decoding. But later studies also emphasize the importance of syntactic clauses as significant units of speech perception. The evidence for both positions will be reviewed in the following section. It will soon be apparent that clause structure affects early steps in sentence processing; but the source of these effects is still unclear.
CHAPTER I

1. Review of the Literature: 

Effects of syntactic variables on sentence analysis

The experiments in question fall into several groups: roughly, those which focus on effects of surface phrases, and those which may also reveal effects of clause structure. The latter studies can even be further divided, depending on whether they show a relationship between deep or surface clauses, and performance. Each group of studies will be considered separately in the following discussion.

a. Surface phrases

The research that is summarized in this section suggests that sentences are analyzed into surface structure phrases; i.e., the representations of sentences that are immediately computed by the listener contain the same kinds of structural information as surface phrases. Evidence for this position can be found in a study by Stewart and Gough (1967), who used a "two-word probe" technique. In this paradigm, a subject is presented with a sentence, which is immediately followed by a pair of words called "probes." The subject must decide whether the words oc-
CHAPTER I

1. Review of the Literature:

Effects of syntactic variables on sentence analysis

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curred in the sentence just presented. If so, he pushes a button marked IN; if not, he pushes the OUT choice. Response latency is measured.

Tests with this technique revealed faster reaction time (RT) to probes from the same surface constituent than from different constituents. From this result, Stewart and Gough concluded that "... constituent structure existed formally in the immediate memory representations [of their test material]." In short, the findings from two-word probe tests support the claim that the formal property of constituency has a psychological correlate in the immediate memory representations for sentences.

The same conclusion was reached by N. Johnson (1966), who looked at patterns of errors made when subjects learned lists of sentences. His results showed a significant increase in the probability of errors for recall of the first word in each of the major surface phrases in a sentence. Johnson interpreted this finding to mean that "... sentence learning is facilitated by decoding a sentence into grammatical phrases."

One way of explaining these results is to say that sentences are decoded into perceptual units which correspond to major syntactic phrases in surface structure. This explanation was, in fact, proposed to account for the data from click location tests (Fodor and Bever, 1965). The
click paradigm consists of placing a short noise burst in sentences and asking listeners to locate the burst relative to the sentence. Sentence stimuli are presented dichotically, so that subjects hear a sentence in one ear and a click in the other. In the Fodor and Bever (1965) experiment, subjects indicated their judgments of the click location after each test sentence. Accuracy of location and distribution of errors were scored by the experimenters.

Results from the study showed that subjects made more errors on those clicks which were placed within major syntactic phrases, as compared to the clicks which were objectively put into phrase boundaries. In other words, subjects were more accurate in locating clicks which occurred between syntactic units. Furthermore, the errors of location formed a revealing pattern; viz., clicks placed before and after major phrase boundaries were subjectively located at the boundary point. Again, this result fits a model in which surface structure formalism has psychological reflexes.

b. **Phrase or clause structure?**

The results of the early research were simply interpreted as showing that constituent boundaries in general affected the listener's segmentation of sentences. But the nature of these structural effects was still un-
determined. A question that has preoccupied investigation in this area is whether the crucial boundaries in perception are, for example, NP and VP breaks; or whether clause boundaries are more central to perceptual analysis.

Later experiments have suggested that surface and underlying clause structure is indeed more relevant to initial sentence segmentation than is surface phrase structure. For example, Wanner (1968) found that performance on a recall task was a function of underlying clausal structure, as would be captured by an Aspects-type representation.

He used a prompted recall technique, in which subjects were presented with sentences like (3) and (4) below.

(3) The governor asked the detective to prevent drinking.

(4) The governor asked the detective to cease drinking.

Following each sentence, a prompt word was given. In the case above, the prompt was detective. Subjects then had to recall as many words from the sentence as they could. The experimenter recorded the number of words that were recalled.

Detective was found to be a better prompt in the (4) version than in the (3) version. Wanner explained this result as a function of the number of times the prompt word occurred in the underlying representation. (Detective occurs three times in the (4) version, but only two times
in the (3) version, as in the following diagrams:

Rough deep structure (4)  Rough deep structure (3)

Fig. I-3. Deep structures for Wanner's sentences

Thus, if one accepts Wanner's argument, there is reason to think that computed structures do resemble the base representations of the Standard Theory. This conclusion would imply that sentences are segmented into clauses during perception, since base structures reflect underlying clausal structure (by definition).

Additional evidence for this claim can be found in
the results from several tests of immediate memory. For example, Walker, et al. (1968) used a two-word probe technique to find out whether probe words from the same underlying clause are recognized faster than words from different clauses. In this study, subjects were shown sentences that had relative clauses embedded on the subject-NP of the matrix-S.

   E.g., 5: The scouts the Indians saw killed a buffalo.

Rough underlying structure

Each sentence was followed by a pair of probe words. For the above sentence, the probe pairs included Scouts killed, Indians saw, scouts saw, and Indians killed. Latencies for these probes appear in Table I-1 below. Notice that the fastest responses were made for members of the same deep structure clause (scouts killed), and the slowest for members of different deep structure clauses (Indians killed).
TABLE I-1
LATENCIES FOR PROBE TESTS OF WALKER ET AL. (1968). REACTION TIME IN SECONDS:

<table>
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<th>Verb in Probe Pair</th>
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<tbody>
<tr>
<td></td>
<td>Embedded (Saw)</td>
<td>Matrix (Killed)</td>
<td></td>
</tr>
<tr>
<td>matrix (scouts)</td>
<td>1.06</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>embedded (Indians)</td>
<td>1.06</td>
<td>1.12</td>
<td></td>
</tr>
</tbody>
</table>

Moreover, the fastest probe pair, scouts killed, does not include words from the same surface constituent (i.e., the words are separated by a relative clause in the surface string). In fact, it does not seem to matter whether both words of a probe pair occur in the same surface constituent. For instance, both Indians saw and scouts saw arise from the same embedded clause, The Indians saw the scouts. Yet only Indians saw appears in the same surface constituent. Even so, response latency for the surface constituent Indians saw is the same as for scouts saw, even though the latter is not a surface constituent.

These observations all suggest that underlying, rather than surface structure, crucially affects performance on this task. The results can therefore be explained in terms of perceptual processes that take account of deep structure clause units; i.e.,
(1) When a sentence is being perceived, lexical items in the surface string are grouped into underlying clauses.

(2) The computed structure expresses this grouping.

(3) When a subject sees a pair of probe words, he "searches" through his computed structure until he finds the target lexical items.

(4) It takes less time to recognize lexical entries which have been grouped into the same clauses than into different clauses (where "same" or "different" refer to items dominated by the same, or different S-nodes in base structures). Again, cf. the definition of constituency that was given earlier (p. 6).

(One might object that this clausal explanation represents only a possible means of accounting for the data; i.e., the data are compatible with this particular interpretation, but might be explained in other ways as well. For instance, the reported effect might be a function of grammatical relations, since subjects recognized grammatically related pairs (scouts killed) faster than grammatically unrelated pairs (Indians killed). But even if the RT difference is a function of grammatical relations, it is best interpreted as a deep structure effect. This
conclusion follows from the fact that base structures (of the Standard Theory) are supposed to represent logical relations (or at least enough information so that these relations can be inferred).

c. **Clause structure, processing, and memory**

The research that has been reviewed so far suggests that both surface and deep structure variables affect early processing, and that clause structure determines the immediate analysis of sentences. The question is, "How?" Wanner's and Walker's studies provide some clues to this problem, assuming that their paradigms are indeed sensitive to underlying variables.

The results of these experiments can be accounted for if there is a cognitive process or strategy that **groups surface items into common deep structure clauses.** There must be such a grouping process at some point in the analysis scheme, if it is true that listeners have to determine underlying structure in order to understand a sentence. And, according to the Wanner and Walker studies, which test initial perception, this strategy applies very early.

Of course, it might be argued that recall and recognition tasks are more relevant to memory than to immediate perception. However, there is independent evidence from other paradigms that also indicates perceptual effects of
clause structure. In particular, experiments with the click location technique demonstrate that clause boundaries have specific effects on initial segmentation.

In several studies, subjects report the location of a single click in a complex sentence as closer to the clause boundary than to its objective location. This is the general finding with sentences like the following one:

6. After the team walked onto the court, the fans cheered.

(▲ indicates the position of click)

A click in the middle of "court" or "the" or "fans" will be subjectively located between "court" and "the."

Notice that the break between "court" and "the" corresponds to both a major syntactic boundary in surface structure, and a clause boundary in deep structure. This is true of most of the clause breaks in the test material. Hence, the results cannot be used as evidence for an exclusive deep or surface structure effect. Nonetheless, they do suggest that boundary position (a formal property of phrase markers) is determined by early perceptual processes.

The question still remains, then, whether the phrase marker relevant to immediate perception is the surface or underlying one (or some intermediate level). There are two experiments that have tried to address this problem
(Bever, Lackner, and Kirk, 1969; and Fodor, Fodor, Garrett, and Lackner, 1973). Although it is difficult to interpret these studies in a clear-cut fashion, due to problematic structures of the test sentences, analyses of the data point to the (relevance of the) underlying phrase marker. Moreover, the pattern of results is consistent across the two experiments.

Both studies used test material like the pairs of sentences below:

(7) John persuaded Bill to leave.

(8) John expected Bill to leave.

We will assume, with the investigators of the two studies, that the surface structures of (7) and (8) are similar, but their deep structures differ. (See the diagrams below)

![Diagram](Fig. I-4. Deep structures of 7, 8)

In short, the main difference in the deep structures for (7) and (8) lies in the position of the clause boundary
within each string. The break in (7) falls between "Bill" and "Bill leave," but in (8) it comes between "expect" and "Bill."

The click location technique was used in the two experiments mentioned above. Bever, et al. looked at a migration pattern in the responses, whereas Fodor, et al. used accuracy as the dependent variable in the tests. In the Bever study, clicks were placed in the positions indicated by △; and in the Fodor study, as indicated by the numbers (1) and (2).

a) △ persuade (1) NP (2) VP
b) △ expect (1) NP (2) VP

The authors, in predicting the results of a click location task, reasoned as follows:

If the click effects are a function of deep structure clause boundaries, subjects should subjectively locate clicks at deep structure clause breaks, even if they are not actually placed there. Hence, clicks in the V and NP in persuade- sentences should migrate toward (2), above, because a deep structure break occurs at this point. But clicks in the expect- sentences should migrate toward (1), since the deep structure break occurs before the NP rather than after it, as with the persuade- sentences.

Similarly, the persuade- sentences should show more accurate placement of clicks that are located at (2) than
at (1); and the expect- sentences should show more accurate placement at (1) than at (2).

The predictions about migration are supported by the results of Bever, et al. (1969), and those about accuracy by preliminary results from the Fodor, et al. study, still in progress.

Thus, the outcome of the two experiments would argue for a deep structure interpretation, at least at first glance. However, this position must be qualified. The deep structure account only makes sense if the surface structures of I-4 are the same. If they are different, then the pattern of response differences might be a function of surface rather than underlying structural variables. Another possibility is that both deep and surface factors affect click location. It is this claim that seems to be the best conclusion to draw from the two studies, especially since Fodor, et al. have found more accurate location of clicks in sentences with overt surface markings; e.g., better location in unreduced relative clauses than in reduced versions. In the examples below, responses to the a) version were more accurate than to the b) version

a) NP ▲ who is V-ing . . . .

b) NP ▲ φ V-ing . . . .
Perhaps the best way to summarize the findings reported above is that they indicate that surface constituent boundaries which correspond to junctures between sentoids define the potential points of perceptual segmentation of sentences; whether any such point is in fact taken as the boundary of a perceptual unit may depend on a variety of structural features of sentences (Fodor, Bever, and Garrett, 1974, Cha. 6, MS, pp. 6-34).

d. The interaction of clausal analysis with memory

If the conclusion on the preceding page is correct, there should be an increase in decision-making associated with the surface clause break in a sentence. Further, if processing activity is high near the end of a clause, it should take listeners longer to perform a perceptual task. This prediction is, in fact, supported by a click test involving RT to clicks which were placed in different places relative to the clause boundary. Abrams and Bever (1969) found that RT to clicks just before the boundary was slow, as opposed to RT to clicks placed just after the boundary. T. Bever (unpub. study) also found that detectability of clicks was low just before the break.

The results of the studies reported above suggest that processing demands increase at the end of a clause and decrease at the beginning. This state of affairs is expected if the perceptual system has a buffer storage which cannot be cleared until the end of a clause is reached, but
must be cleared afterward. As soon as the end approaches, the buffer itself reaches its maximum capacity.

On the basis of this model, there is a straightforward prediction about access to lexical material; viz., as soon as the buffer in short term memory (STM) is cleared, accessibility becomes poorer for material that is more than one clause away when retrieval is attempted. This hypothesis was confirmed in an experiment by Jarvella (1971), who gave listeners short stories having interruptions. The subjects had to recall the preceding material verbatim. The results showed that rote recall was best for the clause immediately before the interruption. But performance was worse for rote recall of words coming before that (penultimate) clause, as illustrated in the diagram below:

...prior clauses... [...penultimate clause], s[...X...]s
poorest recall rote recall best
site of interruption

Jarvella used these results to argue that items decay from STM as a function of the serial order of clauses in a sentence, and, consequently, that the unit of transfer from STM to a longer storage system is about one-clause-long.

More pertinent evidence to the problem of perceptual analysis is provided by probe tests by Caplan (1971). He used both auditory and visual presentations of a single-word-probe, and showed that probes with targets in the
first clause of a two-clause sentence were harder to recognize than probes with targets in the second, or most-recent clause heard. He explained this effect by saying that listeners segment sentences one clause at a time. When two-clause sentences are heard, structure is first assigned to the leftmost clause; this clause is then transferred from STM to LTM (long term memory). The rightmost clause undergoes some initial syntactic analysis at this point. Since the first clause is no longer being analyzed in STM, its lexical items should be harder to recognize than items from the second clause.

Again, Caplan's study certainly suggests a clausal explanation like the above, but alternative accounts are possible too. Obviously, more research must be done to test the effects of both deep and surface structure clauses on immediate perception. Before any experiments are designed, however, it is important to list the conditions that are required by a clausal model. In the following section, we first state these conditions; then consider some problems in Caplan's material; and finally, outline an experiment that replicates his study while controlling for confounding variables.

2. **Clausal effects: a function of boundary position, or other factors?**

   In order for Caplan's model to work, the following must be assumed: (1) There is a specific perceptual pro-
cess (or set of processes) that is sensitive to clause boundary position in the surface string; and (2) A clause can only be dismissed from STM when the boundary (between clauses) has been perceived. The evidence for assumption (1) has been reviewed in the preceding section, but the evidence for (2) is somewhat less patent—especially since there may be other aspects of sentence structure that determine when a clause can be dismissed from a buffer storage. In particular, in the Caplan experiment the reported "boundary effects" might be a function of different factors, such as the relations among clauses, instead of the existence of surface clause breaks per se. The clearest expression of these relations is the relative position of S-nodes in the underlying tree hierarchy (e.g., the dominance relation, as illustrated in Figure I-2, p. 7).

Grammatical properties like dominance may affect the way a sentence is initially segmented, given the processing model that was proposed earlier (p. 17); viz., (a) Listeners compute a syntactic representation as they hear a sentence; and (b) This computed structure resembles underlying and/or surface tree structures of the grammar.

Then the important question is to find out whether listeners compute information about dominance relations online, as they are perceiving a sentence, or whether they
derive dominance facts later, after they have applied some type of inference rules to the computed structures. In other words, is dominance represented directly in the computed structures, or must it be inferred from the semantic interpretation of a sentence? This problem is hard to answer. One approach is to see whether boundary information and dominance facts are available to the listener at the same time (during his initial perception of a sentence).

There are already hints within Caplan's own study that suggest perceptual effects of dominance. This interpretation is possible because his stimulus materials confound differences of clause type (main vs. subordinate) with probe position (target word from first vs. second clause). A brief example of the stimuli will illustrate both the method and the problem:

a) \[ \underline{X} , \underline{\_} , \underline{\_} . \underline{x} \]
subord. \hspace{1cm} main

b) \[ \underline{\_} , \underline{\_} , \underline{X} . \underline{\_} , \underline{\_} . \underline{x} \]
subord. \hspace{1cm} main

(where "X" indicates the position of the target in the sentence, and "x" denotes presentation of the probe word immediately following each sentence).

Example sentences:

a) Now that artists are working in [OIL, prints are rare.] OIL

b) Now that artists are working fewer hours,

[OIL prints are rare.] OIL
(Brackets enclose material which was spliced onto the left-hand portion of each sentence.)

Using stimuli like those on the preceding page, Caplan found that probes from the second clause were responded to faster than probes from the first, even though both words were equidistant from the end of matched sentence pairs, in addition to being acoustic copies. But notice that nearly all of his test sentences had the clause order [[subordinate, main] (hereafter, "S,M."). Hence, second-clause (main-clause) probes yielded faster RT's than did first-clause (subordinate-clause) probes. The difference in clause order is of course interpretable with respect to dominance properties in the structural description of the sentences.

In order to decide whether this RT effect was indeed due to dominance properties, or to surface clause breaks, we performed another experiment in which two factors were varied: **probe position** (target word from first vs. second clause) and **clause order** ([S,M] or [M,S]). This study was directed at the following questions:

1. Does sentence analysis proceed clause-by-clause?
2. If so, which aspects of clause structure influence decisions about clause boundaries? (The presence of surface breaks, or the dominance relations between clauses, or both?)
(3) Which structural details, if any, affect access to the computed representation? And finally,

(4) How long is the information about clause structure available to the listener?

This experiment is discussed in detail in the next section.

3. Experiment I

This probe-latency study was designed to test whether surface clause boundaries and/or dominance relations affect the initial perception of two-clause sentences. There are two main sets of predictions for the outcome of this experiment, as outlined below:

(Numbers refer to the leftmost (first) or rightmost (second) clause in a two-clause sentence. "RT" refers to median reaction time.)

a. Hypotheses

(1) Surface structure boundary effect, or "recency."

\[ H_{O_1} \]: The serial (and temporal) order of clauses in the surface string has no effect on RT; i.e., RT to probes from clause-1 = RT to probes from clause-2.

Alternative Hypothesis

\[ H_{A_1} \]: There is an effect of surface clause order; RT to probes from clause-1 \( \neq \) RT to probes from clause-2.
(2) Effect of dominance properties.

\( H_{02} \): Dominance properties among clauses have no effect on RT; i.e., RT to probes from main clauses = RT to probes from subordinate clauses.

or RT to probes in sentences with the order [main..sub.] = RT to probes in sentences with the order [sub...main].

Alternative Hypotheses

\( H_{A2} \): There is an effect of dominance properties; i.e., RT to probes from main clauses ≠ RT to probes from sub. clauses.

or RT to probes from sentences with the order [main..sub] ≠ RT to probes from sentences with the order [sub...main].

These claims only predict the existence of significant RT differences. Predictions about the direction of these differences will be brought up in the Discussion section.

b. Construction of preliminary materials

Forty-seven sets of sentences were constructed, each of which occurred in four versions:

a) ________ \( X \), ________
   subordinate, main

b) ________, \( X \) ________
   subordinate, main

c) ________ \( X \), ________
   main, subordinate

d) ________
   main, \( X \) ________
   subordinate.

(where "X" marks the position of the target word)

Several factors were controlled in designing each set, viz.,
1) **Length of entire sentence in syllables.**

Sentences ranged from 14 to 20 syllables. All versions of each set had the same number of syllables.

2) **Distance from end of probed word to end of sentence (in syllables).**

This distance ranged from 5 to 9 syllables across the 47 sentences, but for each set the distance was kept constant.

3) **Distance from end of probed word to end of sentence (in words).**

This measure ranged from 3 to 9 words across all sentences. For any given set, the word count varied at most by one word.

4) **Lexical and semantic content.**

For the sentences in any given set, the lexical items and semantic relations between clauses were kept nearly the same throughout, unless the resulting sentence sounded unnatural. Negative expressions, anaphoric nouns, and pronouns were avoided so as to make the processing load relatively light. (If each sentence was hard to understand, due to the presence of anaphors or negatives, the difficulty might mask the desired effects.)

5) **Syntactic category of probed word.**

This was kept constant for each set; e.g., if a probe word functioned as the head noun in an adj. phrase in versions a) and c), it also was the head noun in the corresponding b) and d) versions of the sentence. By
keeping the form class constant in this way, we avoided possible effects due to shifting the category of the probe word. (Cf. the shift of nouns to noun–noun to adj.–noun compounds in Caplan's sentences; e.g., "OIL" "OIL prints," p. 27.)

6) **Position of target with respect to clause boundary.**

The target word was placed as near to the clause break as possible within each set. A sample sentence in all four versions is given below: (A complete set of stimulus materials is found in Appendix I–A.)

a) After you read the fine print on the LEASE, check the tax clause carefully.

b) After you have read the fine print, the LEASE should be checked for tax clauses.

c) You should read all the fine print on the LEASE, after you've checked the tax clause.

d) You should read the fine print, after the LEASE has been checked for tax clauses.

  c. **Naturalness of preliminary material**

In constructing each sentence set, it was desired that all four versions be as natural as possible, and that all be equally natural. For this reason, the sentences were rated for naturalness before they were selected for the actual experiment. Thirty-six sets of sentences were finally selected for use in the probe test. (See Appendix
B (pp. 158-171) for details of the naturalness test and sentence selection. Appendix B-11 (pp. 172-181) contains the list of sentences resulting from the selection process.)

d. Design of the actual experiment

(1) Construction of materials:

Thirty-six test sentences, 58 filler sentences, and 20 sentences for pre-test training were used. A complete stimulus set that consisted of 114 sentences. The test material was selected from the original list of 47 on the basis of naturalness ratings (as described above). The fillers consisted of 36 2-clause sentences and 22 one-clause sentences. Among the two-clause sentences, 12 were constructed with main clause first; 12 with subordinate first; and 12 with coordinate clauses. This variation was intended to prevent subjects from forming a response set to the actual test sentences. The 20 sentences for pre-test training consisted of 12 one-clause sentences and 12 two-clause sentences (4 with main clause first; 4 with subordinate first; and 4 with coordinate clauses). The same speaker recorded all sentence material.

(2) Probes

Probe words for each sentence were typed on a white card, photographed, and made into slides. All test sentences had IN probes, i.e., the probe word did occur in the
sentence. Among the 58 filler sentences, there were 22 IN-probes and 36 OUT-probes ("OUT" meaning that the word did NOT occur in the sentence). The pre-test sentences consisted of 10 IN-probes and 10 OUT-probes. In short, the complete stimulus set for any given subject included 68 IN-probes and 46 OUT-probes, roughly a ratio of 4:3.

(3) **Stimulus tapes and apparatus**

Four stimulus tapes were prepared. Each tape consisted of 20 pre-test sentences, 36 test sentences, and 58 filler sentences. Both the pre-test and filler material was the same on all four tapes, but the test sentences were recorded with one version (out of four) per tape.

(See Appendix C (p. 182) for a complete set of the filler sentences, and Appendix D (p. 187) for the pre-test ones.)

This arrangement of test and filler material varied the sequence of sentences so that subjects would not form a response set to clause order, probe position, or IN vs. OUT-probes.

**Recording**

All of the test material was recorded on Channel 1 of each stimulus tape. An adult male speaker read the sentences with normal, conversational intonation. He spoke rapidly in order to minimize pauses which separated clauses. At the end of each sentence, a high frequency noise burst
(inaudible to the subject) was recorded onto Channel 2. This burst triggered a millisecond timer and a Carousel projector which flashed the probe word on a screen in front of the subject. (See Appendix E (p. 189) for a description of the apparatus.)

(4) **Subjects**

Forty-eight M.I.T. undergraduates were paid to participate in the experiment. All were right-handed, and native speakers of English. It was necessary to choose only right-handed subjects because of the way the subject response-key was designed.

(5) **Procedure**

Subjects were told that they were participating in an experiment on the perception of sentences. They were first shown the apparatus and then seated in a semi-anechoic chamber, which was equipped with headphones, subject's microphone, a rear projection screen, and a telegraph key for subject's responses. Subjects had approximately five minutes in which to get used to the chamber, and were then given instructions; *viz.*, they were asked to decide whether or not the probe word occurred in each sentence, and then indicate their decision by pressing the key towards the IN or the OUT position. (See Appendix F (p. 190) for more detailed instructions.)
At this point, all Ss heard a series of 20 pre-test sentences. After a short break, the actual test began. On 20 of the 114 total sentences, Ss were asked to repeat as much as they could of the sentence just presented. This was done to keep subjects alert, and to make sure that they were listening to every sentence closely.

e. Data and results

(1) Scoring

Each S's RT to every sentence was recorded in msec. Errors on the telegraph key were also recorded, as well as mistakes in repetitions. Only about 5 percent of all responses were erroneous, and errors occurred mainly during the pre-test practice session.

Reaction times on erroneous responses were not used in the final analysis; the empty cells were filled by using the mean of all other scores in that condition.

The experiment was treated as a two-way analysis of variance (probe position vs. clause order), with subjects (48) by replications (9) as the error term. Table I-2 summarizes the design.

In this design, the total variance in the data is estimated by three factors: row effect, column effect, and their interaction.
TABLE I-2

2 X 2 DESIGN OF EXP. I

<table>
<thead>
<tr>
<th>Probe position/Clause order: S,M</th>
<th>M,S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Clause</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a)</td>
</tr>
<tr>
<td></td>
<td>X,</td>
</tr>
<tr>
<td></td>
<td>Sub.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(c)</td>
</tr>
<tr>
<td></td>
<td>X,</td>
</tr>
<tr>
<td></td>
<td>Main</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Clause</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b)</td>
</tr>
<tr>
<td></td>
<td>, X</td>
</tr>
<tr>
<td></td>
<td>Sub.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(d)</td>
</tr>
<tr>
<td></td>
<td>, X</td>
</tr>
<tr>
<td></td>
<td>Main</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Row A ← Row B

Column C ↓ Column D

Row effect + Column effect + their interaction
due to surface clause recency (probe from 1st or 2nd clause?)
due to clause order (probe from S,M or M,S?)
due to kind of clause (probe from main clause or subordinate?)

The relevant comparisons of RT scores in each cell are as follows:

Row effect: If \( \text{RT}_{c+a} = \text{RT}_{d+b} \), Row A = Row B, and no effect of surface clause recency.

If \( \text{RT}_{c+a} \neq \text{RT}_{d+b} \), Row A \( \neq \) Row B, and there is an effect of clause recency.

Column effect: If \( \text{RT}_{c+d} = \text{RT}_{a+c} \), Col. C = Col. D, and no effect of clause order.

If \( \text{RT}_{c+d} \neq \text{RT}_{a+c} \), Col. C \( \neq \) Col. D, and there is an effect.
Interaction: If $RT_{c+b} = RT_{d+a}$, there is no effect of the kind of clause variable.
If $RT_{c+b} \neq RT_{d+a}$, there is an effect of the kind of clause variable.
(i.e., target from main vs. subordinate clause).

(2) Results

In Table I-3, we give median RT for different clause orders as well as for different probe positions. (Means of medians were used in the analysis because they are preferred for a skewed distribution.)

Neither the clause order factor, nor the interaction (of probe position x kind of clause) approached significance. For clause order, $F = .773$, d.f. = 1/47; and for the interaction, $F = .201$, d.f. = 1/47.

The main effect for probe position (probe in the first vs. second clause) was highly significant. ($F = 10.828; d.f. 1/47, p < .003$). Probes in the first clause averaged 656 mscec., as compared to probes from the second clause, which averaged 632 msec. The net effect was therefore a difference of 24 msec., as shown to the right of Table I-3.

In short, it looks as though clause boundary position had a specific effect on performance, but dominance properties did not. This result
### TABLE I-3

ANOVA RESULTS FOR EXP. I
(Means of medians in msec.)

<table>
<thead>
<tr>
<th>Clause Order</th>
<th>S,M</th>
<th>M,S</th>
<th>Significant RT Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Probe position:</strong> 1st</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) 651</td>
<td>c) 660</td>
<td></td>
<td>( \frac{a+c}{2} = 656 \text{ msec.} ) (1st clause)</td>
</tr>
<tr>
<td>b) 631</td>
<td>d) 632</td>
<td></td>
<td>( \frac{c+d}{2} = 632 \text{ msec.} ) (2nd clause)</td>
</tr>
</tbody>
</table>

Net effect: 24 msec.

(where small letters stand for the four conditions, as on the preceding page)

raises an important question: are dominance factors irrelevant to early perceptual analysis? (hence no significant effects) or, are they relevant, and therefore, do they have specific effects that were simply masked in this particular study? In order to answer this question, it is necessary to look for any systematic differences in RT which were not due to the predicted (structural) variables. This kind of non-syntactic variation could stem from individual subjects, groups of subjects, test material, or a combination of subjects and material. In other words, one needs to determine whether a) separate groups of subjects responded differently to all the sentences; b) there were non-structural differences in the sentence sets; and/or c) separate groups responded differently to different test
sentences (i.e., there was an interaction of groups-by-sentences).

An ANOVA was done to reveal possible differences that could have arisen from the sources listed above. The results of this analysis show that a) mean RT differences between groups were not significant (F = 1.399; d.f. 3/44); but b) differences between sentence sets were (F = 4.987; d.f. 35/1540; p < .001). Furthermore, the source of the sentence-set-differences was not a particular group of subjects. All groups responded similarly to any given set, as is shown by the lack of a significant group-by-sentence interaction (F = 1.218; d.f. 105/1540).

These findings all suggest that alternative (b) above is correct: viz., one or more of the stimulus sentences was peculiar. In brief, a materials effect seems to have been present, and it may have been large enough to mask the potential influence of dominance properties on performance. (Details of the group- and sentence-set analyses are given in Appendix H, pp.193-196).

Because of this possibility, it seemed reasonable to look for sources of consistent variation in the stimulus sentences. Several post-hoc tests were devised for this purpose, as described in Appendix I, pp.197-202. As expected, these measures revealed regular, non-structural differences in the stimuli. Moreover, a trend for
the dominance effects appeared when the RT's from one
group of sentences were analyzed separately (henceforth,
the "good" sentences); but the trend did not appear for
the other sentence-group (the "bad" ones). Thus, the re-
sults of the post-hoc tests confirmed the existence of a
materials effect that was large enough to mask the domi-
nance factors.

f. Discussion and conclusions

This experiment shows that the serial order of
clauses has a major role in the information processing
system for sentences.\(^8\) At this point in the research,
the clause recency effect seems to be a general phenomenon,
since it was highly significant across all subjects and
all conditions ($F = 1.828$; d.f. 1/47, $p < .003$); i.e.,
mean RT to second-clause probes was significantly faster
than mean RT to first-clause probes, for both clause
orders—not just for sentences in [S,M] order, as in
Caplan, 1971. It might appear, therefore, that dominance
had no effect on performance, particularly since neither
the clause order nor kind-of-clause factor reached sig-
nificance, as did the boundary variable.

According to this interpretation, which we will
call Alternative A, the results of EXP. I suggest that
sentences are analyzed clause-by-clause. That is, while
a sentence is being perceived, it is first segmented into
serial clausal units. During this phase of the analysis,
the listener is presumably making decisions about the structure of the entire sentence. The outcome of these decisions is expressed in a structural representation, which should therefore contain information about clause boundary position (but not necessarily about dominance relations between clauses). By the time the sentence has ended in real time, parts of the computed structure are still accessible to the listener; there is at least enough syntactic information available to reflect the position of lexical items, relative to the clause boundary.

The role of clause boundaries in this model can be readily explained in terms of STM variables. For example, consider the early perceptual analysis of two-clause sentences: First, the leftmost clause begins to fill the STM buffer. As soon as the rightmost boundary of this clause is recognized, the clause is dismissed from the STM buffer and enters a more permanent—and less accessible store (LTM). The buffer now has room to receive the second clause. When the end of the sentence is encountered, the second clause should be "freshly" represented in the STM buffer. Hence, its lexical items should be recognized faster than those from the first clause (ceteris paribus).

Although the mean RT's in EXP. I follow the above prediction, and would therefore be compatible with Alternative A, there is another possibility (Alternative B): both the group and sentence analyses suggested a confounding
effect of materials, and this effect was indeed confirmed by post-hoc ratings of the test material. The fact that statistical analysis of some of the sentences showed a trend for the dominance factors implies that the latter really were influential, but were simply masked by materials differences. If so, the preceding remarks about serial processing would have to be qualified; viz., the recency effect may or may not be independent of dominance factors, depending on whether the latter really have specific effects during early perceptual analysis. The results of EXP. I are inconclusive; further tests with revised material are needed to settle the issue.
NOTES TO PREFACE AND CHAPTER I

1See J. Katz and T. Bever, 1973, pp. 29ff. for more examples of this type.

2Fodor, Bever, and Garrett, 1974 (Chapter 5) give an extensive review of this research.

3This division is perhaps oversimplified. Most of the studies do not explicitly separate effect of surface from deep structure, since surface clause boundaries most likely coincide with underlying breaks. Nevertheless, it still is useful to divide the research according to what the results imply about structural variables.

4Fodor, Bever, and Garrett, 1974, MS Chapter 5, p. 67a, Table 5-4.

5However, one cannot conclusively rule out a surface structure analysis, especially since the greatest differences appeared for the matrix subject-verb pair (scouts killed) vs. the pair Indians killed. Since the subject-verb relation holds in the surface string, a surface structure description of the sentence is sufficient to model the results for these cases. But for the weaker differences (viz., for scouts saw vs. Indians killed), the
evidence seems to require a deep structure interpretation; i.e., the only place where the verb-object relation between saw and scouts is represented is in the underlying structure of the embedded relative clause. Scouts saw is not a constituent in surface structure.

In short, Walker's two-word paradigm does appear to be sensitive to deep structure variables, although not exclusively so. In order to find out whether the technique definitely is sensitive to such variables, stimulus material would have to be used that had different surface and underlying structural descriptions.

Sentences that have undergone last cyclic rules would provide suitable stimuli, because such rules have the property of distorting base forms. (J. Kimball, 1973, pp. 42ff.) Examples of last cyclic rules include the following:

Subject-aux. inversion (after question formation)

I suggested that you go shopping to buy Wh-kind of shirt→

What kind of shirt did I suggest that you go shopping to buy?

Heavy NP shift

The boss told that lazy woman in the outer office to resign.

The boss told to resign that lazy woman in the outer office.

or
The boss asked that lazy woman in the outer office to leave.

The boss asked to leave that lazy woman in the outer office.

Extrapolation from PP

A photo of the salamander's navel will appear in the next volume of *Science.*

A photo will appear in the next volume of *Science* of the salamander's navel.

Suppose that sentences with distorted surface structures, like the ones above, had been used in the Walker, et al. two-word probe test. If subjects had responded faster to grammatically related probe pairs from these sentences than to unrelated ones, this would be support for a deep structure effect. But since the material in the Walker, et al. study had nearly identical deep and surface representations, even though subjects responded faster to grammatically related words, the results cannot be used to decide between deep and surface effects of grammatical relations.

6 See Garrett, Bever, and Fodor, 1966; Bever, Fodor, and Garrett, 1966; and Experiment #1 in Bever, Lackner, and Kirk, 1969. A detailed discussion of these studies can be found in Fodor, Bever, and Garrett, 1974, Chapter 5.

7 Fodor, Bever, and Garrett, 1974. In Chapter 6, the authors give more details about this claim.
In this context, "grammatical clause" means "the lexical material which is dominated by the same S-node, in the surface phrase marker, or the underlying phrase marker, or both." Since the sentences in EXP. I all have overt surface clause boundaries, the results do not indicate a clear surface or deep structure effect.
CHAPTER II

1. **Experiment II**

   Although the results of EXP. I showed no significant influence of dominance properties on RT, the existence of a materials factor leaves open the possibility of such effects. Therefore, another experiment was designed with more homogeneous sentences. All of the "bad" lexical strings from EXP. I were revised, according to the criteria used in rating the material in post-hoc tests; **viz.**,

   (1) Semantic and syntactic dominance relations correspond.

   (2) The meaning of the adverbial clause is approximately the same in all four versions.

   (3) The lexical material is roughly constant.

   (4) The same degree of naturalness is maintained throughout.

   (5) All versions describe expected or normal circumstances.

   The "good" sentences were also changed slightly in order to improve their naturalness. In all cases, the same probe word was kept in the revised versions as occurred in the originals. Similarly, the number and arrangement of test sentences, fillers, and pre-test stimuli were re-
corded as before, and were used to construct four stimulus tapes. (For a complete list of the new material, see Appendix IIA, p. 204, in the Appendix section.)

The number of subjects was changed, however, chiefly because new timing apparatus was available. The new equipment allowed two subjects to be run at the same time, which permitted us to use a total of 88 Ss, divided into four equal groups, one group per stimulus tape. Appendix II-B (p. 214) describes other minor differences in experimental method.

a. **Data and results: main effects and interactions**

Both accuracy and RT were recorded for each subject, as before (p. 36). The experiment was again treated as a two-way analysis of variance, with probe position by clause order as the major factors. The results are summarized in Table II-1.

Both the dominance and recency effects were significant for $p < .08$ or better, on each of the following ANOVA's: CLx PP xGR, CLx PP, CL xPP xTR (corrected for the mean), and CLx PP xSE (corrected for the mean); where CL = clause order, GR = groups of subjects, PP = probe position, TR = trial, and SE = sentence. Summary results are listed in Table II-2; complete reports of the analyses are given in Tables A8-12 in Appendix C, pp. 215-218.
TABLE II-1
ANOVA RESULTS OF EXP. II
(Overall means)

<table>
<thead>
<tr>
<th>Clause Order</th>
<th>[[subordinate][main]]</th>
<th>[[main][subordinate]]</th>
<th>Overall PP Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe Position</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target from 1st Clause</td>
<td>a) X, ___</td>
<td>c) X, ___</td>
<td>681 = a) + c) / 2</td>
</tr>
<tr>
<td></td>
<td>693 msec.</td>
<td>669 msec.</td>
<td></td>
</tr>
<tr>
<td>Target from 2nd Clause</td>
<td>b) ___ , X ___</td>
<td>d) ___ , X ___</td>
<td>662 = b) + d) / 2</td>
</tr>
<tr>
<td></td>
<td>661 msec.</td>
<td>663 msec.</td>
<td>d = 19 msec.</td>
</tr>
<tr>
<td>Overall CL difference</td>
<td>667 = a) + b) / 2</td>
<td>666 = c) + d) / 2</td>
<td>d = 11 msec.</td>
</tr>
</tbody>
</table>

(Where "X" denotes the position of the target word. Small letters indicate the conditions for each lexical string. Reaction times represent the mean response latencies for all subjects on all test sentences.)


**TABLE II-2**

MAIN EFFECTS AND INTERACTION, EXP. II

1. Recency Effect (as shown by PP FACTOR):

Mean RT to second-clause probes is faster than mean RT to first-clause probes.

\[
\begin{align*}
\text{RT}_{\text{first-clause probes}} &= 681 \text{ msec.} \\
\text{RT}_{\text{second-clause probes}} &= 662 \text{ msec.} \\
\text{Net effect} &= 19 \text{ msec.}
\end{align*}
\]

For S,M order only:

\[
\begin{align*}
\text{first-clause probes} &= 693 \text{ msec.} \\
\text{second-clause probes} &= 661 \text{ msec.} \\
\text{Net effect} &= 32 \text{ msec.}
\end{align*}
\]

2. Dominance effects

a) Clause order (as shown by the CL FACTOR):

Mean RT to M,S probes is faster than mean RT to S,M probes.

\[
\begin{align*}
\text{RT}_{\text{sentences in S,M order}} &= 677 \text{ msec.} \\
\text{RT}_{\text{sentences in M,S order}} &= 666 \text{ msec.} \\
\text{Net effect} &= 11 \text{ msec.}
\end{align*}
\]

For probes in first-clause only:

\[
\begin{align*}
\text{RT}_{\text{S,M order}} &= 693 \text{ msec.} \\
\text{M,S order} &= 669 \text{ msec.} \\
\text{Net effect} &= 24 \text{ msec.}
\end{align*}
\]
b) Kind of clause effect (as shown by the interaction of CIxPP):

Mean RT to main-clause probes is faster than mean RT to subordinate-clause probes.

\[ \text{RT}_{\text{subordinate probes}} = 678 \text{ msec.} \]
\[ \text{main-clause probes} = 665 \text{ msec.} \]
\[ \text{Net effect} = 13 \text{ msec.} \]

b. Discussion

The statistical analyses show the main effects to be significant over the whole experiment; yet examination of the mean RT/cell reveals substantial response differences on just certain conditions. (The 2 msec. difference between b) and d) in Table II-1 (p. 50) is negligible, as is the 6 msec. difference between c) and d).\(^1\) In fact, the only sizeable variance is between a)/b) and a)/c), which represent S,M order and first-clause-probe-position, respectively.

This pattern of results can be viewed as a consequence of the way the main effects interact. Apparently, the influence of clause order shows up in just the conditions where the force of the recency effect is weak, or nonexistent; viz., in first-clause probe position. And the influence of clause recency comes out in only one condition of clause order, S,M.
The simplest way of rationalizing these "complementary" results is to appeal to different phases of sentence processing: the initial computation of a structural representation (i.e., the assignment of syntactic structure to the input string); and the search of that structure (for recognition of the probed item). We claim the emergence of PP differences in S,M order relates more to the computation phase, whereas the CL effect in just first-clause position is more closely tied to the search phase. Both PP and CL response differences are considered in detail below.

lb.

(1) PP differences in S,M order: reflexes of early assignment of structure

Tables II-1, 2 show that the mean PP difference across all conditions is 19 msec., and that the size of this difference varies with clause order; i.e., in S,M order the effect goes up to 32 msec., whereas in M,S order, it is only 6 msec. These "divergent" RT differences may be explained in terms of a perceptual strategy that listeners would use during the very earliest aspects of sentence analysis. To wit: suppose the occurrence of a subordinate marker, such as a sentence-initial adverbial, tells the hearer that there will be a subordinate/main clause boundary later on in the string. He would know right away that he was dealing with a complex sentence, and that
he must search for a sentence-internal clause break. Hence, the boundary effect would be enhanced for sentences in S,M order. In M,S sentences, however, there is no sentence-initial subordinate marker. When the listener hears the first few items in the string, he may very well hypothesize that there will be a clause break further on—but he has no special clue that tells him whether this break is sentence-internal or sentence-final. Hence, PP differences in M,S stimuli may be very small, or even nonexistent, since there is some uncertainty in determining the nature of the clause breaks in such sentences.

This line of reasoning has independent support from other studies. The results of several tests argue for the importance of surface clues to clausal structure, such as those provided by relative pronouns, complementizers, and presumably, subordinating adverbs. (See Fodor and Garrett, 1968; Hakes and Foss, 1970; and Hakes and Cairns, 1970, for more discussion on the role of surface markings in sentence processing.)

Thus, the strategy on the preceding page depends crucially on the fact that S,M order presents the listener with an immediate surface clue to dominance distinctions in sentences. The effect of this early clue on performance is to facilitate location of the subordinate/main clause boundary; and it is this "boundary-determination" process that appears to be reflexed by enlarged PP differences for
stimuli in S,M order.

There is still another aspect of the response differences in S,M order that should be emphasized. Notice that the longest RT appears in cell a), (\[X\], subordinate main), which therefore seems to be responsible for the larger difference of 32 msec. between first and second-clause probes. It looks as though this cell, and as a result, S,M order in general, is "harder" to perceive for listeners. This interpretation, which we will call the "difficulty hypothesis," is compatible with the outcome of processing studies with different paradigms. For example, Holmes (1972) and Holmes & Forster (1972) used a technique called R.S.V.P. (Rapid Serial Visual Presentation), which involves flashing words on a screen at an extremely rapid rate—on the order of 16–20 frames per second. Subjects are asked to recall as many words as they can, verbatim. The number of correctly recalled words is taken as an index of relative ease or difficulty in processing. In the studies cited here, fewer items were recalled in order from S,M sentences than from M,S ones. Hence, S,M sentences were "harder"² Although the difficulty model seems to be valid across paradigms, it might appear to result in a dilemma: how can S,M order facilitate assignment of clause structure (as was argued above, pp.3-54), and still complicate processing? In the discussion below, it will become clear that the dilemma is only apparent. S,M order
might indeed aid decision-making about clause boundaries, but it need not facilitate the complete perceptual analysis of sentences. For instance, if listeners always expected sentences to occur in M,S order, the unexpected, or "marked" sequence S,M should occasion extra processing; the latter would show up as a delay in processing.

The above is exactly what one would predict in the light of T. Bever's work on sentence analysis (1970, 1971). He posits two strategies that are based on listeners' expectations of the "canonical" sentence form,

$$\# M [N \ldots V \ldots (N) \ldots ] (S \ldots ]):$$

**Strategy A:** Segment together any sequence X..Y, in which the members could be related by primary internal structural relations, "actor action object . . . modifier."

**Strategy B:** The first N...V...(N)...clause (isolated by Strategy A) is the main clause, unless the verb is marked as subordinate.

(T. Bever, 1970)

(For our purposes, it is important to add another condition to Strategy B to account for cases where the verb in the subordinate clause is finite; i.e., where the verb does not co-occur with morphemes like **ing**, **for-to** complementizers, etc. "B" should then read as follows:

The first N...V...(N)...clause (isolated by "A") is the main clause, unless the verb is marked as subordinate, and/or subordinate expressions, like adverbials conjunctions, occur before the first N."
Now consider how these strategies would apply to perception of two-clause adverbial sentences. As soon as a listener heard the initial adverb, he would know that the clause introduced by that adverb was non-main; i.e., Strategy B could not apply to assign main clause status to the first clause. The effect of not-applying Strategy B would be sensed as "perceptual difficulty," if such strategies are ordered and A and B are primary.

Thus, S,M sentences on the whole might take longer to process, even though decisions about main vs. subordinate clauses and their boundaries would be aided by the initial adverb.

lb.

(2) **CL differences in PP-1 (first-clause probe position):**

Reflexes of early analysis and structural search

According to the interpretation given above, properties of clause order and kind-of-clause are more important during the perception of the first clause than the second. It follows that decision-making about dominance properties should be greater at the end of the first clause (PP-1) than near the beginning of the second (PP-2). If probe RT's are indeed a function of early processing activity, then CL and kind-of-clause differences should be enhanced in PP-1, but not in PP-2.
The lack of a CL effect in PP-2 may also be a consequence of clause recency. The argument goes as follows: Assume that RT's to second-clause probes are lowered because the target items are still "fresh" in STM. This effect might override the influence of dominance in PP-2, since that position is favored with respect to recency. PP-1, however, is not favored; hence, the dominance properties CL and kind-of-clause come through, unobscured.

In short, the solution that is proposed in sections a) and b), above, accounts for the response pattern in terms of both dominance and recency factors in the syntactic structure of sentences, and in terms of STM variables that would affect recognition of lexical items.3

(3) **Summary**

Thus far, several reasons have been given why the main effects occurred in just certain conditions, and why sentences in S,M order present special problems to the listener. With these arguments in hand, we can rationalize the mean RT that appeared in every cell of the 2x2 matrix:

<table>
<thead>
<tr>
<th>clause order</th>
<th>S,M</th>
<th>M,S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe position--1st</td>
<td>a) 693</td>
<td>c) 669</td>
</tr>
<tr>
<td>2nd</td>
<td>b) 661</td>
<td>d) 663</td>
</tr>
</tbody>
</table>

*Ceteris paribus,* responses should be faster for main clause probes than from subordinate (if main clauses are repre-
sented higher in the tree and the direction of the search goes from top to bottom in the tree structure); responses should be faster to second clause probes than to first clause probes (if the second clause is still in STM at probe-time); and finally, they should be faster to sentences in M,S than in S,M order (if the S,M order gives the listener computation trouble). Therefore, assuming that both recency and dominance effects add, the fastest RT should occur in the second clause when it is a main clause (cell b), and the slowest responses should occur in the first clause when it is subordinate (cell a). Latencies in the other conditions should fall somewhere in the middle, since the effects would counteract each other. This appears to be approximately what happened in EXP. II.⁴

Comparisons between EXP.'s I and II

But the results for all the sentences in EXP. I did not follow our predictions; largely because of the strong materials effect that obscured the influence of dominance distinctions:

<table>
<thead>
<tr>
<th>Probe Position</th>
<th>Clause Order</th>
<th>Target from 1st Clause</th>
<th>Target from 2nd Clause</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[subordinate][main]</td>
<td>[main][subordinate]</td>
<td></td>
</tr>
<tr>
<td>651 msec.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>660 msec.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>631 msec.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>632 msec.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESULTS--EXPERIMENT I
The source of the materials problem in EXP. I seems to have been both semantic and pragmatic. Some clauses described events that were only loosely connected in meaning; the "semantic dependency" between clauses in such sentences was weak. Others contained clauses with strong semantic dependencies but with limited plausibility; these could be called "pragmatically" weak. When the material was revised for use in EXP. II, these dependency relationships were enhanced. Just because (semantic and pragmatic) dependency was the only variable that was intentionally changed for EXP. II, it is likely that it was responsible for the different results between EXP. I and II. In short, the syntactic effects of dominance did not appear until the semantic-pragmatic dependency relations discussed above were made to correspond with hierarchical relations in the phrase marker. And our predictions were not confirmed until the material had been revised.

(4) **Conclusions**

Analysis of the results in both studies reveals that surface boundaries and dominance properties affect the early perceptual segmentation of sentences; yet at this point in the research, the nature of these effects is still unclear. The outcome of EXP. II suggests that the recency effect is much less general, and the relation between dominance and recency much more complex than was
previously supposed. Now we need to determine whether or not both factors are independent, and whether they are specific to certain types of sentences. The latter problem is especially important, since the stimuli in both studies illustrate only one type of complex sentence structure, \textit{viz.},

\textit{main clause + overt surface adverbial clause}.

Because this sentence type differs from other kinds of sentences that contain relatives or complements, there might well be effects of these syntactic differences on immediate perception. Similarly, there may be effects of syntactic structure within each clause. (See the Appendices to Chapter II, pp. 221-256, for detailed discussion of possible effects on RT.). The subsequent chapter will deal with differences among subordinate clause types and their potential influence on sentence processing.
NOTES TO CHAPTER II

1 See Post-Hoc Tests, p. 219, for statistical confirmation of these observations.

2 This finding correlates well with listeners' intuitions about complex sentences. Weksel and Bever (1966) and Schwartz, et al. (1970) both report that subjects themselves judge S,M sentences as harder than other sentence types to understand. Though the judgments of listeners do not necessarily correspond to their responses on processing tests, the correlation still makes the difficulty hypothesis more compelling.

3 This is not the only way of rationalizing the results of EXP. II. There is an alternative explanation that appears to differ from the one given in the text, but this apparent alternative is really only a variant; viz., it may be that the a/b and a/c RT differences are merely reflexes of the kind-of-clause factor, acting alone, because both pairs of conditions represent |probe_{Sub} - probe_{main}|; i.e.,

\[
\text{in PP-1: } a) \left[ \frac{X}{S}, \frac{X}{M} \right] - c) \left[ \frac{X}{M}, \frac{X}{S} \right]
\]
in S,M order:
\[
\begin{align*}
&\text{a)} \left[ \frac{X}{S}, \frac{M}{M} \right] \quad \text{b)} \left[ \frac{S}{S}, \frac{X}{M} \right]
\end{align*}
\]

Hence, the only real effect would be kind-of-clause, instead of a combination of clause order and recency.

By implication, the STM representation should reflect hierarchical distinctions (such as kind-of-clause) more clearly than linear properties of the surface string. If so, subjects in the probe studies might very well adopt the following search strategy:

Look for the target item by searching the computed structure from top (main clause) to bottom (subordinate(s)).

Application of this strategy would explain why responses to main-clause probes were faster than those to subordinate-clause probes. However, in order to explain the lack of a kind-of-clause effect in PP₂ and M,S order, we would be forced to say 1) either that the strategy simply does not apply in these conditions, or 2) that it does, but its effect is swamped by other factors. The first choice is no choice at all—it amounts to a simple description of the results themselves, and is not an explanation. The second choice, on the other hand, is just a restatement of the position in the text. Therefore, the latter seems to be the more desirable solution, at this point in the research. It represents a "mixed" account of recency and dominance, which, after all, would require decision-making about
kind-of-clause distinctions.

4 Possible effects of other factors:

As in EXP. I, it is possible that non-structural factors also influenced RT. Therefore, the ANOVA results were examined to reveal any effects that might have confounded the influence of the PP and CL variables. Although differences between groups of subjects were significant at the 3 percent level in the CL x PP x GR analysis (Trials x subjects = error term), they were not in the CL x PP X TR analysis (subjects within groups = error), which is the more relevant analysis with respect to groups. Moreover, there were no significant interactions of groups with CL, PP, or CL x PP (as shown in Table A-11, Appendix IIc(1), p.217.). Similarly, there appear to be significant differences between sentence sets on the CL x PP x SE analysis; but again, there were no interactions of SE with the major factors. (With the possible exception of the PP x SE interaction. The latter appears in Table Al2, Appendix IIc, p.218, and is discussed in detail in Appendix IID, pp. 219ff.)

Because the interactions of both the group and sentence variables with the other factors did not reach significance, we will assume that RT means for the main effects are reliable estimates, and that there was no confounding influence from the test material, as in EXP. I.
Even so, one could still argue that structural, but non-syntactic factors (such as prosody) determined the pattern of results. Differences in sentence intonation might indeed account for some of the variance. The size of the response latency for a) \[\frac{X}{S}, \frac{M}{S}\] is a case in point. Assuming there are surface cues of pausing intonation at the clause break for a), but not for the corresponding condition c), \[\frac{M}{S}, \frac{X}{S}\]; mean RT might be longer for a) than for c). This difference could arise if the pausing cue in condition a) triggered a specific cognitive process (that would of course not come into play for sentences in condition c)). The extra computing step for a) would show up as longer RT.

Note that this argument requires RT to be a reflex of (processes sensitive to) prosodic cues; i.e., listeners would be expected to use acoustic differences, like changes in $F_o$, to segment sentences. However, such distinctions cannot be the only basis for sentence analysis. Caplan (1971) has already shown that the boundary effect still obtains when there are no obvious pauses in the boundary itself. Furthermore, post-hoc tests for our EXP. II revealed no relation between RT for each sentence and pause time at the clause break (see pp.221-224.).

In the absence of evidence to the contrary, we will assume that prosody is not responsible for the RT differences, though it is undoubtedly important for complete comprehension of a sentence.
CHAPTER III

1. **Experiment III**

At the end of the last chapter, we noted that sentences with adverbial clauses were the only ones used as stimuli in EXP.'s I and II. This fact leaves open the possibility that the PP and CL effects are confined to material with just this kind of clause. If sentences with other kinds of subordinate clauses were to be used as test material, a different pattern of responses might obtain. In short, we would like to find out whether dominance effects vary with the type of syntactic subordination in the test material.

For this purpose, several structural types of subordinate clauses were used in composing the stimulus sentences for a third study. The material included sentences with adverbial clauses, similar to those used previously; restrictive relatives, NP and VP complements, and coordinated clauses. These particular clause types were chosen for the following reasons: The distinct syntactic properties of each type can be represented in different tree structures. This fact makes it possible to test whether differences in the structural representation of
each type have perceptual consequences.

The probe-latency paradigm is well-suited for revealing such effects, given a model in which listeners compute a tree structure representation during their immediate perception of a sentence, and make a vertical search through the computed structure as soon as a probed word is presented. According to this model, recognition time should vary (in part) with the vertical location of the target item in the tree structure. Therefore, there should be a strong effect for differences in RT to main and subordinate probes with the relative and complement sentences, since the subordinate clauses are immediately dominated by an NP and VP node, rather than by the topmost-S, as are main clauses; a slight effect for loosely-attached adverbials, since they are attached to the topmost-S and are therefore more similar to main clauses than are the relative and complement clauses; and no effect at all for coordinated clauses, since they are of equal depth of embedding, and are, in fact, main clauses. Thus, coordinates would function as "control" stimuli in the experiment.

The table below summarizes these predictions.

<table>
<thead>
<tr>
<th>Clause Type</th>
<th>Dominance Effect</th>
<th>RT to different clauses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Coordinate</td>
<td>none</td>
<td>=</td>
</tr>
<tr>
<td>2. Adverbials</td>
<td>slight, if any</td>
<td>≠</td>
</tr>
<tr>
<td>3. Relatives and Complements</td>
<td>strong</td>
<td>≠</td>
</tr>
</tbody>
</table>
a. **Stimulus material and procedure**

The same paradigm was used as before. The major difference between EXP. III and the former two was the arrangement and design of stimuli. Since there was only one kind of complex sentence type in EXP.'s I and II, and since only two factors were being tested in these studies, each lexical string appeared in just $2 \times 2 = 4$ versions. In EXP. III, however, four clause types were included; hence, $4 \times 2 \times 2 = 16$ versions. (This total should actually be reduced by 2, because only 2 versions of the coordinates occurred with any given conjunction.)

A sample paradigm is given on the following pages.

Sample Paradigms for EXP. III
(Sentence frames)

"X" indicates position of the target word in each version. The target word itself appears in capitals.

1. **COORDINATES.** (examples for control stimulus; no syntactic dominance effect expected)

   a) _____X and _____.

   b) ____ and X ____.

   E.g.,

   a) The band got into violent argument with the SINGER, and the director was provoked at rehearsals.

   b) The band got into violent arguments, and the SINGER became more and more provoked at the rehearsals.
2. **ADVERBIALS** (examples of loosely attached clauses, immediately dominated by the topmost-S in the phrase marker)

   a) \[\text{Adv.} \quad \text{Main} \quad \text{X} \quad \text{Main}\]

   b) \[\text{Adv.} \quad \text{Main} \quad \text{X} \quad \text{Main}\]

   c) \[\text{Main} \quad \text{Adv.} \quad \text{X} \quad \text{Main}\]

   d) \[\text{Main} \quad \text{Adv.} \quad \text{X} \quad \text{Main}\]

   E.g.,

   a) After the band had many arguments with the SINGER, she was finally fired by the director.

   b) After the band had too many arguments, the SINGER was finally fired by the director.

   c) The whole band had many arguments about the SINGER, after she was fired by the director.

   d) The whole band had many arguments, after the SINGER was finally fired by the director himself.

3. **COMPLEMENTS** (examples of sentential subjects and objects; strong dominance effects expected)

   a) \[\text{Comp.} \quad \text{Main} \quad \text{X} \quad \text{Main}\]

   b) \[\text{Comp.} \quad \text{Main} \quad \text{X} \quad \text{Main}\]

   c) \[\text{Main} \quad \text{Comp.} \quad \text{X} \quad \text{Comp.}\]

   d) \[\text{Main} \quad \text{Comp.} \quad \text{X} \quad \text{Comp.}\]
E.g.,

a) Arguing violently with the band about the SINGER provoked the director during most rehearsals.

b) Arguing violently with the band provoked the SINGER during almost every one of the rehearsals.

c) Arguments with members of the band about the SINGER provoked the director into firing her.

d) Arguments provoked the director into firing the SINGER during almost every one of the rehearsals.

4. RELATIVES (embedded as modifiers of the subject or object NP; strong dominance effects expected)

a) (head) \[ \text{X, } \text{Main} \]
   \[ \text{Rel.} \]

b) (head) \[ \text{X, } \text{Main} \]
   \[ \text{Rel.} \]

c) \[ \text{X, } \text{Main} \]
   \[ \text{Rel.} \]

d) \[ \text{X, } \text{Main} \]
   \[ \text{Rel.} \]

E.g.,

a) \[ \text{Rel-S} \]
   The arguments that the band got into about the SINGER provoked the director during most rehearsals.
   \[ \text{Rel-S} \]

b) Arguments that the band got into provoked the SINGER during almost every one of the rehearsals.

c) Almost every member of the band had got the SINGER into arguments that provoked the director.
   \[ \text{Rel-S} \]
   \[ \text{Rel-S} \]

d) The band got into arguments that provoked the SINGER during almost every one of the rehearsals.
In designing the sentences, the same constraints were obeyed as before, in terms of syllable counts, lexical items, and naturalness (see pp. for particulars). In addition, there were several new criteria that had to be considered for the sentences with relative and complement clauses; viz.:

(a) No surface deletions were allowed in the case of relative pronouns or underlying NP controllers. This constraint was followed because a number of studies have already shown that processing becomes more difficult when such \( \text{NP}_{[+\text{Pro}]} \) are omitted (Fodor and Garrett, 1967; Hakes and Foss, 1970; and Hakes and Cairns, 1970). Although the experiments themselves mainly involved cases of relative pronoun deletion, we reasoned that similar results might obtain for deletion in other subordinate clauses. Therefore, sentences undergoing EQUI-NP DELETION were avoided if possible.

(b) Symmetry was maintained in each group of four versions; i.e., if a sentence contained a for-to sentential subject in versions a and b, it contained a for-to VP-complement clause in versions c and d.
(c) Nearly all complement types were sampled across sentence sets; e.g.,

Sentential subjects
For Mary to cut 64 green beans with one whack of the bowie knife would be a surprise.
That Mary cut 64 green beans ... was a surprise.
The fact that Mary cut 64 green beans ... was a surprise.
Mary's cutting 64 green beans ... was a surprise.

VP and object complements
Mary informed Bob about the fact that she had cut 64 green beans ... 
| promised Bob that she would cut 64 green beans ... |
| forced Bob into cutting 64 green beans ... |
| caused Bob to cut 64 green beans ... |

A number of other subordinate clause types were used, including result clauses after so much that (S), and by V-ing modifiers of the VP. (See Appendix IIIA, p. 258 for a complete list of stimulus sentences in all 14 versions.)

Arrangement of material for presentation
Twenty-four sets of sentences were composed. Each set included 4 different clause types: coordinates, adver-
bials, complements, and relatives (henceforth, Co, Adv, Comp, and Rel.). Each type, except Co, occurred in 4 versions, in order that all 4 conditions of the CL x PP matrix would be sampled. (It is impractical to give every subject every sentence in all conditions because of learning or recall effects.) We presented a given subject with all 4 combinations of CL by PP:

\[
\begin{array}{cccc}
S & X & M \\
S & M & X \\
M & X & S \\
M & S & X \\
\end{array}
\]

but only one of the 4 versions from any sentence set, and only 2 out of the 4 clause types (coordinates, adverbials, complements, and relatives).

Thus, within a given subject, the structural variables were confounded with materials effects; but across subject-groups, the materials effects were counterbalanced.

Since the greatest RT differences were expected for "topmost-S" vs. embedded clauses, the following pairs of clause types were chosen for presentation to each of 8 groups of subjects: (See Table III-1, p. 74) For this design, 128 subjects were required, 16 per group. The first four groups received the same clause types as the second, but heard different sentences in each test condition. (Appendices III-B, C, pp. 288-290 illustrate how sentences were assigned to each group of subjects.)
TABLE III-1

PRESENTATION OF CLAUSE TYPES

<table>
<thead>
<tr>
<th>Clause type</th>
<th>Topmost-S</th>
<th>Embedded-S</th>
<th>Subject Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinate</td>
<td>Rel</td>
<td>Comp</td>
<td>1,(5)</td>
</tr>
<tr>
<td>Adverbial</td>
<td>Rel</td>
<td>Comp</td>
<td>2,(6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3,(7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4,(8)</td>
</tr>
</tbody>
</table>

Filler sentences

As in EXP.'s I and II, filler sentences were designed so that subjects would not form hypotheses about the crucial factors in the test material. Filler sentences ranged from one to three clauses in length, and included both IN and OUT probes, "phrase" and "non-phrase" probes,\(^1\) probes from first and second clauses, from main vs. subordinates, from different clause types, etc. Altogether, there were 101 filler sentences, 24 test sentences, and 20 practice ones, for a total of 145 in each test session. Appendix D, pp. 291-301, contains a complete list of filler sentences for the experiment.

The sentences were recorded as in EXP.'s I and II, with filler material interspersed between test sentences. Eight stimulus tapes were prepared for presentation in
exactly the same way as in the previous studies. Some of the test apparatus was different from the equipment used in the first two experiments, however. The changes are described in Appendix E, p. 302.

There were no major departures from the first two studies in the rest of the procedure.

b. Data and results

Analysis

The same procedure in recording RT and in analyzing the results was followed as in EXP.'s I and II, with the exceptions listed below: Two ANOVA's were done on the data from all 128 subjects. Because the lexical material differed for each subject group, a group analysis was in order. And because responses were expected to vary with the kind of clause that was probed, a clause-type analysis was also done (across groups). In order to determine mean RT to individual sentence sets, and to versions within each set, it was necessary to analyze the data from each block of 4 groups separately. Hence, a group- and clause-type analysis were done for groups 1-4, and for groups 5-8, in addition to the analyses combining both groups.

Results: Main effects and interactions

(1) Recency Effect (as shown by PP factor):

Mean RT to second-clause probes is faster than RT to first-clause probes.
The PP factor did not reach significance when collapsed across all clause types and clause orders. The only case of a pure PP effect occurred in the coordinates, where the mean difference in RT between first- and second-clause-probes was 24 msec. (p < .04). (Responses to adverbials did show a substantial difference, 36 msec., but only for sentences in the [subordinate, main] clause order, just as in EXP. II. In the other order, [main, subordinate], an equally large difference appeared, but in the opposite direction (-34 msec.).)

(2) **Dominance effects**

(a) **Clause order (CL):**

Mean RT to M,S probes is faster than mean RT to S,M probes. This was the only main effect that was significant across all clause types and probe positions, and within each clause type (excluding the coordinates, which did not vary wrt clause order; i.e., the only CL condition possible was M,M.) Mean response differences are reported in Table III-2, below, which reveals a hierarchy of RT differences for CL and PP within each clause type.

It looks as though the size of the CL effect is inversely proportional to the size of the PP differences in S,M order. In other words, the PP differences were largest for the adverbials; whereas the CL effect was the weakest. The reverse situation holds for the relatives.
TABLE III-2

CL AND PP DIFFERENCES FOR EACH CLAUSE TYPE

<table>
<thead>
<tr>
<th>Clause type</th>
<th>CL effect: ( d = S,M - M,S ) (significant)</th>
<th>PP differences: ( (S,M \text{ only}) d = p_{p1} - p_{p2} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverbials</td>
<td>21 msec.</td>
<td>35 msec.</td>
</tr>
<tr>
<td>Relatives</td>
<td>29 &quot;</td>
<td>15 &quot;</td>
</tr>
<tr>
<td>Complements</td>
<td>53 &quot;</td>
<td>16 &quot;</td>
</tr>
</tbody>
</table>

and complements: stronger dominance effects and very weak differences with respect to PP. Thus, at first glance it appears that there is a trade-off in the size of the recency and dominance differences for the subordinate clause types. But since the recency differences did not reach significance across both S,M and M,S orders, it is not certain whether there even is a real recency effect for sentences with subordinate clauses. (See pp.94-95 for more detailed discussion of this issue.)

(b) **Kind of clause** (as shown by the interaction of the CL x PP factors):

Mean RT to main-clause probes is faster than mean RT to subordinate-clause probes.

The overall analysis across clause types revealed this interaction to be significant (\( p < .03 \)). That is, over all conditions, responses were on the average faster to main clause probes than to subordinate clause probes—
irrespective of the (subordinate) clause type. However, when one ignores the clause order factor and collapses across both orders, differences do show up between clause types: for the adverbial sentences alone, the kind of clause interaction was significant for both conditions of probe position; but for the relative and complement sentences, the effect was only obtained for first-clause-probes. Moreover, in second-clause probe position, there was an apparent reversal of the effect for the relatives and complements, as shown by the negative values in Table III-3b, p. 79.

c. Summary

The pattern of recency and dominance results corresponds to the predicted differences between coordinate clauses, adverbials, and relatives/complements. We have obtained evidence that sentences with coordinates are analyzed differently from sentences with subordinated clauses, since the coordinates were the only type having a significant recency effect. The subordinates, on the other hand, emerged as a natural class with respect to performance, at least on the basis of the clause order and kind of clause factors; i.e., responses were significantly faster to sentences in M,S order than in S,M order—no matter what the clause type was. Similarly, responses were faster to main clauses than to subordinates, at least for first-clause
### TABLE III-3
MAIN EFFECTS FOR 128 SUBJECTS IN EXP. III

<table>
<thead>
<tr>
<th>Clause Type</th>
<th>RECENTY DIFFERENCES</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PP-1</td>
<td>PP-2</td>
<td>[(pp-1)-(pp-2)]</td>
<td>In S,M</td>
<td>In M,S</td>
</tr>
<tr>
<td>(a+c) / 2</td>
<td>(b+d) / 2</td>
<td>(a-b)</td>
<td>(c-d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adverbs:</td>
<td>595</td>
<td>594</td>
<td>+1</td>
<td>+36</td>
<td>-34</td>
</tr>
<tr>
<td>Relatives:</td>
<td>620</td>
<td>621</td>
<td>-1</td>
<td>+15</td>
<td>-17</td>
</tr>
<tr>
<td>Complements:</td>
<td>623</td>
<td>611</td>
<td>+12</td>
<td>+16</td>
<td>+ 7</td>
</tr>
<tr>
<td>Coordinates:</td>
<td>637</td>
<td>613</td>
<td>+24</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

**DOMINANCE:**

**a) Clause Order Differences**

<table>
<thead>
<tr>
<th>Clause Type</th>
<th>S,M (a+b) / 2</th>
<th>M,S (c+d) / 2</th>
<th>[(S,M)-(M,S)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverbs:</td>
<td>605 584</td>
<td></td>
<td>+21</td>
</tr>
<tr>
<td>Relatives:</td>
<td>635 606</td>
<td></td>
<td>+29</td>
</tr>
<tr>
<td>Complements:</td>
<td>644 591</td>
<td></td>
<td>+53</td>
</tr>
<tr>
<td>Coordinates:</td>
<td>---</td>
<td></td>
<td>---</td>
</tr>
</tbody>
</table>

**b) Kind of Clause (Interaction of CL x PP)**

<table>
<thead>
<tr>
<th>Clause Type</th>
<th>S (a+d/2)</th>
<th>M (c+b/2)</th>
<th>S-M</th>
<th>In PP-1 (a-c)</th>
<th>In PP-2 (d-b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverbs:</td>
<td>612 577</td>
<td>+35</td>
<td>+56</td>
<td>+56</td>
<td>+14</td>
</tr>
<tr>
<td>Relatives:</td>
<td>629 613</td>
<td>+16</td>
<td>+44</td>
<td>+44</td>
<td>-12</td>
</tr>
<tr>
<td>Complements:</td>
<td>620 615</td>
<td>+ 5</td>
<td>+58</td>
<td>+58</td>
<td>-49</td>
</tr>
<tr>
<td>Coordinates:</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>
probes on all clause types. This is not to say that all subordinate clause types were treated the same way by subjects. On the contrary, there was a distinct pattern of recency and kind-of-clause results for each particular structural type (Cf. the RT values in Tables III-3, 4). Some reasons for these differences are discussed at length in the following sections.

### TABLE III-4

**SIGNIFICANCE LEVELS FOR MAIN EFFECTS AND INTERACTIONS**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Error = Subjects</th>
<th>F</th>
<th>d.f</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL (Across all clause types except coordinates)</td>
<td></td>
<td>65.802</td>
<td>1/31</td>
<td>&lt;&lt;.001</td>
</tr>
<tr>
<td></td>
<td>CL (For each clause type)</td>
<td>Adverbial</td>
<td>9.939</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relative</td>
<td>8.252</td>
<td>&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complements</td>
<td>27.736</td>
<td>&quot;</td>
</tr>
<tr>
<td>CL x PP (Overall, except coordinates)</td>
<td></td>
<td>11.210</td>
<td>&quot;</td>
<td>&lt;.003</td>
</tr>
<tr>
<td>within each clause type: adverbs</td>
<td></td>
<td>16.536</td>
<td>&quot;</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PP (Only significant for coordinates)</td>
<td></td>
<td>4.334</td>
<td>&quot;</td>
<td>&lt;.04</td>
</tr>
</tbody>
</table>
TABLES III-5-8

2 X 2 MATRICES FOR EACH CLAUSE TYPE—
Results from all 128 subjects in EXP. III

### TABLE III-5

**COORDINATES**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe in 1st Clause</td>
<td>637 msec.</td>
</tr>
<tr>
<td>Probe in 2nd Clause</td>
<td>613 msec.</td>
</tr>
<tr>
<td></td>
<td><strong>d = 24 msec.</strong></td>
</tr>
</tbody>
</table>

### TABLE III-6

**ADVERBIALS**

<table>
<thead>
<tr>
<th></th>
<th>S,M</th>
<th>M,S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe 1st Clause = 595</td>
<td>a) X, 623</td>
<td>c) X, 567</td>
</tr>
<tr>
<td></td>
<td>b) , X 587</td>
<td>d) , X 601</td>
</tr>
<tr>
<td>Probe 2nd clause = 594</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\bar{X} = 605 \quad CL = 21 \text{ msec.}
\]
**TABLE III-7**

**RELATIVES**

<table>
<thead>
<tr>
<th>Probe 1st Clause = 620</th>
<th>a) 642</th>
<th>c) 598</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe 2nd Clause = 621</td>
<td>b) 627</td>
<td>d) 615</td>
</tr>
</tbody>
</table>

\[ d = -1 \]

\[ \bar{X} = 635 \]

\[ CL = 29 \text{ msec.} \]

**TABLE III-8**

**COMPLEMENTS**

<table>
<thead>
<tr>
<th>Probe 1st Clause = 623</th>
<th>a) 652</th>
<th>c) 594</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe 2nd Clause = 611</td>
<td>b) (636)</td>
<td>d) 587</td>
</tr>
</tbody>
</table>

\[ d = 12 \text{ msec.} \]

\[ \bar{X} = 649 \]

\[ CL = 53 \text{ msec.} \]

d. Discussion of results and implications for a theory of sentence analysis

The results of EXP. III help resolve several questions about the recency and dominance effects, such as were raised in EXP. I, and particularly, in EXP. II. The clearest findings from EXP. III are the following:
(1) The clause recency effect is independent of dominance, since a "pure" PP effect was obtained for the coordinates alone, where there are no syntactic distinctions of clause hierarchy.

(2) For sentences with sub ordinate clauses, on the other hand, clause hierarchy is the more relevant factor for early perceptual analysis. Moreover, the dominance variables, clause order and kind-of-clause, affect the perception of complex sentences in general: i.e., the existence of significant dominance effects per se does not depend on a particular type of subordinate clause (since both dominance factors were significant across clause types, and within each type).

(3) But the type of subordinate clause does matter when one considers the size and direction of both recency and dominance differences: viz., We claim that coordinates were treated differently from sentences with subordinate clauses; among the latter, sentences with adverbials were treated differently from those with relative or complement clauses; and finally, stimuli with relative clauses were further distinguished from those with complement clauses. We will abbreviate these differences in the following way--

On the basis of performance,

a) Responses to coordinate clauses ≠ responses to subordinate ones;

b) Responses to adverbial clauses ≠ responses to relatives and complements;
c) Responses to relative clauses ≠ responses to complement clauses.

a) The Coordinates

The evidence for (a) is the most straightforward. The coordinates were the only stimuli which exhibited no difference in clause hierarchy, and which evoked a significant recency effect. These two facts about the coordinates furnish the main evidence for the independent nature of the effect. In no other sentence type is there an indication of an entirely separate and isolable recency factor. The response pattern for the adverbials does show substantial differences between first- and second-clause probes, but only for sentences in S,M order. Even smaller differences between probe positions were obtained for stimuli with relative and complement clauses; and again, in S,M order only. (See Table III-1, p. 74), for specific values of CL and PP differences for each particular clause type.) We will assume, then, that recency was the only factor that was relevant to the perceptual analysis of stimuli with (syntactically) coordinate clauses.

b) The Subordinates

In sentences with subordinate clauses, on the other hand, differences in clause hierarchy are defined. The dominance factors CL and kind-of-clause must therefore be considered along with the recency variable, if we are to explain how listeners analyze material with various types
of embedded clauses.

Several findings from EXP. III bear on this issue. First, there were smaller clause-order differences for stimuli with adverbials than for matched stimuli with relatives and complements. Second, the predicted kind-of-clause effect (main faster than subordinate probes) held for both probe positions on the adverbial sentences, but only for PP-1 on the relative and complement stimuli. In short, there was an interaction between CL and PP for the adverbials, but not for the other subordinate clause types. (Recall comparable results with the adverbials in EXP. II) These observations thus provide support for b), p. 83: sentences with adverbials were treated differently from sentences with relatives and complements.

c) The Complements

There is also evidence that the complement stimuli are distinguished from the other sentence types with respect to processing. Consider the contrasts which are summarized below:

The CL effect for the complement stimuli was the strongest of all the other subordinate stimuli. (Cf. 53 msec. 'complements', 29 msec. 'relatives', and 21 msec. 'adverbials'.) Kind-of-clause differences across both probe positions were negligible for the complements, in comparison to the other clause types. (Cf. 5 msec. 'complements', 16
msec. relatives, and 35 msec. adverbials.) In PP-2, the complements were further distinguished from the relatives, by virtue of an apparent reversal that was three times larger (than the comparable reversal for the relatives).
(Cf. 49 msec. complements to 12 msec. relatives.)
These comparisons all point to the fact that each clause type in EXP. III was treated differently.²

d. (1) The relevance of syntactic factors to perceptual analysis

(a) Geometrical properties of tree structures

The most plausible and insightful way to rationalize the findings on the precedings pages is through a structural explanation. At the beginning of this chapter, and in the appendices to Chapter II, pp. 251–256, we noted the following: coordinate and subordinate clause types can be distinguished by distributional (and prosodic) contrasts. To some extent, these differences are reflected in the relative positions of S-nodes in tree structure representations; e.g., coordinated clauses are sister-adjointed to each other, as opposed to the other types; (the adverbials being attached to the topmost-S, and the relatives and complements being embedded under NP or VP nodes). Hence, there are several properties of tree structure geometry that allow clause types to be distinguished—for example, the kind of attachment (sister vs. 
daughter adjunction), site of attachment (under $S_o$, topmost-$S$, NP, or VP nodes), and depth-of-embedding.

Furthermore, given that listeners compute the equivalent of tree structures as they perceive a sentence, we argued that properties like the above should have specific psychological reflexes; hence, clause types should be distinguished by means of performance measures. The results of EXP. III do follow these predictions, since there were distinct response patterns for each type. In addition, the dominance factor CL was strongest for sentences with complement and relative stimuli, the two clause types most "deeply" embedded. And where there were no structural differences in depth-of-embedding between two clauses, as in the coordinates, the only significant factor was recency—a function of the serial position of clauses in the surface string. These facts suggest that there are psychological reflexes of structural variables like depth-of-embedding (or, possibly, site of attachment) and surface order.

(b) Lexical analysis

With this approach, we do not mean to imply that the only syntactic factors that influence immediate perception are tree structure properties. On the contrary—other types of structural information could also be expected to influence early analysis. The role of lexical markings is a case in point. Given a theory of strict subcategorization, such as the one proposed in Chomsky (1965), it is a
relatively simple task to predict the relevance of such markings to sentence processing:

First, one must assume that native language users have internalized a certain kind of lexicon, one which classifies the lexical items in a language wrt the deep structures that they can occur in. It is this assumption that provides the link between lexical features and tree structure properties; i.e., listeners can be expected to know the constraints that determine which lexical items can be inserted into which sorts of deep structure configurations.

This view of lexical information is actually much broader than its original portrayal in Aspects (Chomsky, 1965). The position we are adopting here is closer to Bresnan's system (1970, 1972), which allows verbs not only to bear transitivity markings, as in Aspects, but also complementizer features. Carried to its logical conclusion, the idea of COMP-markings could amount to designating verbs "+ transitive, + infinitival complement, -that complement, etc." If this model is correct, it is plausible to assume that the listener makes full use of the syntactic information conveyed by the verbs in complex sentences; i.e., Once he recognizes the main verb (by applying Strategies like A and B, pp. 56ff.), he would be able to compute one or more deep structures consistent with the other lexical items in a given sentence.

Note that the number of possible deep structures
associated with a particular verb is determined automatically—it is a function of the number of phrase or complement types which are designated by lexical features. If the value of this number exceeds one, the listener has a potential problem, given that he must eventually arrive at a unique structural analysis in order to fully comprehend a sentence. In fact, there should be a correlation between the perceptual complexity of a given sentence and the number of complementizers that are allowed by its main verb; viz., as the deep structure possibilities increase, so should processing difficulty. This prediction is indeed borne out on experimental tasks ranging from immediate paraphrasing to "perceptual paradigms," like R.S.V.P. and click location.5

Thus, lexical information, in the form of strict subcategorization features, appears to have specific effects on sentence analysis. Or, to phrase it somewhat differently, there seems to be a cognitive process (or processes) that is sensitive to such features, and which would therefore be triggered by the listener's recognition of the main-V in sentences. These conclusions, though tentative, provide a natural way to account for the "divergent" response patterns for the complement stimuli in EXP. III. Recall that they were treated differently from the other clause types, including the relatives. With just a tree structure model of perceptual analysis, this finding
is difficult to explain, since both the relatives and complements in the test material were at the same level of embedding. But with a model that allows for the influence of lexical information from the main verb, the explanation is straightforward. Listeners could use their knowledge of the deep structure possibilities of a particular verb, to help them assign clauses to a hierarchical position in the phrase marker of complement sentences. However, for sentences with other types of clauses, knowing the range of COMP possibilities for a verb would not be as relevant. Hence, the subcategorization information from the main verb would be expected to enhance the size of dominance differences for the complement material, but not for other kinds of subordinate clauses. The outcome of EXP. III certainly seems to follow this prediction, judging from the 53 msec. CL effect for the complements, as compared to 29 msec. for the relatives and 21 msec. for the adverbials. 6

(c) Perceptual processes, reconsidered

The results of the research reported in the preceding chapters suggests there are (at least) four separate processes that apply very early in the course of perceptual analysis:

I. BOUNDARY DETERMINATION (as reflected by the recency effect).

This factor operates independently of the others
and initially assigns clause boundaries, mainly on the basis of the serial order of N- and V-constituents in surface structure. (Cf. Bever's "Strategy A," as discussed on p.56). Once potential clauses are isolated through I, they are given tentative hierarchical positions in a computed structure. Three more operations are responsible for more accurate determination of dominance relations and boundaries.

II. MAIN CLAUSE STRATEGY (as reflected by the kind-of-clause interaction).

The first N...V..(N) sequence which is identified through I is given main clause status, unless such a sequence is marked as subordinate (e.g., by means of a sentence-initial adverb, non-deleted relative pronoun or complementizer, or non-finite verb form). Just in case II cannot apply, because of these surface clues to subordination, III becomes relevant.

III. CLAUSE ORDER STRATEGY (as reflected by the clause order factor).

Presence of a subordinate marker in the first sequence determined by I signals that there will be a subordinate/main boundary near the middle of the string.

IV. SUBCATEGORIZATION STRATEGY (as reflected by the different pattern of responses to the complement stimuli).
Recognition of the main verb in a complex sentence allows the listener to postulate one or more deep structures, depending on the number and kind of complements allowed by a given verb. Hence, he may be forced to suspend analysis of an \( S,M \) sentence until he hears the main verb in the second clause, especially if the subordinate contains a complementizer and/or non-finite verb form.

Several aspects of these processes should be emphasized. First, III and IV differ from I in that they take account of clause hierarchy in addition to serial position of clauses in a sentence. Second, the order of steps from I-IV is only partially determined. II logically follows I, and III succeeds II, but logical order need not extend to sequence in real time. III itself states that dominance information enhances initial segmentation, which is properly the domain of I and II. And the results of Bever, et al. (1969) suggest that subcategorization information does the same. In other words, it is quite possible that such processes as I-IV apply simultaneously.

Thus, the best way to interpret the ordering is to assume it represents a potential sequence of cognitive events. The particular ordering given here is necessary to explain the reflexes of these processes on performance:

i) Main clauses are responded to faster than are subordinates, particularly in sentence-initial position (where root-Ss would be immediately segmented by operations I and II).
ii) M,S sentences are responded to faster than are S,M sentences, since the latter are subject to extra steps (III and/or IV) in the analysis sequence.

iii) Sentences whose main verbs allow more than one complement type are treated differently than those whose main verbs do not, due to the listener's construction of more than one potential deep structure.

In effect, we are claiming that I is responsible for the independent recency factor that operates on coordinates; II and III for the overall dominance effects for sentences with subordinate clauses; and IV for the specific pattern of results on the complement stimuli. The main advantage to this solution is that it allows us to explain the actual distribution of RT means in all clause types on EXP. III, as is detailed below:

First, we will assume that M,S order is expected and preferred by the listener. This assumption is implemented by strategies I and II (pp. 89-90); to wit, listeners make an attempt to identify main clauses before they do any other structural analysis. When this attempt fails, that is, when I cannot immediately apply, processing is delayed. This claim is supported by the results of EXP's II and III, since a significant CL effect was obtained in both studies: RT was longer to probes from S,M sentences than to probes from M,S sentences, irrespective of clause type.
Now notice that cell c reflects the preferred order, but cell b does not.

Cell c: \[\frac{X}{M}, \frac{\_}{S}\]

Cell b: \[\frac{\_}{S}, \frac{X}{M}\]

Hence, if clause order is more important than recency, it should facilitate responses on c, but impair it on b. Cell c should then be the fastest. For subordinate stimuli with adverbials and relatives, the dominance factor CI was indeed more important than recency—cell c, with a first-clause target from the main-clause, was faster than b, with a second-clause target from the subordinate. (See Tables III-5-8, on p. 81)

The complements are, however, an exception to the above remarks, so that d was fastest, even though the target occurred in the subordinate clause for this condition; and this should have slowed down RT (in view of our earlier prediction about the direction of search going from top to bottom in a tree). Instead, main-clause probes in second position were unusually slow (i.e., cell b for the complement sentences: \[\frac{X}{M}, \frac{\_}{S}\]). The fact that b was slower than expected, and d (\[\frac{\_}{M}, \frac{X}{S}\]) was fastest seems to be the net result of all four strategies; i.e., RT's to d would be faster than those to b, since the segmentation processes I and II apply immediately to M,S
sentences like d, but not to S,M sentences like b. Responses to d should also be faster than b because of the subcategorization strategy, IV. Listeners may be forced to store a (first-clause) subject complement, as in the b-version, in the STM buffer until the main-V is reached; i.e., until subcategorization information becomes available. But an object complement in the second-clause, as in the d-version, would present no delay, since the main-V would already have been encountered. This would account for longer RT in the S,M or b-version for complement sentences, since that condition contains subject- rather than object-complements.

Notice there is an important difference between this solution, which will be called the "exclusive dominance position," and the one given earlier, to cover the results of EXP. II. That model, a "mixed recency-dominance position," assumed dominance and recency to be additive in S,M order, and to subtract from each other in M,S order. Cell a, then, (___X, ___) was supposed to evoke slowest RT's, and cell b, (___, X___), fastest.8

The outcome of EXP. II follows these predictions, but the outcome from EXP. III does not.9 The problem with the "mixed" model, in addition to its failure to cover all the data, is that it is too limited. It is based solely on responses to sentences with adverbial clauses, and moreover, to sentences whose main-V do not allow comple-
ments. When sentences with other subordinate clause types and verbs are tested, as in EXP. III, recency does not have a significant effect on processing. Instead, the dominance factors CL and kind-of-clause are primary. It is only with the perception of syntactically coordinate clauses that recency seems to be operative to any appreciable extent. 10

e. Summary of experimental research: Experiments I-III

In EXP. I, the basic problem was to determine the source of Caplan's probe-latency effect: was it due to the temporal order of clauses, as he maintained, or to dominance factors? The only significant effect in EXP. I was recency, thus suggesting that the serial order of clauses in the surface string determined responses, and not hierarchical distinctions in the tree structure. However, because of a materials effect, the problem was still not resolved. And with revised stimuli in EXP. II, the dominance factors (clause order and kind-of-clause) did reach significance, along with the recency variable. Close examination of the mean RT for each condition in the experiment showed the main effects to be much less general than originally predicted; viz., PP differences were only obtained in S,M order, and CL differences only in first-clause probe position. At this stage of the research, it appeared that both recency and dominance were influencing RT's, but the relationship
between the two factors was still unclear. In addition, it was uncertain whether the effects were specific to adverbials, since they were the only sentence type used in EXP.'s I and II, as well as in Caplan's crucial test.

In order to resolve these issues, a third experiment was conducted. The material for EXP. III consisted of sentences with several types of clauses, including coordinates, where dominance distinctions would presumably be absent. As expected, the coordinates were the only stimuli in which there was a significant recency effect. One of the original problems thereby was solved—the recency effect was indeed independent of the other factors. The question about the specificity of the effects was also settled, since the dominance factor CL was significant for all the subordinate clause types tested, not just for the adverbials. Similarly, substantial kind-of-clause differences were obtained for every subordinate clause type, at least in first clause probe position. Therefore, in terms of the overall influence of the dominance factors, the subordinate sentence types seem to have been treated as a natural class. On the other hand, in terms of the size and direction of the PP, CL, and kind-of-clause factors, each type of subordinate clause was treated differently.
f. **Implications for a theory of sentence processing**

The most natural way of explaining these results is to say that listeners postulate a tree structural description for sentences during immediate perception. Different aspects of syntactic structure become relevant to processing at different points in time. **At the stage which is tapped by the probe task**, the dominance factors are clearly more important than recency for the analysis of subordinate material; whereas recency is the most relevant factor for segmentation of coordinate clauses.

The experimental results, in addition to suggesting which aspects of syntactic structure influence perception, also provide some clues to the means by which structural information is used to analyze sentences. In particular, the unique RT patterns that were obtained for each clause type can be viewed as the net result of four separate performance strategies (discussed on pp. 89ff.):

I. **Boundary determination**, which is primarily sensitive to the serial order of clauses, and seems to operate most clearly for coordinate material;

II. **Main clause location**, which identifies the first-V as the main-V unless subordinate markings are present in the surface string;

III. **Clause order**, which applies to S,M sentences and signals the presence of a sentence-internal (subordinate/main) clause boundary; and
IV. **Subcategorization**, which takes account of strict subcategorization information conveyed by the main-V, and enables the listener to compute one or more deep structure configurations.

Admittedly, these strategies are only first approximations toward a solution. They are based on the research reported in this thesis, as well as the results from previous studies, many of which used different paradigms. Whether or not these particular strategies are correct remains a question for future work.
NOTES TO CHAPTER III

1 The "phrase, non-phrase" distinction is treated in detail in the Appendices to Chapter II, pp.

2 See Table III-3, p. 79, for actual RT means.


4 Ibid.

5 For example, Fodor, Garrett, and Bever (1968) used an anagram task with self-embedded sentences containing verbs such as slap (+transitive, -COMP) or like (+transitive, +COMP, +poss-ING, + that, etc.). They found that subjects were less accurate in paraphrasing sentences with like, which has the greater range of possible complement structures. Similarly, Holmes and Forster (1972) report the number of words recalled on an R.S.V.P. test was lower for one-clause sentences with +COMP verbs, than the number recalled for matched material with -COMP verbs. (See p. 55 for a description of this paradigm).

Finally, the results of click tests for expect- vs. persuade-sentences (as discussed above, pp. 20-23) can also be interpreted in terms of subcategorization
information. Bever, et al. (1969) found a stronger migration effect to a point after the \textit{V} im the NP\textsubscript{1}..V sequence of \texttt{expect}-sentences, but after the \texttt{direct object} (NP\textsubscript{2}) in the NP\textsubscript{1}..V..NP\textsubscript{2} sequence of \texttt{persuade}-sentences. These effects may well be the direct reflexes of hypotheses about S-boundaries, which the listener makes on the basis of subcategorization features for [\texttt{expect (\_\_S)}] vs. \texttt{persuade [\_\_NP S].}]

There is an additional point in favor of the subcategorization interpretation. It helps resolve the problem of why the adverbials in EXP. III yielded different results from those in EXP. II. The reason for the contrast may lie in the lexical class of verbs that were used in the two studies, coupled with the clause types required for each test. In EXP. III, versions of all clause types were needed: coordinates, adverbials, relatives; and NP subject, object, or VP complements. But in EXP. II, the adverbials were the only type used. As a result, nearly all of the verbs in EXP. III sentences had to allow at least one type of complementizer; yet none of the verbs in EXP. II did.

Then, too, it may be that the semantic (and pragmatic) dependency relations between the two clauses in EXP. II-sentences were "looser" than corresponding dependencies in EXP. III-stimuli. Lack of tight dependencies could very well be responsible for the absence of real differences
between RT means for conditions b,c,d in EXP. II (669, 661, 663 msec.) as opposed to the substantial differences with EXP. III-adverbials (587, 567, 601 msec., respectively). This explanation is especially plausible, in view of the post hoc tests for EXP. I; i.e., tight dependency relations appear to be needed to obtain even a trend for the dominance effects. (When semantic/pragmatic dependencies were weak, as in EXP. I, the RT differences for the dominance factors did not reach significance.)

7It is also quite possible that a combination of subject and sentence variance (between the first and second blocks of 64 subjects) is responsible for the different results on the complements. If so, then RT to cell c of the complements might really have been fastest, just like the other clause types. Inspection of the 2 x 2 matrices (see top of p. 102) from the first-(vs. the second)-64 subjects shows that this interpretation may be correct.

8Originally, it was predicted that RT should be faster to main clause probes than to subordinate, ceteris paribus, since main clauses are represented as higher in the tree structure (see pp. 58ff.). And, that since second-clause probes should be faster than first-clause probes, the fastest RT should occur when the main clause is second, and the target occurs in it.
(*636) indicates the mean of three out of four groups of 16 subjects who responded to sentences in condition b. Unfortunately, the three sentences to appear in condition b for this particular subject group appeared in c during the presentation.

(Cell b, below). The slowest should be Cell a, in which the subordinate clause is first and the target is contained in it. Cells c and d should have RT's somewhere in between, because the recency and kind-of-clause effects would counter each other. These predictions are diagrammed in the chart that follows.

**Original Predictions**

2x2 Matrix for EXPERIMENTS I-III
Cell b was not the fastest, and this fact holds for all the clause types that were tested. Instead, c, \[ \frac{\text{X}}{\text{main}} \frac{\text{X}}{\text{sub}} \], was the fastest for the adverbs and relatives, and d, \[ \frac{\text{X}}{\text{main}} \frac{\text{X}}{\text{sub}} \], was fastest for the complements.

There is a slightly less plausible solution, which falls somewhere between the "mixed" recency-dominance and the "exclusive" dominance positions. The alternative would say that recency does effect the perception of sentences with adverbial (and coordinate) clauses, but no relative and complement clauses. Hence, only the analysis of clauses immediately dominated by \( S_o \) or the topmost-\( S \) would be influenced by recency.

This solution is based on the following evidence:

i) The greatest PP differences showed up for adverbial stimuli in \( S,M \) order on EXP. III (viz., 36 msec. vs. 24 msec. coordinates, 15 msec. relatives, and 16 msec. complements).

ii) The adverbials were the only clause type having a significant CL x PP interaction in EXP. III, and also in EXP. II.

iii) Both recency and dominance effects did seem to be additive in EXP. II.

iv) Caplan obtained positive recency results with adverbial material.
According to this solution, coordinate and adverbial sentences fall together as a natural class wrt perceptual analysis. This conclusion has independent linguistic motivation: both clause types have relatively free movement possibilities when compared to relatives and complements; both are marked off by pausing intonation; and both are dominated by the topmost-\$ in tree structure representations.

At the present stage of research, there is not enough evidence to decide between this proposal and the exclusive-dominance story. We are adopting the latter for the moment, since it seems to cover the data more accurately.
CHAPTER IV

EPILOGUE: SOME IMPLICATIONS OF THE
EXPERIMENTAL RESEARCH

Thus far, the main thrust of the work has been to relate the results from studies of processing to certain syntactic properties of sentences. In particular, we have examined how structural relations among clauses affect the initial analysis of complex sentences; and we have suggested a number of strategies that listeners might use during this early phase of processing. The research itself, as well as the strategies needed to account for the results, may have more far-reaching implications for the theory of grammar. For example, perceptual strategies, similar to those proposed in Chapter III, have proved to be useful in describing the difficulty with a number of marginally acceptable sentences; e.g.,

a) The rabbitt the fox the hunter saw chased died.
b) The boat floated on the river sank.
c) The pitcher tossed the ball tossed the ball.

Once cases like these are diagnosed as "perceptually difficult," rather than "ungrammatical," many pseudo-problems in the theory of syntax disappear.¹ One
no longer is pressed to rationalize ad hoc constraints on rules, or powerful metaconditions which are needed to block generation of the examples in question. Instead, the task is to account for the listener's confusion in analyzing such sentences.

There have been several attempts to explain perceptual confusion as a function of syntactic structure. The proposals have ranged from node counting metrics (Yngve, 1960) to general parsing principles (Kimball, 1973). In the following section, we shall first rephrase the problem of perceptual complexity in terms of the processing model suggested by our research, and then evaluate a few proposals which deal with the issue. It will become clear that the most useful approach is the Surface Structure Que theory (SSC) of Fodor and Garrett (1967). Finally, we show how an explanation based on this position accounts for a rather diverse group of "?*" sentences that have attracted attention in the recent linguistic literature.

1. Perceptual complexity: a working definition

By assumption, listeners must (at least) recover the equivalent of a deep structural description in order to understand a sentence. Problems, or obstacles that interfere with recovery would then be sources of processing difficulty. If we can obtain data on surface configurations that would impede recovery of deep structures, we would have
clues to the nature of perceptual complexity.

The argument for this approach requires several steps. First, several cases of supposedly complex sentences will be examined. Attempts will be made to describe the source of the processing difficulty with this material. It will become clear from these examples that a subjective treatment of complexity is fraught with problems. We then outline a more objective method for obtaining data, and show how this method leads to viewing perceptual complexity as the result of problems in recovering deep SD's.

a. **Intuitions about effort in analyzing sentences**

Let's begin with the simple premise that all sentences are more or less hard to analyze. The notion of perceptual complexity then becomes a relative relation; i.e., sentences can be ordered along a "complexity scale" by their relative ease, or difficulty, in processing. Thus, the real issue is to find reasons why differences in sentence structure give rise to differences along such a scale.

There is both a subjective and objective side to this problem. On the one hand, listeners share subjective impressions about the kind of effort needed to analyze certain sentences. For example, "garden path" examples like those below mislead us into thinking a sentence has ended before it really has:
(where "/" represents the first guess about the location of a clause boundary)

1) The boat floated down the river / sank.

2) The women sold the sick puppies / cried.

The sensation of difficulty arises when we make an initial guess about the boundary and are then forced to backtrack and reanalyze the string. The opposite phenomenon can also occur; i.e., the first guess about sentence structure might be correct, but items late in the string could convince us to change our initial hypothesis wrt boundary location. E.g., where "/" = the first guess, and "//" = the second one,

3) The bartender sold that guy drinks after hours./ ."... ."... sold//that guy drinks after hours.

With other sentences, the feeling is not so much "being misled," but rather "being hard-pressed to remember items."

Left-branching constructions are a case in point:

4) The innocent psych. student, the hangmail on the left finger of whom had been promised by his advisor to the top floor wizards for histology, knew nothing of his fate in the department.

5) My aunt's mother's uncle's pet hen's young chicks' food supply was growing short.

One could go on and on in this way, trying to correlate impressions of "effort" with syntactic structures,
in an attempt to understand the source of processing difficulty. Unfortunately, as the examples show, there are a variety of construction types that can elicit similar feelings of confusion. Conversely, one particular structure may be associated with several different subjective reactions. And, what is even more important, listeners are too often unaware of any special effort needed to understand the majority of sentences.

Thus, even though language users might be conscious of difficulty in some extreme cases, intuitions are just not systematic enough to serve as the sole basis for an explanation of perceptual complexity. What is needed is an objective database—such as the kind supplied by performance differences on tests of sentence perception. In fact, response differences that can be related to a given structural property suggest that it affects recoverability; i.e., that property influences the ease with which the listener can correctly determine the structure of stimulus strings.\(^2\) The argument for this claim goes as follows:

First, response variance is interpreted as a contrast in the way structure is assigned (or, possibly, retrieved). (For example, recall our treatment of the latency differences between S,M and M,S sentences, and between first- and second-clause probe positions in EXP.'s II and III.) The effect is then rationalized in terms of linguistic and psychological factors. The idea is to
explain why certain syntactic variables seem to influence the size or direction of the variance. Ideally, this explanation will also reveal how these syntactic factors make it easier or harder to recover deep SD's. Or, in other words, how the factors affect the complexity of sentences.

In short, we are saying that performance measures can be viewed both as indices of recoverability and complexity. The chart on the following page summarizes this viewpoint.

b. **Mechanisms of recoverability**

There are several possible means by which listeners could recover deep structures. For instance, they could simply work backwards from the surface string, "undoing" the effects of rules, one-by-one. One form of this hypothesis, known as the Derivational Theory of Complexity (DTC), predicts that complexity is a function of the number of rules required to generate a sentence (given that all transforms of a sentence derive from the same source, and the simple active declarative is the base form). Although the results of a number of studies seem to support DTC (McMahon, 1963; Gough, 1965, 1966; Savin and Perchonock, 1965; and Compton, 1967), there are just as many studies that fail to confirm it. (See, for example, Bever and Mehler, 1965; Jenkins, Fodor, and Saporta, 1965; and Fodor
Psycholinguistic tests of sentence processing

Response differences, related to structural distinctions in test material

(implies)

Differences in recoverability

(implies)

Degrees of perceptual complexity

Fig. IV-1. Performance, Complexity, and Recoverability Measures.
and Garrett, 1967.) In addition to the lack of clear experimental evidence, DTC fails on internal grounds: it predicts that sentences which have not undergone a particular rule, or rules, will be perceptually easier than those that have. Even though this prediction holds for the difference between reduced and unreduced relatives (embedded on the matrix subject), such as in IV-la, b and IV-la', b',

IV-la. The rabbit the fox the hunter saw chased died.
b. The boat floated on the river sank.
la'. The rabbit that the fox that the hunter saw chased died.
b'. The boat which was floated on the river sank.

It is counterintuitive for other examples. E.g., IV-6, below, would have to be more difficult to perceive than IV-7 from which it is derived (especially since three rules have applied to the underlying structure of IV-6—relativation, pronoun deletion, and adjective proposing—but none of these have applied to IV-7).

IV-6. The pink pot shattered when there was an earthquake.

7. The pot which was pink shattered when there was an earthquake.

Similarly, shortened passives, such as Sally was smacked, would have to be harder than their expanded versions; e.g., Sally was smacked by someone.
Even in cases where DTC and intuitions correspond, the theory is questionable. It is often impossible to tell whether subjective difficulty is due to the addition of a rule, or to the fact that a given surface structure has been distorted from its deep structure source. Discrepancy between deep and surface structure can, in fact, cause a delay in processing, and thereby contribute to our subjective impressions of effort, or difficulty in understanding a sentence.

Thus, instead of claiming that numbers of rules are responsible for problems in recovering deep structures, it is more reasonable to focus on details of surface structure. Namely, recoverability should be easier or harder, depending on the degree to which the surface string indicates (provides clues to) the arrangement of constituents in base structures. Hence, sentences with overt clues, such as expressed relative pronouns, should be less complex than sentences with relative pronoun deletions. This prediction was confirmed in a sentence repetition task having several conditions.³

c. Perceptual strategies again

Fodor and Garrett's (1967) position (hereafter, the Surface Structure Cue theory (SSC) assumes surface markings (such as complementizers, relative pronouns, non-finite verb forms, etc.) can be used to reconstruct
base forms. The question is, how?

Some insights to this problem can be found in the research on early segmentation. Recall that the results of several studies suggested a stage in which the listener identified the clauses which were contained in the input string (Walker, et al., 1968; Jarvella, 1971; Caplan, 1971; and Schlesinger, 1968). Each such clause in the input will have a subject–NP, a verb, and optional object. Since the sequence NP...V...(NP) usually expresses this order of subject...verb...(object), it would be reasonable for listeners to use the NVN sequence as the crucial clue for identifying potential clauses.\textsuperscript{4} If listeners actually use such a strategy during early processing, they should run afoul on sentences whose surface strings have some other sequence. Hence, sentences with a different surface structure ordering should be harder to analyze.

Research with several different paradigms provides support for this hypothesis; e.g., Bever (1968) found that subjects made more paraphrasing errors for sentences like IV-8 than for sentences like IV-9 below:

IV-8. The editor authors the newspapers hired liked died.

9. The editor the authors the newspapers hired liked died.

The nature of the paraphrase errors is important; \textit{viz}., subjects interpreted \textit{authors} (in 8) as a verb instead of
an NP. In short, they restructured the surface string into an N...V...N sequence.

Holmes (1970) and Forster (1970) used subject vs. object relative clauses in subject position as stimuli in tests with the R.S.V.P. technique. (See p.55 for details about this paradigm). They reported that sentences with subject relatives, e.g.,

IV-10. The boy who kicked Bob was a bully.
were easier than sentences with corresponding object relatives, e.g.,

11. The boy whom Bob kicked was a bully.
This result is expected if listeners use the strategy, since the sequence of surface constituents within the relative in IV-10 follows the normal order--

\[
\text{subject} \quad \text{kicked} \quad \text{Bob}
\]

but the sequence in IV-11 does not.

\[
\text{object} \quad \text{whom} \quad \text{Bob} \quad \text{kicked}
\]

\[
\text{object} \quad \text{subj.} \quad \text{verb}
\]

And finally, the results from our own research are compatible with the idea of a grouping strategy, which we have called BOUNDARY DETERMINATION. As we have shown, the recency effect in the experiments can be explained if items are grouped together into clauses in STM and then "pushed out" to a longer term store. (See pp. 23-25; 41-43.)
Possibly more direct cases which support the use of cues and strategies come from the findings with subordinate stimuli in EXP. III. For instance, it is reasonable to make sense of the faster RT to M,S stimuli by saying that listeners expected the first clause to be the main one. Consider the case of the complement sentences, too. The unique response pattern for these stimuli can best be interpreted as the reflex of different strategies the listener could use in analyzing strings with +COMP verbs and expressed complementizers in surface structure. In particular, the presence of a +COMP verb would itself act as a cue, since it would enable the listener to guess at possible deep structure configurations.5

d. Summary--Section IV-1

In the preceding discussion, we have done the following:

(1) mentioned the unsystemmatic nature of our intuitions about processing difficulty;
(2) suggested a more empirical method of obtaining data;
(3) shown how performance differences can be viewed as measures of recoverability;
(4) examined two opposing theories which deal with the character of recovery operations;
(5) argued that a variant of the surface cue
theory of Fodor and Garrett is the better approach; and

(f) discussed some strategies which depend on surface cues (like constituent order and subordinate markers).

So far, the evidence for our analysis of SSC and perceptual strategies has come mainly from the results of performance tests. There is also independent support for the strategy view; viz., the constraints which English syntax seems to place on the output of movement and deletion rules. In the next section, several rather clear-cut cases of deletion will be cited, in which syntactic restrictions appear to dovetail with perceptual factors. Some more problematic examples will then be considered, in order to see how a strategy explanation might resolve the theoretical conflicts that arise when one insists on a purely linguistic solution.

2. The relationship between syntactic rules and recoverability

a. Deletion

Given the position outlined above, it is reasonable to examine syntactic rules, to determine whether they delete or rearrange crucial clues to base structures. If they do, one might expect the rules themselves to be constrained—by the ability of the listener to recover the
underlying phrase marker from the final derived one.\textsuperscript{6} Once we acknowledge factors like "perceptual recoverability," we can begin to understand why a general rule may seem to be blocked from applying in certain situations.

For example, consider deletions that could create problems for the correct assignment of dominance relations. RELATIVE PRONOUN DELETION is a typical rule, since it would optionally remove one of the key clues to the main/subordinate relation. This rule appears to operate freely when the pronoun replaces the object of the subordinate clause, as in IV-12 and IV-13 below:

IV-12. The arm\textsubscript{i} \textsubscript{S} \[the medic amputate the arm\textsubscript{i} \textsubscript{S} \rightarrow \]

(relative clause formation)

(R.C.F.)

12a. The arm that the medic looked at had been infected.

(relative pronoun deletion (RPD))

12b. The arm the medic looked at had been infected.

13. Someone \textsubscript{S}[the Feds pay someone]\textsubscript{RCF} \textsubscript{S} \textsubscript{RCF} would agree to the proposal.

13a. Someone whom the Feds pay would agree to the proposal.

b. Someone the Feds pay would agree to the proposal.

But RPD must not apply when the pronoun replaces the subject of the relative clause:
14a. The arm that looked bad to the Medic was infected.

b.* The arm looked bad to the medic was infected.

15a. Someone that pays the Feds would agree to the proposal.

b.* Someone pays the Feds would agree to the proposal.

Even though a formal constraint could be placed on the rule, to keep it from operating in cases like IV-14, the condition itself would be unexplained, at least within the domain of syntactic theory. On perceptual grounds, however, the constraint is motivated. That is, listeners would first apply Strategy I, BOUNDARY DETERMINATION, to the deleted versions 15, 15 b, thereby taking the first N.V..(N) sequence as a clause, erroneously:

\[
\begin{align*}
\text{[the arm looked bad to the medic]} \\
\text{[someone pays the Feds].}
\end{align*}
\]

As Langendoen says, this perceptual explanation would "... explain why the relative pronoun ... deletion transformation is restricted in its application the way it is; it is inapplicable in just those cases in which it would create sentences whose structures would be misleading to the listener" (1973, pp. 139-140).

A similar explanation helps us understand the constraints on WHIZ-deletion, the rule that removes the sequence, \([NP^{+\text{Pro}}] + \text{be}\), from sentences like IV-16 and IV-17, below. \[WH^{+\text{Wh}}\]
IV-16. I saw the boy \{ who was \} in the yard.
\{ \varnothing \}

IV-17. I saw the boy \{ who was \} handsome. (Adj. Preposing)
\{ \varnothing \}
(I saw the handsome boy.)

These sentences are not counterexamples to the deletion constraint mentioned on page 118, which prohibits removal of a relative pronoun if it stands for the subject of the subordinate clause; IV-16, 17 simply show that deletion of a "subject-pronoun" can occur when a form of be immediately follows.

Even though WHIZ-deletion is technically distinct from RPD, the relative pronoun deletion rule, the effect of both rules is the same from the standpoint of perception; viz., in removing the relative pronoun, they deprive the listener of one of the key clues to dominance relations. Hence, we might expect WHIZ-deletion to be constrained, just as RPD is. Sentence IV-18 suggests that our expectation is correct.

IV-18. The pitcher tossed the ball tossed the ball.
This sentence is unacceptable. The question is whether it is ungrammatical, or whether the unacceptability is due to some other factor. If it is ungrammatical, there would have to be some way of blocking derivation of this sentence but allowing others to be generated, like those below:

IV-19. The pitcher who was tossed the ball tossed the ball.
IV-20. The pitcher thrown the ball threw the ball back.

Suppose that a constraint is placed on WHIZ-deletion itself. This constraint would have to be extremely complex, since it must block IV-18 but allow sentences like IV-20 to be generated.

The statement would block such deletion just in those cases where the relative clause on the initial noun is passivized and the past participle form of the verb in the relative clause is homomous with the simple past of the verb. Such a rule would require that at least the two verb forms 'run through' the phonological component of the grammar to make sure that they would not turn out to be homomous. That is, the grammaticality of the derivation underlying sentences like . . . [IV-19] . . . would depend upon the confusability of part of that derivation with another potential one.7

Constraints of this type are known as "trans-derivational," (henceforth, TV), because they depend on a search throughout the derivation in order to determine whether a particular surface structure will result if a rule applies. The main problem with TV devices is that the search would be endless, since there are an infinite number of possible derivations. Such a solution would therefore add extra, and perhaps unwarranted power to the theory. It is not clear that such powerful devices are actually needed, especially if the main reason for having them comes from examples like IV-18 and IV-19 where there is a viable perceptual explanation available.

To wit: if listeners apply Strategy I, BOUNDARY
DETERMINATION, very early in the sequence of processing IV-18, they would analyze the string "The pitcher tossed the ball" as a main clause. After a right-hand boundary was assigned, the clause would be dismissed from STM, leaving "... tossed the ball." At this point, the listener would be forced to reanalyze the original string, so that tossed is construed as a past participle that modifies the pitcher, instead of as the main verb. Reanalysis presents a problem because items from the main clause would now be relatively inaccessible (since they have been pushed out of STM). Hence, the sentence is felt to be "perceptually complex."

Still another example where deletion is constrained (in a way that is difficult to state in syntactic terms) is the optional deletion of that when it functions as a complementizer. Just as in the RPD case, that functioning as a direct object can be freely deleted; e.g.,

IV-21. I mentioned \{that\} you didn't want any.
\{φ\}

But when the that-clause shows up as the surface subject, deletion cannot occur:

IV-22a. \{That\} you didn't want any was obvious to everyone.

b. \{* φ\}

Here, too, a solution in terms of perceptual strategies explains the restriction. Because the subordinate morpheme is gone in IV-22b, listeners would apply BOUNDARY DETERMI-
NATION and MAIN CLAUSE STRATEGY (p.90 ), and mistakenly construe

/ you didn't want any/

as the main clause. In short, this example shows that

that must appear sentence-initially in surface structure
so as to cue listeners to S,M order. 8

b. Movement and Deletion

The situation with that-deletion is actually much more complicated than it appears from the above. It is permissible to delete that from a complement clause which functions as the deep subject if it has been extraposed first; e.g.,

Extrap. from S

IV-23a. That you didn't want any was obvious.

b. It was obvious { that } you didn't want any.

Why should a movement rule like EXTRAPOSITION FROM S "undo" the force of a deletion-constraint? And, if it is really true that listeners must derive an underlying SD to understand a sentence, why is it that the extraposed versions are simpler to perceive (intuitively)—the non-extraposed versions should be easier on the face of it, since the surface order would mirror the underlying order of clauses.

Both questions can be answered on the basis of previous discussion. We argued earlier that the crucial factors that affect perceptual complexity are not the differences between deep and surface structures, per se, but
the degree to which surface structures conform to the listener's expectations of constituent and clause order, and the degree to which the surface string clues the appropriate deep structure configuration.

For the extrapolosed case, there are several reasons which override the fact that surface structure differs from deep. Notice first that extrapolposition changes an underlying S,M structure to an M,S one—and this is the expected clause order from a perceptual standpoint, even though we are assuming it is not the deep structure one. Secondly, the movement does not interfere with BOUNDARY DETERMINATION and MAIN CLAUSE STRATEGY. The listener can segment each NVN sequence and identify the first as the main clause; i.e.,

\[ \text{s[ ]it--be--obvious}_S \quad \text{s[ that you didn't want any]}_S \]

Nor does optional deletion of that cause problems in determining the boundaries. The recovery of deep structure dominance relations is still possible, since the pro-form it acts as clue to the source of the complement-clause.

And finally, rightward movement of clauses would be favored from what is known about memory systems; viz., processing space is limited for left-branching structures such as non-extraposed strings. When listeners hear such sentences, they would have to store the material from the left branch in the STM buffer (until the items from the
rest of the sentence have been perceived). On the other hand, the non-extraposed, right-branching structures would not tax storage facilities. Hence, rightward movement of an embedded-S would be favored perceptually, but not leftward.

A similar argument could be made for the difference in complexity between multiple self-embedded sentences like la, The rabbit the fox the hunter saw chased died, and the corresponding right-branching structures, such as

IV-24. The hunter saw the fox that chased the rabbit that died.

Comparable cases include strings resulting from the application of COMPLEX NP SHIFT, the rule that converts sentences like IV-25 to IV-26. (The phrase to be moved is underscored.)

IV-25. The Dean gave a special award that was presented at the 17th annual assembly of the student body to the junior class V.P.

IV-26. The Dean gave to the junior class V.P. a special award that was presented at the 17th annual assembly of the student body.

Again, rightward movement is allowed, and even favored perceptually, but leftward movement is extremely awkward, if it is allowed at all.

IV-27. * A special award that was presented at the 17th annual assembly of the student body the Dean gave to the junior class V.P.
c. Effects of late movement rules: some qualifications on perceptual complexity

From the discussion above, there would seem to be a number of different perceptual factors that interact to explain why that can be deleted from extraposed clauses. Therefore, it would be misleading to say that any one factor, like rightward vs. leftward movement, or presence vs. absence of a cue, generally makes surface strings "easier" or "harder" to process. Yet this type of argument has been used recently in papers by Kuno (1972) and Kimball (1973). Kimball's work is more interesting because he makes explicit claims about the importance of surface clues, or "traces," in his terms. However, he overlooks the effects of other perceptual factors, by claiming that all right global last cyclic (RGLC) rules, except for COMPLEX NP SHIFT, leave behind a trace, and therefore simplify processing; but most left-GLC (LGLC) rules do not. In the context of Kimball's paper, "right" and "left" global refer to right and left last cyclic rules which move constituents over variables (Kimball, 1973, p. 46). RGLC rules have already been exemplified in our discussion of EXTRAPosition and COMPLEX NP SHIFT. Cases of LGLC rules appear below. These include TOPICALIZATION, WH-FRONTING (part of REL. CLAUSE FORMATION), and LEFT DISLOCATION. Kimball holds that the outputs of such rules are "no more complex perceptually than the phrase markers they operate on . . ." That is, the LGLC rules have no effect on com-
plexity, presumably because they do not leave a trace, but the RGLC rules simplify processing.

This position is dubious and should be qualified, especially since there are counterexamples in Kimball's own data. In particular, there are problems with both parts of the claim that reads as follows:

a) LGLC rules do not leave traces, but RGLC rules do, and

b) RGLC rules yield "easier" structures than do LGLC rules. First of all, every example of an LGLC rule that Kimball gives leaves some sort of surface marking. E.g., compare the sentences below, in which we have circled the surface cues.

IV-27. **Topicalization** (moves an NP to the front of the main S)

a. Joe told Martha to ask Susan to test the bagel for Will.

b. The **bagel** Joe told Martha to ask Susan to test for Will.

28. **Relative Clause Formation**

a. Joe spanked the child Bill had seen Betty kiss wh-child

b. Joe spanked the child **which** Bill had seen Betty kiss.
29. **Left dislocation** (like Topicalization, except leaves a pronoun)
   a. Joe gave the book to Sally
   b. The **book,** Joe gave it to Sally.

   Consider how these rules operate. TOPICALIZATION, for instance, removes an NP object from an embedding in sentence 27, and fronts it to sentence-initial position, where it bears contrastive stress. The marked intonation could count as a clue to the listener; *viz.*, "The item bearing contrastive stress has been removed from its post-verbal source in deep structure." Even though this cue might facilitate processing, the movement itself should increase difficulty. According to the NVN strategy, the listener must hold the **bagel** in storage until he can pair it with its verb, **test**. Thus, it seems counterintuitive that an LGLC rule like TOPICALIZATION would be neutral wrt perceptual complexity. If anything, the effect of this rule would be to increase it.

   Similarly, Kimball’s analysis of RELATIVE CLAUSE FORMATION runs counter to his claims about LGLC rules. Since RCF leaves a relative pronoun when it applies to a string, there is a surface cue or "trace" present in the string, unless of course the pronoun has been deleted. The presence of this cue might counter the difficulty that a listener might have with a constituent that has been moved to the left. Likewise for **LEFT DISLOCATION**: the
pronoun *it* marks the place of the fronted object. In short, all these rules leave some form of surface marking to help the listener identify common deep structure clauses, contrary to part a) of Kimball's claim. Thus, the LGLC examples themselves bring out the need for qualifying statements about the relationship between late rules and perceptual complexity.

There are also problems with part b), the claim that RGLC rules simplify processing. This prediction might be true in certain cases of **EXTRAPosition FROM NP**, and **COMPLEX NP SHIFT**, such as in sentences IV-30, 31; but it will not hold up as a general principle.

**IV-30**

a. The woman who was pretty entered. 

b. The woman entered who was pretty.

31a. The provost ordered the student who wore a G-string to class to be strung up. 

b. The provost ordered to be strung up to the student who wore a G-string to class.

In these examples, one could make a case for the b versions being easier since the main clause subject would be immediately followed by its verb—{woman entered provost ordered} and not separated from it, as in the a versions. Hence, in the b versions, the strategies of **BOUNDary DETermination** and **MAIN CLAUSE** would not be thwarted, as they would be by the
a versions.

Unfortunately, this explanation will not work for other cases where EXTRAPPOSITION and COMPLEX NP SHIFT have applied. Let's consider first what would happen if EXTRAPPOSITION FROM NP is allowed to operate freely. The sentences below illustrate the range of cases:

IV-32a. The woman who was very sad saw the child.

b. The woman saw the child who was very sad.

33a. The woman who disliked the dog raised fleas.

?? b. The woman raised fleas who disliked the dog.

34a. The insecure debutante who bought herself bras all the time married that guy.

?? b. The insecure debutante married that guy who bought herself bras all the time.

35a. I gave the baby who was feeling bloated an enema.

??b. I gave the baby an enema who was feeling bloated.

Not only are the b versions more difficult to understand than the a ones, they are ungrammatical as well, for most speakers. Thus, the examples illustrate two main points: 1) the RGLC claim about simplifying structure is very limited, if it is correct at all; and 2) EXTRAPPOSITION needs to be constrained. The first point has just been
made with the sentences above; the second is discussed in
detail in the following section.

d. Constraints on global rules

Just as in the case of RELATIVE PRONOUN-, WHIZ-, and THAT-COMPLEMENT DELETION, the constraint on EXTRA-
POSITION FROM NP is complicated, if not impossible to state
in purely syntactic terms. At first glance, there is a
syntactic difference between the phrase markers underlying
the acceptable IV-30b,

IV-30. The woman entered who was pretty.

and the unacceptable strings IV-33, 34, 35b: viz., the
relative clauses in 33-35b pass over another NP in being
shifted. Since there is no such NP in IV-30b, the move-
ment appears to be freely allowed. (Cf. the analysis in
Ross, 1967.)

But there must be more to the restriction than
this. The "passover" constraint would not explain the
range of diminishing acceptability from IV-32b to IV-35b.
In these sentences, acceptability seems to depend on the
plausibility of interpreting the relative clause as a
modifier of the object-NP. What kind of restriction is
this? If syntactic, that would mean transformations could
be blocked just in case they produced ambiguities, such as
head/modifier relations. This is essentially Hankamer's
(1973) position:
The Structural Recoverability Hypothesis

Deletion [and chopping] rules involving variables are universally subject to a transderivational condition which prevents them from applying in such a way as to introduce structural ambiguity.

(Brackets added, J.R.K.)

Here again, the syntactic solution required a powerful metacondition. Just as with previous examples, such a constraint is not needed for the cases in question. There is a viable perceptual explanation instead: listeners simply use a strategy which tells them to "construe the relative as modifying the nearest available NP, unless it is implausible to do so." Consider how this strategy would work in the context of the others suggested by our own research:

In the a) version of each string, i.e.,

a) \( \text{NP}_1 \text{ who } \text{V}_1 (\text{NP}_2) \text{ V}_2 (\text{NP}_3) \)

the \textit{who} signals that an NP-modifier clause is coming. At this point in time, the \textit{only} NP is \( \text{NP}_1 \), which it taken as the head of the relative clause. No problem. In the b) versions, however, the listener hears \( \text{NP-V-} (\text{NP}) \) before \textit{who}: i.e.,

b) \( \text{NP}_1 \text{ V}_1 (\text{NP}_2) \text{ who } \text{V}_2 (\text{NP}_3) \).

Strategies I, \textsc{Boundary Determination}, and II, \textsc{Main Clause}, can apply. A righthand boundary is thereby assigned, and the main clause leaves STM.
Now the listener is left with the remaining string,

... who \textit{V}_2 (\textit{NP}_3).

The \textit{who} clues an NP-modifier, but the head of the relative clause is not yet fully determined; i.e., the relative could modify either the subject-NP, \textit{(NP}_1\textit{)}, or the object-NP, \textit{(NP}_2\textit{)}. Thus, there should be some uncertainty about the referent of the \textit{who}-clause, especially since items from the main clause (the first, and hence the dismissed clause) will be relatively inaccessible after the boundary.\textsuperscript{11} This is the point where the listener fixes on the \textit{nearest-NP} as the head of the clause.

If this strategy is applied to sentence 32b,

32b. The woman saw the child who was very sad.

the predicate "be very sad" is sensed to be a plausible modifier of the nearest (object) NP, and indeed, "the child be very sad" is the preferred interpretation for the sentence. In 33b, the strategy would yield the structure

... \textit{fleas}_i \textit{g}_i[\textit{fleas}_i \textit{dislike dog}].

This is certainly a possible deep structure. The problem arises with the selectional features that are attached to the relative pronoun \textit{who} as it appears in the surface string. Most speakers would expect \textit{who} to be marked [+human], and which, [± human]; so that when the \textit{who}-clause is interpreted as a modifier of \textit{fleas}, the listener is confused.
In 34b, the problem is worse. After the "nearest-NP" strategy applies, guy would be identified as the referent of the relative clause. The pronoun who is all right as a modifier of guy, but the string guy bought herself bras all the time is both semantically implausible and ungrammatical, due to lack of gender agreement between the head-NP and the reflexive, herself. And finally, in 35b, there is also the double dilemma of construing

[ who +animate ] with [ enema -animate ], and breaking the selectional restriction that [ feel ] requires an animate subject.

With these examples, we have seen how a perceptual explanation helps to account for gradients of acceptability judgments. Admittedly, the solution is sketchy, and more research must, of course, be done to determine how much semantic analysis really takes place on-line.

In closing, we will consider some constraints on a different RGLC rule, COMPLEX NP SHIFT. This rule moves an NP immediately dominating an S to a post-verbal position. In the structure below, the circled NP is the one shifted by the rule:

```
  S
    NP
      VP
        V
          NP
            NP
              NP
                NP
                  S
```
Just as in previous examples, some rather confusing sentences result if the rule is allowed to apply freely:

36a. /* The dean \{wants \} to be executed all the \{expects\} first year students who failed their exams.

37a. /* The dean \{wants \} to be destroyed the \{expects\} transcripts of all the students who were involved in the demonstration against him last week.12

When confronted by these sentences, the listener has a tendency to take the sequences, "The dean \{wants \} to be \{executed \}" as main clauses; i.e., he applies BOUNDARY DETERMINATION and MAIN CLAUSE: then he hears the surface object, \(\{\text{students}_{(36)}\}\) , and is forced to reanalyze. \(\{\text{transcripts}_{(37)}\}\)

Thus, the unacceptability of the two sentences above is in part a function of processing difficulty. The problem is to explain why perceptual confusion does NOT arise for the virtually identical examples below:13

36b. The dean sent to be executed all the first-year students who failed their exams.

37b. The dean ordered to be destroyed the transcripts of all the students who were involved in the demonstration against him last week.

According to J. Hankamer (1973), the crucial difference between the a and b versions of 36-37 is the main
verb. COMPLEX NP SHIFT seems to operate freely with most verbs, but not with ones that take EQUI NP DELETION (e.g., want and expect). Specifically, the shift cannot occur when a) the main-V allows the subject of a subordinate-S to be embedded as an object; and b) that object-NP can be deleted by EQUI. (Compare sentences 36 and 37a, with the +EQUI verbs want and expect, to 36 and 37b, with the -EQUI verbs send and order.)

These restrictions are impossible to state within the confines of the Standard Theory (Chomsky, 1965) or the Revised Standard Theory (Chomsky, post-1968), and would seem to require a transderivational constraint. E.g., "[COMPLEX NP SHIFT] is blocked just in case its output is a sentence which looks like a product of Equi, with an extra NP tacked at the end" (Hankamer, 1973, p. 55). Notice that this constraint merely restates the fact that listeners can get confused by analyzing strings derived from $[N..V..;[[V..NP]_{VP}]_{S_{s}}]_{S} \rightarrow [N..V..(N)]_{S}$ sequences. Thus, the restriction itself might be better understood as an aspect of performance, rather than as a condition on the operation of a syntactic rule. There are a number of reasons for this claim. First of all, there appears to be a general correlation between the number and kind of complements allowed by a given verb, and the listener's potential confusion in processing sentences
with that verb. Compare the (intuitive) differences in complexity in the pairs of examples below, whose verbs differ in their subcategorization properties:

38. The professor that the students admired was arrested by the police.

? 39. The professor that the students believed was arrested by the police.\textsuperscript{14}

40. Have you seen the man who I want to hit?

? 41. Have you seen the man who I want to leave the room in a hurry?\textsuperscript{15}

In examples 39 and 41, just as in the questionable cases of COMPLEX NP SHIFT (\#'s 36 and 37a), the listener can become confused about where to assign clause boundaries; i.e., 39 could be interpreted as the erroneous string,

39a. $s[\text{the professor}_i [\text{the students believed [(the professor}_i \text{) was arrested by the police}]_{V????'}]\]_S$

(on the model of the sentence,

39b. The professor that the students believed was arrested by the police died.),

instead of the grammatical one,

"[The professor\textsubscript{i} [the students believed the professor\textsubscript{i}] was arrested by the police\textsubscript{S}."

Sentence 41 is even more perplexing to analyze. One could assign boundaries at a number of points within the relative; e.g.,
41a. Have you seen the man]
    Have you seen the man who I want]
    Have you seen the man who I want to leave]
    Have you seen the man who I want to leave the room]

or

    Have you seen the man] who..[I want to leave]
    Have you seen the man] who..[I want to leave
    the room], etc.

In these examples, the intuitive differences between 36-37a
and b, 38 and 39, and 40 and 41 suggest that lexical
properties of verbs have a direct relation to perceptual
complexity—and indeed, this is the conclusion of many
experimental studies. 16 It is not the case, then, that a
particular rule must be blocked from applying in percep-
tually ambiguous cases. Instead, it seems better to say
that listeners may have trouble determining clause bounda-
ries and dominance relations in some sentences, because of
the syntactic properties of certain verbs. Hence, the
constraint on COMPLEX NP SHIFT emerges as a special case
of a more general performance factor.

e. **Summary:** Section IV-2

At the beginning of this thesis, we outlined a
performance model which requires interactions, or inte-
gration of linguistic knowledge with cognitive factors.
According to this approach, there should be some linguistic phenomena that are not the result of purely grammatical operations. The examples in the preceding pages are typical cases, where information about non-grammatical factors proves useful in describing "unacceptable ambiguities,"\(^{17}\) and obviates the need for powerful metaconditions on rules of the grammar, such as transderivational constraints.

Admittedly, this method of analysis is speculative, and crucially depends on the results of experimental studies. Although many of the ideas expressed in this chapter are extrapolations from such research, they at least suggest how the inquiry might proceed.
NOTES TO CHAPTER IV

1 These examples and other comparable ones have appeared in the following sources:
   a) Chomsky and Miller, 1963;
   b) Bever, 1970; and

2 (Just in case these differences are obtained on material that varies only by the property in question).

3 For a detailed report of these tests, see Fodor, Bever, and Garrett, 1974, Ch. 6, for more details.

4 Ibid.

5 For a more detailed discussion, see pp.

6 It is this premise that seems to be the basis for syntactic constraints on deletion rules. Cf. Chomsky's original proposal: (1965, pp. 144-145):

We are proposing the following convention to guarantee recoverability of a deletion: a deletion operation can eliminate only a dummy element, or a formative explicitly mentioned in the structure index (for example, you in imperatives), or the designated representative of a category (for example, the WH-question transformations that delete Noun Phrases are in fact limited to indefinite pronouns—cf. Chomsky, 1964, §2.2), or an element that is otherwise represented in the sentence in a fixed position.
Further discussion of this case can be found in Bever and Katz, 1973, pp. 60ff.

That-deletion is discussion at length in Langendoen, 1973, pp. 140ff., and Bever, Fodor, and Garrett, 1974, MS pp. 6-44.

Where "nearest" means "most recently heard."

Cf. the two-part strategy of Bever and Landendoen, 1971, p. 436.

7a) \( X_1 \) Nominal \( V_f X_2 \rightarrow X_1 \) \( s^{[\text{Nominal } V_f X_2]} \)

7b) \( X_1 s^{[\text{Nominal } V_f (\text{Nominal}) X_2]} \rightarrow X_1 s^{[\text{Nominal } V_f (\text{Nominal})]} X_2 \).

This claim is supported by the results of Caplan (1971) and Kornfeld (Experiments II and III reported here).

12 Courtesy of J. Hankamer (1973, p. 55, sentences #151-152.)

13 Ibid., sentences #153-154.

14 Suggested by sentences #100 and 103 in Jackendoff and Culicover, 1971, p. 407.

15 Ibid., p. 408.

16 See Fodor, Bever and Garrett, 1968; Holmes and Forster, 1972; Bever et al., 1969; and a discussion of
their work, ftnt 5, pp. 99-100. Cf. also the remarks on pp. 86-88.

17 From the title of the paper by J. Hankamer (1973).
APPENDICES
APPENDICES TO CHAPTER I
p.w. = number of syllables from end of the target word to sentence end.

m. = number of syllables from clause boundary to end of sentence.

w. = number of words from end of target word to end of sentence.

1. a) Although there are lots of brands of diet COLA, Tab sells better than others.  m=7=pw; w=5
   b) Although there are lots of soft drinks, diet COLA sells better than the others.  m=11; pw=7; w=5
   c) Today there are lots of brands of diet COLA, although Tab sells more than most.  m=pw=7; w=6
   d) There are lots of soft drinks, although diet COLA sells better than the others.  m=13; pw=7; w=5

2. a) While the crowd waited for the SPEAKER, someone tried the microphone.  m=pw=7; w=4
   b) While the large crowd waited, the SPEAKER adjusted the microphone.  m=10; pw=7; w=3
   c) The large crowd waited for the SPEAKER, while someone tried out the mic.  m=pw=7; w=6
   d) The large crowd waited, while the SPEAKER adjusted the microphone.  m=11; pw=7; w=3

3. a) Because you put these new drapes in SUNLIGHT, many bright colors will fade.  m=7=pw; w=5
   b) Because you put up these new drapes, SUNLIGHT will fade many bright colors.  m=9; pw=7; w=5
   c) Put up these drapes away from SUNLIGHT, because bright colors will fade.  m=pw=7; w=5
d) Put these drapes over there, because SUNLIGHT will fade many bright colors. m=11; pw=7; w=6

4. a) When the bombing was stopped by the Americans, the blasts had destroyed the firebase. m=8; pw=8; w=6

b) When all the bombing was stopped, the AMERICANS had destroyed most of the firebase. m=13; pw=8; w=6

c) All the bombing was stopped by the AMERICANS, when the blasts destroyed the firebase. m= pw=8; w=6

d) All the bombing was stopped, when the AMERICANS had destroyed most of the firebase. m=14; pw=8; w=6

5. a) If careful shoppers watch for SALES, some nice items can be found. m=7; pw=7; w=6

b) If careful shoppers look hard, SALES on nice items can be found. m=8; pw=7; w=6

c) Careful shoppers should watch for SALES, since nice items can be found. m=7; pw=7; w=6

d) Careful shoppers look hard, since SALES on nice items can be found. m=9; pw=7; w=6

6. a) When the school invited the POLICE, the students asked about drugs. m=7; pw=7; w=5

b) While the teachers listened, the POLICE told the students about drugs. m=9; pw=7; w=5

c) The high school invited the POLICE, when the students studied drugs. m=7; pw=7; w=5

d) The teachers listened, while the POLICE told the students about drugs. m=10; pw=7; w=5

7. a) Because shipping rates rose for COFFEE, retail prices went up. m=6; pw=6; w=4

b) Because shipping rates increased, COFFEE went up sharply in price. m=8; pw=6; w=5

c) Shipping rates have increased for COFFEE, because wages went up. m=6; pw=6; w=4
d) Shipping rates rose, because COFFEE needs special packing crates.  m=9; pw=6; w=4

8. a) When the teacher came into the CLASS, the room was quite noisy.  m=pw=6; w=5

b) When the school teacher came in, the CLASS was making lost of noise.  m=8; pw=6; w=5

c) The school teacher came into the CLASS, when the room was noisy.  m=pw=6; w=5

d) The school teacher came in, when the CLASS was making lost of noise.  m=9; pw=6; w=5

9. a) When the librarian was dusting the BOOKS, all the shelves fell over.  m=pw=6; w=5

b) When the librarian was dusting, the BOOKS on the shelves fell over.  m=8; pw=6; w=5

c) The art librarian was dusting the BOOKS, when the shelves fell over.  m=pw=6; w=5

d) The librarian was dusting, when the BOOKS on the shelves fell over.  m=9; pw=6; w=5

10. a) If you usually like a spy NOVEL, this book will intrigue you.  m=pw=6; w=5

b) If you like a good plot, this spy NOVEL will surely intrigue you.  m=10; pw=6; w=4

c) You will probably like a spy NOVEL, if good plots intrigue you.  m=6=pw; w=5

d) You should like this book, if a spy NOVEL usually intrigues you.  m=11; pw=6; w=3

11. a) While the camera crew waited for the ACTRESS, she checked on the script.  m=pw=5; w=5

b) While the whole camera crew waited, the ACTRESS checked over the script.  m=8; pw=5; w=4

c) The whole camera crew waited for the ACTRESS, while she checked the script.  m=5=pw; w=5
d) The whole camera crew waited, while the ACTRESS checked over the script.  $m=9$; $pw=5$; $w=4$

12. a) Since Bob only skimmed his notes in ART history, the test was difficult.  $m=6$; $pw=8$; $w=5$

b) Since Bob only skimmed through his notes, ART history was very difficult.  $m=9$; $pw=8$; $w=4$

c) Bob read his notes for the quiz in ART history, since tests were always hard.  $m=6$; $pw=8$; $w=6$

d) Bob read over all his notes, since ART history was very difficult.  $m=10$; $pw=8$; $w=4$

(where history is read with two syllables)

13. a) Now that the farmer gives plums to the CHILDREN, everyone will act more friendly.  $m=pw=8$; $w=5$

b) Now that the farmer gives out plums, the CHILDREN will act a good deal more friendly.  $m=11$; $pw=8$; $w=7$

c) The farmer gives away plums to the CHILDREN, so that everyone will be friends.  $m=pw=8$; $w=6$

d) The farmer gives out plums, so that the CHILDREN will act a good deal more friendly.  $m=13$; $pw=8$; $w=7$

14. a) As Sue was just sitting down for the CHURCH service, the choir began the third psalm.  $m=7$; (where choir = 1 syllable) $pw=9$; $w=7$

b) As Susan was just sitting down, the CHURCH service began with the thirteenth psalm.  $m=11$; $pw=9$; $w=6$

c) Susan was just sitting down for the CHURCH service, as the choir sang the third psalm.  $m=7$; $pw=9$; $w=8$

d) Susan was just sitting down, as the CHURCH service began with the thirteenth psalm.  $m=12$; $pw=9$; $w=6$

15. a) Though our team unfortunately lost the GAME, the match was quite exciting.  $m=pw=7$; $w=5$
b) Though our team unfortunately lost, the GAME had been very exciting.  m=9; pw=7; w=4

c) Unfortunately, our ball team lost the GAME, though the match was exciting.  m=pw=7; w=5

d) Unfortunately, our team lost, though the GAME had been very exciting.  m=10; pw=7; w=4

16. a) When the state housing board pushed through the NEW bill, the people got upset.  m=6; pw=7; w=5

b) When the state passed a housing plan, the NEW bill got the people upset.  m=9; pw=7; w=5

c) The state housing council pushed through the NEW bill, when the people were upset.  m=6; pw=7; w=6

d) The state passed a housing plan, when the NEW bill got the people upset.  m=10; pw=7; w=5

17. a) Since you make long distance calls at the NIGHT rates, you can save money.  m=5; pw=6; w=5

b) Since you make long distance phone calls, the NIGHT rates will save you money.  m=8; pw=6; w=5

c) Make your long distance phone calls at the NIGHT rates, since you save money.  m=5; pw=6; w=5

d) Make your long distance calls at ten, since NIGHT rates will save you money.  m=8; pw=6; w=5

18. a) Since you really enjoy a strong DRINK, you should have scotch instead of wine.  m=pw=8; w=7

b) Since you like liquor, have a strong DRINK with good scotch instead of cheap wine.  m=12; pw=8; w=7

c) You must really enjoy a strong DRINK, since you have scotch instead of wine.  m=8=pw; w=7

d) You must enjoy liquor, since you DRINK good scotch instead of cheap red wine.  m=11; pw=8; w=7

19. a) After the cardshark walked out of the HOTEL, the gambling room closed.  m=pw=5; w=4
b) After the cardshark walked outside, the HOTEL closed the gambling room. m=8; pw=5; w=4

c) The sly cardshark walked out of the HOTEL, after gambling closed. m=pw=5; w=3

d) The cardshark walked outside, after the HOTEL closed the gambling room. m=10; pw=5; w=4

20. a) While Mom relaxed in the living ROOM, the maid cleaned up the house. m=pw=6; w=6

b) While Mom was resting, the living ROOM was cleaned up by the maid. m=10; w=6

c) Mom was resting in the living ROOM, while the maid cleaned the house. m=pw=w=6

d) Mom was resting, while the living ROOM was cleaned up by the maid. m=12; pw=6=w

21. a) Though the rough seas were bothering the CREW, the ship sailed through the bad storm. m=pw=7 & w=7

b) Though the rough seas were bothersome, the CREW sailed the ship through the bad storm. m=9; pw=7; w=7

c) The rough seas were bothersome to the CREW, though the ship sailed through the storm. m=pw=7=w

d) The rough seas were bothersome, though the CREW sailed the ship through the bad storm. m=10; pw=7; w=7

22. a) Though the peasants built dikes before the FLOODS, water still ruined the village. m=pw=8; w=5

b) Though the peasants built dikes before spring, FLOODS still ruined most of the village. m=9; pw=8; w=6

c) The peasants had built dikes before the FLOODS, though water ruined the village. m=pw=8; w=5

d) The peasants built dikes before spring, though FLOODS still ruined most of the village. m=10; pw=8; w=6
23. a) After you read the fine print on the LEASE, check the tax clause carefully.  $m=pw=7; w=5$

b) After you have read the fine print, the LEASE should be checked for tax clauses.  $m=9; pw=7; w=6$

c) You should read all the fine print on the LEASE, after you've checked the tax clause.  $m=pw=7; w=6$

d) You should read the fine print, after the LEASE has been checked for tax clauses.  $m=11; pw=7; w=6$

24. a) If good wine is left exposed to the AIR, the taste will go flat.  $m=pw=w=5$

b) If wine is exposed very long, the AIR makes the taste go flat.  $m=7; pw=w=5$

c) That wine must have been exposed to the AIR, if the taste went flat.  $m=pw=5=w$

d) That wine must have been exposed, if the AIR made the taste go flat.  $m=8; pw=5=w$

25. a) Because the artist drew sketches on the WALLS, the room was very attractive.  $m=8=pw; w=5$

b) Because the artist hung up sketches, the WALLS were unusually attractive.  $m=10; pw=8; w=3$

c) The artist drew sketches on all of the WALLS, so the room would be attractive.  $m=pw=8; w=6$

d) The artist hung up his sketches, so the WALLS would appear much more attractive.  $m=11; pw=8; w=5$

26. a) After several plumbers worked on the FAUCET, water still dripped for a whole week.  $m=pw=8; w=7$

b) After the plumber fixed the leak, the FAUCET still dripped for an entire week.  $m=11; pw=8; w=6$

c) Several plumbers finally worked on the FAUCET, after water dripped for a week.  $m=pw=8; w=6$

d) The plumber fixed the leak, after the FAUCET had dripped for an entire week.  $m=13; pw=8; w=6$
27. a) If you have saved some extra MONEY, buy mother a nice Easter gift. \( m=8; w=6 \)

b) If you've saved up, the extra MONEY can go for mother's Easter gift. \( m=13; p=8; w=6 \)

c) You should have saved some extra MONEY, so we can buy mother a gift. \( m=p=8; w=7 \)

d) Please save up, so the extra MONEY can go for mother's Easter gift. \( m=14; p=8; w=6 \)

28. a) After the storm moves away from the SOUTH, we might get pleasant weather. \( m=p=7; w=5 \)

b) After the storm clouds move away, the SOUTH might get some pleasant weather. \( m=9; p=7; w=5 \)

c) These storm clouds must move away from the SOUTH, before we get good weather. \( m=p=7; w=5 \)

d) These clouds must move away, before the SOUTH can get some pleasant weather. \( m=11; p=7; w=5 \)

29. a) When Ann was planting shrubs in the GARDEN, the ground was drenched by showers. \( m=p=7; w=6 \)

b) When Ann was planting the shrubs, the GARDEN was drenched by sudden showers. \( m=10; p=7; w=5 \)

c) Ann was planting the shrubs in the GARDEN, when the ground was drenched by rain. \( m=p=7 \)

d) Ann was planting the shrubs, when the GARDEN was drenched by sudden showers. \( m=11; p=7; w=5 \)

30. a) When John continually plays the DRUMS, his neighbors get angry. \( m=p=6; w=4 \)

b) When John practices all day, the DRUMS make his neighbors angry. \( m=8; p=6; w=4 \)

c) John continually plays on the DRUMS, though his neighbors get mad. \( m=6=p; w=5 \)

d) John practices all day, though the DRUMS make his neighbors angry. \( m=8; p=6; w=4 \)
31. a) Even though farmers grow many kinds of FOOD, grain is still scarce.  \( m=pw=w=4 \)

b) Even though farmers grow many products, FOOD is still quite scarce.  \( m=5; pw=w=4 \)

c) The farmers grow many different kinds of FOOD, though grain is scarce.  \( m=pw=w=4 \)

d) The farmers grow many kinds of grain, though FOOD is still quite scarce.  \( m=6; pw=w=4 \)

32. a) When cooks use hot spices in FOOD, meals taste much more interesting.  \( m=pw=7; w=5 \)

b) When good cooks use hot spices, FOOD tastes a lot more interesting.  \( m=8; pw=7; w=4 \)

c) Good cooks use hot spices in FOOD, so meals will taste interesting.  \( m=pw=7; w=5 \)

d) Good cooks use hot spices, so FOOD will taste much more interesting.  \( m=9; pw=7; w=5 \)

33. a) When your aunt arrived at the STATION, the platform was deserted.  \( m=7; pw=w=4 \)

b) When your great aunt arrived, the STATION was completely deserted.  \( m=10; pw=7; w=3 \)

c) Your great aunt arrived at the STATION, when the place was deserted.  \( m=pw=7; w=5 \)

d) Your great aunt arrived, when the STATION had been completely deserted.  \( m=11; pw=7; w=4 \)

34. a) After the French class ended on TIME, the boys left for the swimming meet.  \( m=pw=8; w=7 \)

b) After French class ended, it was TIME for the boy's yearly swimming meet.  \( m=11; pw=8; w=6 \)

c) The advanced French class ended on TIME, since the boys had a swimming meet.  \( m=pw=8; w=7 \)

d) French class ended soon, since it was TIME for the boy's yearly swimming meet.  \( m=12; w=6; pw=8 \)
35. a) After the students insulted the JUDGE, they were fined for contempt of court.  m=pw=8; w=7
   b) After students yelled out insults, the JUDGE fined them all for contempt of court.  m=10; pw=8; w=7
   c) Militant students insulted the JUDGE, before they were fined for contempt.  m=pw=8; w=6
   d) Students yelled out insults, before the JUDGE fined them all for contempt of court.  m=12; pw=8; w=7

36. a) While the boys worked in the HOT sun, the air felt quite sticky.  m=6; pw=7; w=6
   b) While the boys worked hard, the HOT sun made the air feel sticky.  m=9; pw=7; w=6
   c) The boys worked hard in the HOT sun, while the air was sticky.  m=6; pw=7; w=6
   d) The boys worked hard, while the HOT sun made the air feel sticky.  m=10; pw=7; w=6

37. a) Since my Dad always enjoys his SHOWERS, the bathroom often gets flooded.  m=8=pw; w=5
   b) Since Dad likes lots of water, his SHOWERS often get the bathroom flooded.  m=11; pw=9; w=5
   c) My father always enjoys his SHOWERS, though the whole bathroom gets flooded.  m=pw=8; pw=6
   d) Dad likes lots of water, though his SHOWERS often get the bathroom flooded.  m=12; pw=8; w=5

38. a) Before lightning wrecked the trees in our BACKYARD, the garden had always looked nice.  m=pw=8; w=6
   b) Before lightning wrecked all our trees, our BACKYARD had always looked especially nice.  m=11; pw=8; w=5
   c) Lightning wrecked all of the trees in our BACKYARD, though the garden looked nice before.  m=8; pw=8; w=6
d) Lightning wrecked all of our trees, though our BACKYARD had always looked lovely before. m=12; pw=8; w=5

39. a) Even though this T.V. has OLD parts, the tubes can be replaced. m=6; pw=6; w=6

b) Though this T.V. has its faults, OLD parts can be replaced cheaply. m=8; pw=7; w=5

c) This television set has OLD parts, though tubes can be replaced. m=6; pw=7; w=6

d) This T.V. has its faults, though OLD parts can be replaced cheaply. m=9; pw=7; w=5

40. a) Though prices are high in SMALL stores, customers are faithful. m=6; pw=7; w=4

b) Though prices are high here, SMALL stores have faithful customers. m=8; pw=7; w=4

c) All prices are high in SMALL stores, though patrons are faithful. m=6; pw=7; w=5

d) Prices are high here, though SMALL stores have faithful customers. m=9; pw=7; w=4

41. a) Now that everyone here is QUIET, Grandpa can take a nap. m=pw=6; w=5

b) Now that you're awake, please be QUIET enough for Grandpa's nap. m=10; pw=6; w=4

c) Everyone here has to be QUIET, now that Dad is napping. m=pw=6; w=5

d) You're all awake now, so be QUIET enough for Grandpa's nap. m=10; pw=6; w=4

42. a) Once people keep their cars off the STREETS, the roads can be cleaned more often. m=pw=8; w=7

b) Once we keep cars off the roads, the STREETS can be cleaned up much more often. m=10; pw=8; w=7

c) People will keep their cars off the STREETS, once the roads are cleaned frequently. m=pw=8; w=6
d) We'll keep cars off the roads, once the STREETS are cleaned up more regularly.  m=11; pw=8; w=5

43. a) Although some patients take all kinds of DRUGS, labels can confuse them.  m=pw=6; w=4

b) Though some patients take all kinds of pills, DRUGS sometimes can confuse them.  m=7; pw=6; w=4

c) Some mental patients take all kinds of DRUGS, though labels confuse them.  m=pw=6; w=4

d) Some patients take all kinds of pills, though DRUGS often can confuse them.  m=8; pw=6; w=4

44. a) If the state will only build fast TRAINS, there will be an end to traffic jams.  m=pw=9; w=8

b) If the state builds more railroads, fast TRAINS will bring an end to big traffic jams.  m=11; pw=9; w=8

c) The state government should build fast TRAINS, so there will be an end to traffic.  m=pw=9; w=8

d) The state should build railroads, so fast TRAINS will bring an end to big traffic jams.  m=12; pw=9; w=8

45. a) As the music began for the CHOIR, the singers stood up.  m=pw=5; w=4

b) As the flute music began, the CHOIR stood up in its place.  m=7; w=5; pw=5

c) The flute music began for the CHOIR, as the singers rose.  m=pw=5; w=4

d) The flute music began, as the CHOIR stood up in its place.  m=8; pw=5; w=5

46. a) When the sheriff rode out of TOWN, the people needed protection.  m=8=pw; w=4

b) When the sheriff rode off, the TOWN needed some kind of protection.  m=10; pw=8; w=5
c) The mean sheriff rode out of TOWN, when people needed protection. $m=pw=8; w=4$

d) The sheriff rode off, when the TOWN needed some kind of protection. $m=11; pw=8; w=5$

47. a) When the weatherman predicted a COLD spell, rain turned into sleet. $m=5; pw=6; w=5$

b) When the weatherman forecast hail, a COLD spell turned the rain to sleet. $m=8; pw=6; w=5$

c) The weatherman had predicted a COLD spell, when rain turned to sleet. $m=5; pw=6; w=5$

d) The weatherman forecast hail, when a COLD spell turned the rain to sleet. $m=9; pw=6; w=5$
APPENDIX B

DESCRIPTION OF NATURALNESS TEST

Subjects assigned ratings to each sentence, as described below. Their scores were averaged to obtain an overall mean for each version; i.e., for a, b, c, and d. By hypothesis, the overall means should be equal.

B-1. Materials

The stimulus material consisted of forty-seven sentence sets, constructed with four versions each, as above (in Appendix A). Thirteen filler sentences were also used (see Appendix B-2). All sentences were read by an adult male speaker at a normal rate and with normal (conversational) intonation. The intonational effects of clause boundaries were minimized.

The complete set of stimulus material was first recorded in a semi-anechoic chamber on a Revox recorder. Later the sentences were randomized and cross-recorded onto four daughter tapes. Each such tape had one version of every sentence.

B-2. Subjects

Thirty-two M.I.T. undergraduates were paid to participate. All were native English speakers with normal hearing.
B-3. Procedure

The thirty-two subjects were divided into four groups, corresponding to the four stimulus tapes. Each test session consisted of four students, who sat in small booths equipped with headphones. The four subjects were separated from the experimenter by wood panelling. Each S was given an instruction sheet (see Appendix B-7) and an answer sheet, and told to listen to each sentence and rate it for naturalness (as defined in the instruction sheet). The rating system was as follows:

+2 = perfectly natural and acceptable
+1 = quite natural and acceptable
0 = just acceptable
-1 = quite unnatural
-2 = very unnatural

Sentences were dichotically presented at a rapid rate, in order to insure that Ss would be pressed for time and would have to write down their first reaction to each sentence. Each S heard one version of each test sentence plus the thirteen fillers.

B-4. Data and Results

Rating scores were averaged for each test group. A mean, based on eight observations, was obtained for each version of each sentence set. Standard deviation and range were also calculated (n=8). The means were
then averaged for each particular sentence, as well as the standard deviation (n=4). The effect of these calculations was to give an overall mean for every sentence (see Appendix B-8). In addition, an OVERALL mean was determined for each version across all Ss and all sentences. These means appear in the table below:

TABLE A-1
MEANS OF NATURALNESS RATINGS

<table>
<thead>
<tr>
<th>Sentence Version</th>
<th>Overall Means (on a 5-point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-2, -1, 0, +1, +2</td>
</tr>
<tr>
<td>a</td>
<td>.79</td>
</tr>
<tr>
<td>b</td>
<td>.69</td>
</tr>
<tr>
<td>c</td>
<td>.49</td>
</tr>
<tr>
<td>d</td>
<td>.59</td>
</tr>
</tbody>
</table>

The overall means in the second column are not equal, and thus fail to support the original hypothesis.

B-5. Discussion

The unequal results do not necessarily mean that one version is really different from the others for every sentence. One or more individual sentence sets might be responsible for the inequality. Upon inspection, the data did produce some exceptions. Sentences 19, 22,
31, 34, 38, 42 and 43 all had negative means on at least two versions. Sentences 12, 16, 18 and 24 all had large standard deviations (¢ 2.55) and ranges (R≥1.13). When these sentences were omitted from the scores, the means became more nearly equal: viz.,

a) .79; b) .83; c) .74; d) .72

Omitting the exception sentences mentioned above left a stimulus list of thirty-six sentences, all of which had positive ratings, with low standard deviations and ranges across versions. (For more details, see Appendix B-9).
APPENDIX B-6

FILLER MATERIAL FOR NATURALNESS TEST*

1. Under some circumstances, the courts are correct to resist forcibly.
2. Marriage counselors believe the wives are wise to control in the home.
3. When it comes to favors, strangers are hesitant to offend by asking openly.
4. In grade school, the girls are hard to date regularly.
5. In the summertime, relatives are silly to visit on weekends.
6. During most of the year, trees are tough to grow in Canada.
7. According to managers, boxers are impossible to train too much.
8. Even at a party, models are dangerous to undress in public.
9. According to single women, bachelors are delightful to entertain at home.
10. In Las Vegas, the gamblers are impossible to cheat at cards.
11. Most dogs know snakes are dangerous to bite when stretched out.
12. During a battle soldiers are hesitant to command

*Courtesy of E.T.C. Walker
without enough rank.

13. At Christmas, the children are simple to please all the time.
APPENDIX B-7

INSTRUCTIONS FOR NATURALNESS TEST

Naturalness

We are interested in finding out how natural certain sentences sound. You will have to rate some sentences according to how natural each one seems, as opposed to its being unnatural or strange.

Two examples of sentences that sound perfectly natural and acceptable are: "Mary wept when her dog died," and "We wanted to go to the theatre." However, some sentences are not so natural and fluent. For example, here is a sentence that is constructed in a rather clumsy and awkward style: "It was John that was thought of as by everyone a fool." Sentences may also seem unnatural or bizarre, if you need a lot of imagination to think of anybody ever using them. It would be hard to imagine circumstances in which someone would say: "Covered with fifteen mosquito bites each man leapt over the fence."

We want you to use the concept unnatural to cover sentences which are either awkward stylistically or describe bizarre events or both. You are asked to rate the attached (pairs of) sentences on a five-point scale, as follows:
+2  Perfectly natural and acceptable
+1  Quite Natural and acceptable
 0   Just acceptable
-1  Quite unnatural (clumsy or bizarre)
-2  Very unnatural (clumsy or bizarre)

Don't worry if you don't use each label the same amount of the time. Work quickly. Do not spend much time on any one item, as we want your initial reaction to each sentence. Put your ratings for the items in the space at the right of each item.
APPENDIX B-8

TABLE A-2

NUMERICAL RESULTS OF NATURALNESS TEST
(Scores on a 5-Point Scale,
-2, -1, 0, +1, +2)

<table>
<thead>
<tr>
<th>Sentence Number</th>
<th>Mean Rating (across all Ss and all versions) (a, b, c, d)</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.40</td>
<td>.28</td>
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<tr>
<td>2</td>
<td>1.65</td>
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<td>1.07</td>
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APPENDIX B-9

TABLE A-3

EQUALIZING THE RATINGS
(Sentences with $\phi > .55$
Range $> 1.13$
and/or Negative Means)

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<th>Sentence Number</th>
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<th>c</th>
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New means when these sentences are omitted:

\[
\begin{align*}
\text{a} &= .79 \\
\text{b} &= .83 \\
\text{c} &= .74 \\
\text{d} &= .72 \\
\text{Range} &= .11
\end{align*}
\]

(Compare these values with the means obtained when the above sentences are counted:)

a = .79
b = .69
c = .49
d = .59
APPENDIX B-10

SENTENCES REJECTED BY THE NATURALNESS TEST

12. a) Since Bob only skimmed his notes in ART history, the test was difficult.  m=6; pw=8; w=5

    b) Since Bob only skimmed through his notes, ART history was very difficult.  m=9; pw=8; w=4

    c) Bob read his notes for the quiz in ART history, since tests were always hard.  m=6; pw=8; w=6

    d) Bob read over all his notes, since ART history was very difficult.  m=10; pw=8; w=4
       ( where history is read with two syllables)

16. a) When the state housing board pushed through the NEW bill, the people got upset.  m=6; pw=7; w=5

    b) When the state passed a housing plan, the NEW bill got the people upset.  m=9; pw=7; w=5

    c) The state housing council pushed through the NEW bill, when the people were upset.  m=6; pw=7; w=6

    d) The state passed a housing plan, when the NEW bill got the people upset.  m=10; pw=7; w=5

18. a) Since you really enjoy a strong DRINK, you should have scotch instead of wine.  m=pw=8; w=7

    b) Since you like liquor, have a strong DRINK with good scotch instead of cheap wine.  m=12; pw=8; w=7

    c) You must really enjoy a strong DRINK, since you have scotch instead of wine.  m=8=pw; w=7

    d) You must enjoy liquor, since you DRINK good scotch instead of cheap red wine.  m=11; pw=8; w=7

19. a) After the cardshark walked out of the HOTEL, the gambling room closed.  m=pw=5; w=4

    b) After the cardshark walked outside, the HOTEL closed the gambling room.  m=8; pw=5; w=4
c) The sly cardshark walked out of the HOTEL, after gambling closed. \( m=pw=5; w=3 \)

d) The cardshark walked outside, after the HOTEL closed the gambling room. \( m=10; pw=5; w=4 \)

22. a) Though the peasants built dikes before the FLOODS, water still ruined the village. \( m=pw=8; w=5 \)

b) Though the peasants built dikes before spring, FLOODS still ruined most of the village. \( m=9; pw=8; w=6 \)

c) The peasants had built dikes before the FLOODS, though water ruined the village. \( m=8=pw; w=5 \)

d) The peasants built dikes before spring, though FLOODS still ruined most of the village. \( m=10; pw=8; w=6 \)

24. a) If good wine is left exposed to the AIR, the taste will go flat. \( m=pw=w=5 \)

b) If wine is exposed very long, the AIR makes the taste go flat. \( m=7; pw=w=5 \)

c) That wine must have been exposed to the AIR, if the taste went flat. \( m=pw=5=w \)

d) That wine must have been exposed, if the AIR made the taste go flat. \( m=8; pw=5=w \)

31. a) Even though farmers grow many kinds of FOOD, grain is still scarce. \( m=pw=w=4 \)

b) Even though farmers grow many products, FOOD is still quite scarce. \( m=5; pw=w=4 \)

c) The farmers grow many different kinds of FOOD, though grain is scarce. \( m=pw=w=4 \)

d) The farmers grow many kinds of grain, though FOOD is still quite scarce. \( m=6; pw=w=4 \)

34. a) After the French class ended on TIME, the boys left for the swimming meet. \( m=pw=8; w=7 \)
b) After French class ended, it was TIME for the boy's yearly swimming meet.  m=11; pw=8; w=6

c) The advanced French class ended on TIME, since the boys had a swimming meet.  m=pw=8; w=7

d) French class ended soon, since it was TIME for the boy's yearly swimming meet.  m=12; w=6; pw=8

38. a) Before lightning wrecked the trees in our BACKYARD, the garden had always looked nice.  m=pw=8; w=6

b) Before lightning wrecked all our trees, our BACKYARD had always looked especially nice.  m=11; pw=8; w=5

c) Lightning wrecked all of the trees in our BACKYARD, though the garden looked nice before.  m=8; pw=8; w=6

d) Lightning wrecked all of our trees, though our BACKYARD had always looked lovely before.  m=12; pw=8; w=5

42. a) Once people keep their cars off the STREETS, the roads can be cleaned more often.  m=pw=8; w=7

b) Once we keep cars off the roads, the STREETS can be cleaned up much more often.  m=10; pw=8; w=7

c) People will keep their cars off the STREETS, once the roads are cleaned frequently.  m=pw=8; w=6

d) We'll keep cars off the roads, once the STREETS are cleaned up more regularly.  m=11; pw=8; w=5

43. a) Although some patients take all kinds of DRUGS, labels can confuse them.  m=pw=6; w=5

b) Though some patients take all kinds of pills, DRUGS sometimes can confuse them.  m=7; pw=6; w=4

c) Some mental patients take all kinds of DRUGS, though labels confuse them.  m=pw=6; w=4

d) Some patients take all kinds of pills, though DRUGS often can confuse them.  m=8; pw=6; w=4
APPENDIX B-11

TEST SENTENCES SELECTED BY THE NATURALNESS TEST

p.w. = number of syllables from end of the target word to sentence end.

m. = number of syllables from clause boundary to end of sentence.

w. = number of words from end of target word to end of sentence.

1. a) Although there are lots of brands of diet COLA, Tab sells better than others. m=7=pw; w=5

b) Although there are lots of soft drinks, diet COLA sells better than the others. m=11; pw=7; w=5

c) Today there are lots of brands of diet COLA, although Tab sells more than most. m=pw=7; w=6

d) There are lots of soft drinks, although diet COLA sells better than the others. m=13; pw=7; w=5

2. a) (Note "w" variation)?? While the crowd waited for the SPEAKER, someone tried the microphone. m=pw=7; w=4

b) While the large crowd waited, the SPEAKER adjusted the microphone. m=10; pw=7; w=3

c) The large crowd waited for the SPEAKER, while someone tried out the mic. m=pw=7; w=6

d) The large crowd waited, while the SPEAKER adjusted the microphone. m=11; pw=7; w=3

3. a) Because you put these new drapes in SUNLIGHT, many bright colors will fade. m=7=pw; w=5

b) Because you put up these new drapes, SUNLIGHT will fade many bright colors. m=9; pw=7; w=5

c) Put up these drapes away from SUNLIGHT, because bright colors will fade. m=pw=7; w=5
d) Put these drapes over there, because SUNLIGHT will fade many bright colors. m=11; pw=7; w=6

4. a) When the bombing was stopped by the AMERICANS, the blasts had destroyed the firebase. m=8=pw; w=6

b) When all the bombing was stopped, the AMERICANS had destroyed most of the firebase. m=12; pw=8; w=6

c) All the bombing was stopped by the AMERICANS, when the blasts destroyed the firebase.

d) All the bombing was stopped, when the AMERICANS had destroyed most of the firebase. m=14; pw=8; w=6

5. a) If careful shoppers watch for SALES, some nice items can be found. m=7=pw; w=6

b) If careful shoppers look hard, SALES on nice items can be found. m=8; pw=7; w=6

c) Careful shoppers should watch for SALES, since nice items can be found. m=7=pw; w=6

d) Careful shoppers look hard, since SALES on nice items can be found. m=9; pw=7; w=6

6. a) When the school invited the POLICE, the students asked about drugs. m=7=pw; w=5

b) While the teachers listened, the POLICE told the students about drugs. m=9; pw=7; w=5

c) The high school invited the POLICE, when the students studied drugs. m=7=pw; w=5

d) The teachers listened, while the POLICE told the students about drugs. m=10; pw=7; w=5

7. a) Because shipping rates rose for COFFEE, retail prices went up. m=6; pw=6; w=4

b) Because shipping rates increased, COFFEE went up sharply in price. m=8; pw=6; w=5

c) Shipping rates have increased for COFFEE, because wages went up. m=6; pw=6; w=4
d) Shipping rates rose, because COFFEE needs special packing crates. \( m=9; \ pw=6; \ w=4 \)

8. a) When the teacher came into the CLASS, the room was quite noisy. \( m=pw=6; \ w=5 \)

b) When the school teacher came in, the CLASS was making lots of noise. \( m=8; \ pw=6; \ w=5 \)

c) The school teacher came into the CLASS, when the room was noisy. \( m=pw=6; \ w=5 \)

d) The school teacher came in, when the CLASS was making lots of noise. \( m=9; \ pw=6; \ w=5 \)

9. a) When the librarian was dusting the BOOKS, all the shelves fell over. \( m=pw=6; \ w=5 \)

b) When the librarian was dusting, the BOOKS on the shelves fell over. \( m=8; \ pw=6; \ w=5 \)

c) The art librarian was dusting the BOOKS, when the shelves fell over. \( m=pw=6; \ w=5 \)

d) The librarian was dusting, when the BOOKS on the shelves fell over. \( m=9; \ pw=6; \ w=5 \)

10.a) If you usually like a spy NOVEL, this book will intrigue you. \( m=pw=6; \ w=5 \)

b) If you like a good plot, this spy NOVEL will surely intrigue you. \( m=10; \ pw=6; \ w=4 \)

c) You will probably like a spy NOVEL, if good plots intrigue you. \( M=6=pw; \ w=5 \)

d) You should like this book, if a spy NOVEL usually intrigues you. \( m=11; \ pw=6; \ w=3 \)

11.a) While the camera crew waited for the ACTRESS, she checked on the script. \( m=pw=5; \ w=5 \)

b) While the whole camera crew waited, the ACTRESS checked over the script. \( m=8; \ pw=5; \ w=4 \)

c) The whole camera crew waited for the ACTRESS, while she checked the script. \( m=5=pw; \ w=5 \)

d) The whole camera crew waited, while the ACTRESS checked over the script. \( m=9; \ pw=5; \ w=4 \)
12. a) Now that the farmer gives plums to the CHILDREN, everyone will act more friendly.  m=pw=8; w=5
   b) Now that the farmer gives out plums, the CHILDREN will act a good deal more friendly.  m=11; pw=8; w=7
   c) The farmer gives away plums to the CHILDREN, so that everyone will be friends.  m=pw=8; w=6
   d) The farmer gives out plums, so that the CHILDREN will act a good deal more friendly.  m=13; pw=8; w=7

13. a) As Sue was just sitting down for the CHURCH service, the choir began the third psalm.  m=7; (where choir = one syllable) pw=9; w=7
   b) As Susan was just sitting down, the CHURCH service began with the thirteenth psalm.  m=11; pw=9; w=6
   c) Susan was just sitting down for the CHURCH service, as the choir sang the third psalm.  m=7; pw=9; w=8
   d) Susan was just sitting down, as the CHURCH service began with the thirteenth psalm.  m=12; pw=9; w=6

14. a) Though our team unfortunately lost the GAME, the match was quite exciting.  m=pw=7; w=5
   b) Though our team unfortunately lost, the GAME had been very exciting.  m=9; pw=7; w=4
   c) Unfortunately, our ball team lost the GAME, though the match was exciting.  m=pw=7; w=5
   d) Unfortunately, our team lost, though the GAME had been very exciting.  m=10; pw=7; w=4

15. a) Since you make long distance calls at the NIGHT rates, you can save money.  m=5; pw=6; w=5
   b) Since you make long distance phone calls, the NIGHT rates will save you money.  m=8; pw=6; w=5
   c) Make your long distance phone calls at the NIGHT rates, since you save money.  m=5; pw=6; w=5
d) Make your long distance calls at ten, since NIGHT rates will save you money.  m=8; pw=6; w=5

16. a) While Mom relaxed in the living ROOM, the maid cleaned up the house.  m=pw=6; w=6
   b) While Mom was resting, the living ROOM was cleaned up by the maid.  m=10; w=6; pw=6
   c) Mom was resting in the living ROOM, while the maid cleaned the house.  m=pw=w=6
   d) Mom was resting, while the living ROOM was cleaned up by the maid.  m=12; pw=6=w

17. a) Though the rough seas were bothering the CREW, the ship sailed through the bad storm.  m=pw=7; w=7
   b) Though the rough seas were bothersome, the CREW sailed the ship through the bad storm.  m=9; pw=7; w=7
   c) The rough seas were bothersome to the CREW, though the ship sailed through the storm.  m=pw=7=w
   d) The rough seas were bothersome, though the CREW sailed the ship through the bad storm.  m=10; pw=7; w=7

18. a) After you read the fine print on the LEASE, check the tax clause carefully.  m=pw=7; w=5
   b) After you have read the fine print, the LEASE should be checked for tax clauses.  m=9; pw=7; w=6
   c) You should read all the fine print on the LEASE, after you've checked the tax clause.  m=pw=7; w=6
   d) You should read the fine print, after the LEASE has been checked for tax clauses.  m=11; pw=7; w=6

19. a) Because the artist drew sketches on the WALLS, the room was very attractive.  m=8=pw; w=5
   b) Because the artist hung up sketches, the WALLS were unusually attractive.  m=10; pw=8; w=3
   c) The artist drew sketches on all of the WALLS, so the room would be attractive.  m=pw=8; w=6
d) The artist hung up his sketches, so the WALLS would appear much more attractive. m=11; pw=8; w=5

20. a) After several plumbers worked on the FAUCET, water still dripped for a whole week. m=pw=8; w=7

b) After the plumber fixed the leak, the FAUCET still dripped for an entire week. m=11; pw=8; w=6

c) Several plumbers finally worked on the FAUCET, after water dripped for a week. m=pw=8; w=6

d) The plumber fixed the leak, after the FAUCET had dripped for an entire week. m=13; pw=8; w=6

21. a) If you have saved some extra MONEY, buy mother a nice Easter gift. m=pw=8; w=6

b) If you've saved up, the extra MONEY can go for mother's Easter gift. m=13; pw=8; w=6

c) You should have saved some extra MONEY, so we can buy mother a gift. m=pw=8; w=7

d) Please save up, so the extra MONEY can go for mother's Easter gift. m=14; pw=8; w=6

22. a) After the storm moves away from the SOUTH, we might get pleasant weather. m=pw=7; w=5

b) After the storm clouds move away, the SOUTH might get some pleasant weather. m=9; pw=7; w=5

c) These storm clouds must move away from the SOUTH, before we get good weather. m=pw=7; w=5

d) These clouds must move away, before the SOUTH can get some pleasant weather. m=11; pw=7; w=5

23. a) When Ann was planting shrubs in the GARDEN, the ground was drenched by showers. m=pw=7; w=6

b) When Ann was planting the shrubs, the GARDEN was drenched by sudden showers. m=10; pw=7; w=5

c) Ann was planting the shrubs in the GARDEN, when the ground was drenched by rain. m=7=pw=w

d) Ann was planting the shrubs, when the GARDEN was drenched by sudden showers. m=11; pw=7; w=5
24. a) When John continually plays the DRUMS, his neighbors get angry.  m=pw=6; w=4

b) When John practices all day, the DRUMS make his neighbors angry.  m=8; pw=6; w=4

c) John continually plays on the DRUMS, though his neighbors get mad.  m=6=pw; w=5

d) John practices all day, though the DRUMS make his neighbors angry.  m=8; pw=6; w=4

25. a) When cooks use hot spices in FOOD, meals taste much more interesting.  m=pw=7; w=5

b) When good cooks use hot spices, FOOD tastes a lot more interesting.  m=8; pw=7; w=4

c) Good cooks use hot spices in FOOD, so meals will taste interesting.  m=pw=7; w=5

d) Good cooks use hot spices; so FOOD will taste much more interesting.  m=9; pw=7; w=5

26. a) When your aunt arrived at the STATION, the platform was deserted.  m=7=pw; w=4

b) When your great aunt arrived, the STATION was completely deserted.  m=10; pw=7; w=3

c) Your great aunt arrived at the STATION, when the place was deserted.  m=pw=7; w=5

d) Your great aunt arrived, when the STATION had been completely deserted.  m=11; pw=7; w=4

27. a) After the students insulted the JUDGE, they were fined for contempt of court.  m=pw=8; w=7

b) After students yelled out insults, the JUDGE fined them all for contempt of court.  m=10; pw=8; w=7

c) Militant students insulted the JUDGE, before they were fined for contempt.  m=pw=8; w=6

d) Students yelled out insults, before the JUDGE fined them all for contempt of court.  m=12; pw=8; w=7
28. a) While the boys worked in the HOT sun, the air felt quite sticky.  \( m=6; \ pw=7; \ w=6 \)

b) While the boys worked hard, the HOT sun made the air feel sticky.  \( m=9; \ pw=7; \ w=6 \)

c) The boys worked hard in the HOT sun, while the air was sticky.  \( m=6; \ pw=7; \ w=6 \)

d) The boys worked hard, while the HOT sun made the air feel sticky.  \( m=10; \ pw=7; \ w=6 \)

29. a) Since my Dad always enjoys his SHOWERS, the bathroom often gets flooded.  \( m=8; \ pw=8; \ w=5 \)

b) Since Dad likes lots of water, his SHOWERS often get the bathroom flooded.  \( m=11; \ pw=8; \ w=5 \)

c) My father always enjoys his SHOWERS, though the whole bathroom gets flooded.  \( m=\ pw=8; \ w=6 \)

d) Dad likes lots of water, though his SHOWERS often get the bathroom flooded.  \( m=12; \ pw=8; \ w=5 \)

30. a) Even though this T.V. has OLD parts, the tubes can be replaced.  \( m=6; \ pw=6; \ w=6 \)

b) Though this T.V. has its faults, OLD parts can be replaced cheaply.  \( m=8; \ pw=7; \ w=5 \)

c) This television set has OLD parts, though tubes can be replaced.  \( m=6; \ pw=7; \ w=6 \)

d) This T.V. has its faults, though OLD parts can be replaced cheaply.  \( m=9; \ pw=7; \ w=5 \)

31. a) Though prices are high in SMALL stores, customers are faithful.  \( m=6; \ pw=7; \ w=4 \)

b) Though prices are high here, SMALL stores have faithful customers.  \( m=8; \ pw=7; \ w=4 \)

c) All prices are high in SMALL stores, though patrons are faithful.  \( m=6; \ pw=7; \ w=5 \)

d) Prices are high here, though SMALL stores have faithful customers.  \( m=9; \ pw=7; \ w=4 \)

32. a) Now that everyone here is QUIET, Grandpa can take a nap.  \( m=\ pw=6; \ w=5 \)
b) Now that you're awake, please be QUIET enough for Grandpa's nap.  m=10; pw=6; w=4

c) Everyone here has to be QUIET, now that Dad is napping.  m=pw=6; w=5

d) You're all awake now, so be QUIET enough for Grandpa's nap.  m=10; pw=6; w=4

33. a) If the state will only build fast TRAINS, there will be an end to traffic jams.  m=pw=9; w=8

b) If the state builds more railroads, fast TRAINS will bring an end to big traffic jams.  m=11; pw=9; w=8

c) The state government should build fast TRAINS, so there will be an end to traffic.  m=pw=9; w=8

d) The state should build railroads, so fast TRAINS will bring an end to big traffic jams.  m=12; pw=9; w=8

34. a) As the music began for the CHOIR, the singers stood up.  m=pw=5; w=4

b) As the flute music began, the CHOIR stood up in its place.  m=7; w=5; pw=5

c) The flute music began for the CHOIR, as the singers rose.  m=pw=5; w=4

d) The flute music began, as the CHOIR stood up in its place.  m=8; pw=5; w

35. a) When the sheriff rode out of TOWN, the people needed protection.  m=8=pw; w=4

b) When the sheriff rode off, the TOWN needed some kind of protection.  m=10; pw=8; w=5

c) The mean sheriff rode out of TOWN, when people needed protection.  m=pw=8; w=4

d) The sheriff rode off, when the TOWN needed some kind of protection.  m=11; pw=8; w=5
36. a) When the weatherman predicted a COLD spell, rain turned into sleet. \( m=5; \ pw=6; \ w=5 \)

b) When the weatherman forecast hail, a COLD spell turned the rain to sleet. \( m=8; \ pw=6; \ w=5 \)

c) The weatherman had predicted a COLD spell, when rain turned to sleet. \( m=5; \ pw=6; \ w=5 \)

d) The weatherman forecast hail, when a COLD spell turned the rain to sleet. \( m=9; \ pw=6=w \)
APPENDIX C

FILLER: IN-PROBES (22)
Sentences Ranging from Ten to Twenty-four Syllables

<table>
<thead>
<tr>
<th>2-clause sentences (12)</th>
<th>1-clause sentences (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 main clause</td>
<td>4 main clause</td>
</tr>
<tr>
<td>1st=2</td>
<td>1st=2</td>
</tr>
<tr>
<td>2nd=2</td>
<td>2nd=2</td>
</tr>
<tr>
<td>4 coord.</td>
<td>4 coord.</td>
</tr>
</tbody>
</table>

probes:

<table>
<thead>
<tr>
<th>1st=2</th>
<th>1st=2</th>
<th>1st=2</th>
<th>early=4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd=2</td>
<td>2nd=2</td>
<td>2nd=2</td>
<td>middle=3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>late=3</td>
</tr>
</tbody>
</table>

Probe position in sentence:

- early (4) N, Adj.
- middle (4) Verb.
- last (4) N, Adj.

N=5
Adj.=2
V=5

All together, there are about an equal number of N, Adj., V. probes:

- 6 Adj.
- 9 Verbs
- 7 Nouns
- 22 sentences

2-Clause Sentences

Main clause first—probe from 1st:
1. The content of the student's report was good, though the delivery was poor. CONTENT
2. The family upstairs complained to the police when the party grew noisy. COMPLAINED

Probe from 2nd clause:
3. We can visit those prisoners while they're incarcerated in the state prison. STATE
4. The chipmunks are scampering around, now that spring is here. SCAMPERING
Sub. first--probe from 2nd clause:
5. When you're in Florence, be sure to see the famous statues. FAMOUS
6. As was previously reported, the charges for an off-campus extension will rise sharply. REPORTED

Probe from 1st clause:
7. When the weather is good, thousands of city-dwellers escape to the countryside. WEATHER
8. After the ice sheet melted, deposits of rock were left behind. ICE

Coordinates--probe from 1st:
9. His mother was a peasant woman, but his father was a renowned archaeologist. MOTHER
10. You can keep the old, scraggly rug or you can throw it away. OLD

Coordinates--probe from 2nd:
11. He was a man of great energy yet he remained a clerk. REMAINED
12. The movers will come tomorrow, and then the storage room will be cleaned up. CLEANED

1-Clause Sentences
1. Three-quarters of the institution is still in existence. THREE
2. Five minutes sometimes makes the difference between life and death. MAKES
3. Last month my family earned a total of two hundred dollars. DOLLARS
4. Differences between the two leaders have been exaggerated by the press. DIFFERENCES
5. The mayor last year received double his salary in speaking fees. RECEIVED
6. Boston's black leaders reacted violently to the new busing proposal. NEW
7. Most early studies of integration fail to be supported by the data. EARLY
8. Lint-gathering in Greece is done almost exclusively by the women. DONE

9. The first of the four bulls had already been killed in the arena. FIRST

10. The foghorn in the outer harbor was going constantly. GOING

FILLERS: OUT-PROBES

2-Clause Sentences, Main Clause First

1. The soldiers were very tired because the battle had lasted ten hours. BIRD

2. George paused for a few moments in the middle of Mass. Ave. before he crossed over to Main St. BLUE

3. Customers complained to the manager when lettuce went up to forty cents a head. HEAVY

4. The opera was a success, even though the lead tenor sang off-key. SALTY

5. The maid left after the house looked sufficiently clean. BACON

6. The host started the barbecue after all the guests had arrived. DISCUSS

7. The carpenter measured the room before he bought the materials for the sofa. SEIZE

8. The court must defer further action until the Bar Association studies a few testimonies. TIGER

2-Clause Sentences, Subordinate Clause First

9. When a nineteen-year-old youth was shot, women marchers protested the killing. YIELD

10. Since the crowd was disorderly and noisy in the station, they were arrested. TENDER
11. Because Leroy had always come home early, his parents trusted him. PORK

12. Since the Crow are a friendly, peaceful people, they live quietly in their native villages. PAPER

13. Because the star player had a broken leg, he was excused from the game. TENT

14. Now that the packages have arrived, the children can open their presents. SOLID

15. While Bob was staying at our place, he cooked dinner. DARK

16. Since the U. S. stepped up the bombing, North Viet Nam has shown strains in its home front morale. BUSY

2-Clause Sentences, Coordinate

17. The new bride is a good cook, and she's also quite a seamstress. DIRT

18. Either Jack failed completely, or I have been deceived. BUILD

19. Nine out of twelve jurors voted for conviction, but the judge still acquitted the defendant. SELL

20. An hour ago the man called from the garage, and he was rather angry. PILL

21. The mailman knocked quite loudly, but everyone was away from home. TIGHT

22. Frank has a beautiful tenor voice and he will do a good job on the aria. TELL

23. Please yell, or press the button by your beside. RIPE

24. The board gave its report, and several people immediately denounced the board's proposal. HAMMOCK
1-Clause Sentences

25. The first demand was an immediate end to the war. PALE

26. Six housing units are especially designed for handicapped persons. SILLY

27. Those tennis courts will be ready by next fall. DENY

28. First priority for residents in the new complex will go to senior citizens. SCOUR

29. Any coach fare ticket can save you money. STOVE

30. The last survivor had left an account of the ordeal. DONUT

31. The new treasurer of the club should be honest. LOW

32. The rather grimy individual in the back seat was drunk. DUSTY

33. Dining room tables of dark mahogany are now being sold at fantastic prices. LISTEN

34. The spokesman for the reporters requested an interview. COME

35. Nationwide tests show some improvement in mail service over the past fifteen months. KNOW

36. The rise of the clipper ship changed the character of New England life. EXPLAIN
APPENDIX D
TWENTY SENTENCES FOR PRETEST TRAINING

<table>
<thead>
<tr>
<th>In-probes (10)</th>
<th>Out-probes (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-clauses (6)</td>
<td>1-clause (4)</td>
</tr>
<tr>
<td>Main-1st (2)</td>
<td>Probe early (2)</td>
</tr>
<tr>
<td>Sub-1st (2)</td>
<td>Probe mid (1)</td>
</tr>
<tr>
<td>Coordinate (2)</td>
<td>Probe late (1)</td>
</tr>
</tbody>
</table>

Among the 2-clause sentences (IN-probes), one half have probes from 1st clause, one half from 2nd clause. For the IN-probes, there are 4 N probes, 3 Adj., 3 Verb

10

For the OUT-probes, there are 3 N, 3 Adj., 4 Verb

10

I. IN-probes

2-Clause Sentences

Main clause first:
1. Betty was in high school when she first learned the backstroke. BETTY
2. Ceylon became a republic when the new constitution was adopted. BECAME

Sub clause first:
3. Although the fire department took precautions, many people were injured in the blaze. BLAZE
4. If you live within a mile of your job, you should walk to work every day. LIVE
Coordinate:
5. G.E.'s the fourth largest industrial company, and it's the fifth largest defense contractor. FIFTH
6. The spaghetti itself is good but the sauce is rancid. SPAGHETTI

1-clause:
7. Thorndike is considered as a swing vote in the managerial issue. MANAGERIAL
8. They voted my brother the most popular man in the senior class. POPULAR
9. The Turkish bath is a dying institution. IS
10. Recent lay-offs have cut the minority work force in the plant almost in half. PLANT

II. OUT-probes

Main clause first:
1. John won first prize because his uncle was a judge. SEPARATE (verb)
2. The premier initiated a surprise meeting after the president arrived in Moscow. PINK

Sub. clause first:
3. If on-campus housing becomes available, first choice will go to married students. BOTTLE
4. After several votes were taken, the deadlock still remained in the council meeting. HEAR

Coordinate:
5. You must report this immediately, or you'll be in serious trouble with the police. GIDDY
6. George is a witty journalist but he's a rather poor poet. BLESS

1-clause:
7. The slaying brought the death toll up to two hundred. WAGON
8. Mounted policemen drove hundreds of protestors away from the Pentagon. PENCIL
9. The ads of both candidates plugged at themes on the elderly. MIGHTY
10. The design on the bedroom wallpaper was quite unpleasant. COMPRIZE
APPENDIX E
DESCRIPTION OF APPARATUS

The equipment consisted of an Ampex #PR 10 tape recorder, on which the stimulus tapes were played; a voice-operated relay, which shorted out when the recorded tone on the second channel occurred; a slide-timer activator, which picked up the signal from the voice key and simultaneously started the timer and slide projector; and a telegraph key, which, when pressed, stopped the timer and registered the subject's response as a red or green light on the slide-timer activator.

FIGURE A1. Diagram of apparatus for Exp I.
APPENDIX F

SUMMARY OF INSTRUCTIONS FOR PROBE TEST

Subjects were told to listen to each sentence well enough to be able to repeat it if asked. At the end of each sentence, they saw a word flash briefly on the screen in front of them. If they thought the word occurred in the preceding sentence, they were instructed to press the key toward the position marked IN; if not, they were to press it to the OUT position. Subjects were urged to strive for both speed and accuracy in their responses. Before the test actually began, Ss were encouraged to press the key a few times until they were comfortable.
## APPENDIX G

### TABLE A-4

RANK ORDER OF SELECTED SENTENCES, EXP. I

<table>
<thead>
<tr>
<th>Order</th>
<th>Test No.</th>
<th>RT (MSEC)</th>
<th>Naturalness Ratings</th>
<th>Target</th>
<th>Adverb</th>
<th>Phrase Type and Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>749</td>
<td>1.40</td>
<td>COLA</td>
<td>Although</td>
<td>NP (diet-) compound?</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>741</td>
<td>.47</td>
<td>CHOIR</td>
<td>As</td>
<td>Compound (living-)</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>712</td>
<td>1.00</td>
<td>ROOM</td>
<td>While</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>709</td>
<td>.75</td>
<td>SUNLIGHT</td>
<td>Because</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>694</td>
<td>.47</td>
<td>TOWN</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>685</td>
<td>.53</td>
<td>FAUCET</td>
<td>After</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>681</td>
<td>.50</td>
<td>SALES</td>
<td>If/since=(because)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>31</td>
<td>681</td>
<td>.48</td>
<td>SMALL</td>
<td>Though</td>
<td>AP (small stores)</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>675</td>
<td>.85</td>
<td>AMERICANS</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>13</td>
<td>675</td>
<td>.94</td>
<td>CHURCH</td>
<td>If</td>
<td>(-service) NP compound</td>
</tr>
<tr>
<td>11</td>
<td>26</td>
<td>670</td>
<td>.97</td>
<td>STATION</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>36</td>
<td>665</td>
<td>.04</td>
<td>COLD</td>
<td>When</td>
<td>(-spell) NP</td>
</tr>
<tr>
<td>13</td>
<td>8</td>
<td>662</td>
<td>.17</td>
<td>CLASS</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>23</td>
<td>658</td>
<td>.66</td>
<td>GARDEN</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>17</td>
<td>657</td>
<td>.60</td>
<td>CREW</td>
<td>Though</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>653</td>
<td>.72</td>
<td>QUIET</td>
<td>Now that</td>
<td>Pred. Adj.</td>
</tr>
<tr>
<td>17</td>
<td>25</td>
<td>651</td>
<td>.88</td>
<td>FOOD</td>
<td>When/so</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>15</td>
<td>651</td>
<td>.60</td>
<td>NIGHT</td>
<td>Since (because)</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>10</td>
<td>651</td>
<td>.19</td>
<td>NOVEL</td>
<td>If</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>21</td>
<td>617</td>
<td>.72</td>
<td>MONEY</td>
<td>If/so</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>2</td>
<td>647</td>
<td>.65</td>
<td>SPEAKER</td>
<td>While</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>6</td>
<td>646</td>
<td>.10</td>
<td>POLICE</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>Order</td>
<td>Test No.</td>
<td>RT (MSEC)</td>
<td>Naturalness Ratings</td>
<td>Target</td>
<td>Adverb</td>
<td>Phrase Type and Environment</td>
</tr>
<tr>
<td>-------</td>
<td>----------</td>
<td>-----------</td>
<td>---------------------</td>
<td>----------</td>
<td>----------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>23</td>
<td>12</td>
<td>645</td>
<td>.38</td>
<td>CHILDREN</td>
<td>Now that/so that</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>9</td>
<td>642</td>
<td>.97</td>
<td>BOOKS</td>
<td>When</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>29</td>
<td>638</td>
<td>.09</td>
<td>SHOWERS</td>
<td>(Since/though)</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>28</td>
<td>636</td>
<td>.06</td>
<td>HOT</td>
<td>While</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>27</td>
<td>531</td>
<td>1.07</td>
<td>JUDGE</td>
<td>After/before</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>11</td>
<td>650</td>
<td>.91</td>
<td>ACTRESS</td>
<td>While</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>22</td>
<td>630</td>
<td>.79</td>
<td>SOUTH</td>
<td>After/before</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>19</td>
<td>628</td>
<td>.53</td>
<td>WALLS</td>
<td>Because/so</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>33</td>
<td>619</td>
<td>.47</td>
<td>TRAINS</td>
<td>If/so</td>
<td>(fast-) AP</td>
</tr>
<tr>
<td>32</td>
<td>18</td>
<td>613</td>
<td>.79</td>
<td>LEASE</td>
<td>After</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>14</td>
<td>607</td>
<td>1.28</td>
<td>GAME</td>
<td>Though</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>30</td>
<td>605</td>
<td>.22</td>
<td>OLD</td>
<td>Though</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>7</td>
<td>603</td>
<td>1.04</td>
<td>COFFEE</td>
<td>Because</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>24</td>
<td>583</td>
<td>.91</td>
<td>DRUMS</td>
<td>When/though</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX H

EXPERIMENT I, GROUP AND SENTENCE ANALYSES

1. Between-group Analysis

Recall that subjects were divided into four groups, according to the particular stimulus tape that each group heard. The groups were run in order; i.e., group I consisted of the first 13 subjects who were scheduled for the experiment; group II consisted of the next 11 subjects, etc. In short, the only differences between the groups should be the order of subjects and the tape they heard. However, as the experiment progressed, it is possible that small changes were introduced in the test situation—either in the apparatus itself or in the rate of presentation. If these changes did occur, and if they were large enough to mask the desired effects, there should be significant differences between mean RT of each group. Therefore, overall means were computed per group, by averaging RT’s of all subjects in a group across all 36 sentences. Results of an ANOVA test appear below.

TABLE A-5

GROUP MEANS, EXP. I

<table>
<thead>
<tr>
<th>Groups</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean RT (msec)</td>
<td>659</td>
<td>673</td>
<td>649</td>
<td>641</td>
</tr>
</tbody>
</table>
Differences between groups were not significant ($F$=1.399; d.f. 3/44). In other words, there was no significant difference in the way each group responded to the whole set of sentences.

This result is favorable because it shows that between-group differences were not large enough to mask the structural effects which had been predicted. Thus, (a) on p. 39 is ruled out; there still might be (b) unexpected variation in the sentence sets, and/or (c) an interaction of groups by sentences.

2. Sentence Analysis

Two different methods were used to reveal possible differences between sentence sets. In the first, the mean RT scores of the four groups were averaged over all conditions to give an overall mean per sentence set. These numbers were compared, and an $F$-ratio was calculated. The sentence sets did appear to differ significantly ($F$=4.987; d.f. 35/1540; $p < .001$).

In the second method, the RT scores of all 48 subjects were averaged for each sentence set to give an overall mean per set. These numbers were then compared, and an $F$-ratio was calculated. Again, the sentence sets did appear to differ significantly ($F$=4.869; d.f. 35/1645; $p < .001$).

This result, which is obtained with two methods
of averaging the data, suggests that one or more of the stimulus sentences was peculiar. The effect could be due to the lexical items and semantic interpretations of different sentence sets. However, these differences were thought to be slight when compared to syntactic variation, and were expected to average out over the large number of sentence sets (36). Since they did not, it looks as though a materials effect was present, and it may have been large enough to mask the structural effects of dominance properties.

3. Groups by Sentence Analysis

Even though the sentence analysis reveals differences in the mean RT scores for each set, the source of these differences is still in question. It is not clear whether all subjects responded similarly to any given set, or whether there were idiosyncratic responses to certain sentences. In order to test for effects of the latter alternative, we compared the mean RT scores of each group for each sentence set, and calculated an F-Ratio. The interaction of groups by sentences was not significant \((F=1.218; \text{ d.f. } 105/1540)\); i.e., all groups responded similarly to any given set, even though the sentence analysis showed differences among the sets themselves. This result is evidence against idiosyn-
cratic subject responses to certain sentences. It is therefore a favorable result, since it shows that the mean RT score for each sentence set is not biased by the responses of any particular group. The possibility of a materials effect, as suggested from the sentence analysis, should thus be taken seriously (since the mean RT's represent non-biased estimates from all subject groups in the study).
APPENDIX I

EXPERIMENT I, POST-HOC EXAMINATION OF TEST MATERIAL

Sentence Evaluation

The 36 test sentences were placed in rank order on the basis of length of RT (see Appendix G, p.191). Both the naturalness ratings and category of probe word were compared to the mean RT for each sentence. Inspection revealed no noticeable correlation between naturalness x RT, or RT x probe category, or RT x semantic type of adverbial (temporal vs. causal). Because these post hoc comparisons failed to show consistent differences in the material, a more subjective test was used.

Three psychologists rated each sentence according to the following criteria:

1. Is the first clause in versions (a) and (b) clearly subordinate to the second clause, both in syntactic construction and semantic interpretation?

2. Is the subordinating marker the same in all four versions—and is the meaning of this adverbial constant throughout?

3. Is the lexical material nearly the same across construction types?

4. Are all four sentences in each set equally natural? (as defined in the instructions for the naturalness test)
and 5. Do they describe normal events or circumstances?

The judges worked independently in rating each sentence, and then they pooled their results. Out of the 36 test sentences, 16 were selected as the best, 11 as the worst, and 9 somewhere in between. Judges agreed unanimously on all but two sentences.

RT scores were tabulated for all subjects responding to each version of every sentence; these figures were then used as data for an ANOVA with sentences as the error term. Two analyses were done (with sentences as the repeated measure): one on the 16 best sentences\(^1\) (hence, the "good" ones), and one on the remaining 20\(^2\) (the "bad" ones). The results of these analyses are shown in Tables A-6 and A-7 on the following pages.

\(^1\)The following sentences were selected as the best: #2, 7, 8, 10, 11, 13, 16, 18, 19, 20, 22, 24-26, 32-33.

\(^2\)The remaining sentences included #1, 3, 4-6, 9, 12, 14, 15, 17, 21, 23, 27-29, 30, 31, 35-36.
TABLE A-6
ANOVA RESULTS FOR "GOOD" SENTENCES, EXP. I

<table>
<thead>
<tr>
<th>Clause order</th>
<th>S,M</th>
<th>M,S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe position:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>a)</td>
<td>b)</td>
</tr>
<tr>
<td></td>
<td>652</td>
<td>633</td>
</tr>
<tr>
<td>2nd</td>
<td>c)</td>
<td>d)</td>
</tr>
<tr>
<td></td>
<td>666</td>
<td>630</td>
</tr>
<tr>
<td>difference</td>
<td>14 msec.</td>
<td>8 msec.</td>
</tr>
<tr>
<td>d=19</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

Probe position: net effect

Probe 1st \[
\frac{a+c}{2} = 659 \text{ msec.}
\]

Probe 2nd \[
\frac{b+d}{2} = 632
\]

Net difference = 27 msec.

Again, probe position was highly significant (F=17.563; d.f. 1/15; p<.001). There was a trend for both dominance effects, but neither was significant. (For clause order, F=.456, d.f. 1/15; and for the interaction of probe position by clause order, F=.881; d.f. 1/15.)
<table>
<thead>
<tr>
<th>Clause order</th>
<th>S,M</th>
<th>M,S</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probe position:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>a) 680</td>
<td>c) 673</td>
<td>difference = 7 msec.</td>
</tr>
<tr>
<td>2nd</td>
<td>b) 645</td>
<td>d) 660</td>
<td>difference = 15 msec.</td>
</tr>
<tr>
<td>D = 35</td>
<td></td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

Probe position: net effect

1st clause: 677 msec.

2nd clause: 653" "

net difference 24 msec.

Probe position was significant (F=9.388, d.f. 1/19; p < .008), but clause order was not (F=.201, d.f. 1/19).
The interaction (clause order x probe position) also did not reach significance (F=1.229; d.f. 1/19).

Discussion of the Sentence Evaluation Tests

The results given above are evidence of consistent differences between the two groups of sentences which were determined by the judges' ratings. The following facts support this conclusion:

Differences in RT which are due to probe position are in the same direction, and of the same magnitude.
for both groups.

(Cf. probe--1st = 659 vs. probe--2nd = 632; difference = 27 for good sentences
probe--1st = 677 vs. probe--2nd = 653; difference = 24 for bad sentences)

But this is not the case for RT differences due to clause order.

(Cf. a difference of 14 msec. between the means, probe 1st and a difference of 3 msec. between the means, probe 2nd, for the good sentences)

<table>
<thead>
<tr>
<th>GOOD sentences:</th>
<th>S,M</th>
<th>M,S</th>
<th>d = 14 msec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>652</td>
<td>666</td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>633</td>
<td>630</td>
<td>d = 3 msec.</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

(with a difference of 7 msec. between the means, probe 1st, and a difference of 15 msec. between the means, probe 2nd, in the bad sentences)

<table>
<thead>
<tr>
<th>BAD sentences:</th>
<th>S,M</th>
<th>M,S</th>
<th>d = 7 msec.</th>
<th>d = 15 msec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>680</td>
<td>673</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd</td>
<td>645</td>
<td>660</td>
<td>d = 35</td>
<td>d = 13</td>
</tr>
</tbody>
</table>

Thus, there is a switch of RT differences in direction and magnitude between the good and bad sentences, and there is a similar reversal for differences due to clause order.

Cf. a difference of 36 between the means, order = main...sub.: 673-660

a difference of 19 between the means, order = Good Sentences

sub...main: 652-633
a difference of 13 between the means, order =
main...sub.: 673-660

a difference of 35 between the means, order =
sub...main: 680-645

for Bad Sentences

These reversals indicate that the two subjectively
determined groups were indeed treated differently by
subjects. Hence, there was a materials effect in the
experiment, and it may well have obscured the dominance
factors, especially if subjects used their impressions
of the bad sentences to form hypotheses about all the
test material. If they did, they might have come to
expect "unnatural" sentences (e.g., ones that describe
bizarre events) throughout the test session. Such
negative expectations might well have slowed down, or
even blocked, decisions that are normally made about
syntactic properties like dominance.
APPENDICES TO CHAPTER II, EXP. II
APPENDIX II-A

REVISED STIMULUS MATERIAL FOR EXP. II

1. a) Because some sugar is added to COLA, it has quite a sweet taste.

b) Because extra sugar is added, COLA has a very sweet taste.

c) Some extra sugar is added to COLA, because it tastes bitter.

d) Extra sugar is added, because COLA has quite a bitter taste.

2. a) While the crowd waited for the SPEAKER, someone tried the microphone.

b) While the large crowd waited, the SPEAKER adjusted the microphone.

c) The large crowd waited for the SPEAKER, while someone tried out the mic.

d) The large crowd waited, while the SPEAKER adjusted the microphone.

3. a) Since that roll of color film was exposed to the SUNLIGHT, each picture is probably ruined.

b) Since that color film roll was exposed outdoors, the SUNLIGHT has probably ruined every picture.

c) That roll of film was probably exposed to the SUNLIGHT, since each shot is ruined completely.

d) That film was probably exposed outdoors, since the SUNLIGHT has ruined each picture completely.

4. a) Before the Italians surrendered to the AMERICANS, Palermo had been seriously damaged.

b) Before the Italian troops surrendered, the AMERICANS had damaged Palermo quite seriously.

c) The Italian soldiers surrendered to the AMERICANS, before Palermo was damaged severely.
d) The Italian troops surrendered, before the AMERICANS had damaged Palermo very severely.

5. a) Since thrifty homemakers usually read the ads for SALES, they often find specials on household goods.

b) Since thrifty homemakers always read the ads, they find SALES on many different kinds of household goods.

c) Thrifty homemakers should always read every ad for SALES, since specials on household goods often appear.

d) Thrifty homemakers should always read every ad, since SALES on household goods appear very often.

6. a) Even though the dorms had been raided by the POLICE, some students used illegal drugs openly.

b) Even though the dorms were often raided, the POLICE always caught some students with illegal drugs.

c) The college dorms were seldom raided by the POLICE, even though some students used drugs openly.

d) The dorms were seldom raided, even though the POLICE had caught many students with illegal drugs.

7. a) Because some firms provide hot water for instant COFFEE, it's become popular with employees.

b) Because many firms provide hot water, instant COFFEE has become popular with employees.

c) Some business firms provide hot water for instant COFFEE, because it's popular with employees.

d) Many firms provide hot water, because instant COFFEE has become popular with employees.

8. a) When the principal visited the CLASS, the room was quite noisy.

b) When the principal visited, the CLASS was making lots of noise.
c) The school principal visited the CLASS, when the room was noisy.

d) The principal visited, when the CLASS was making lots of noise.

9. a) When the librarian was dusting the BOOKS, all the shelves suddenly fell over.

b) When the librarian was dusting, the BOOKS on the shelves suddenly fell over.

c) The new librarian was dusting the BOOKS, when the shelves suddenly fell over.

d) The librarian was dusting, when the BOOKS on the shelves suddenly fell over.

10. a) If you usually like a spy NOVEL, this book will intrigue you.

b) If you like a good plot, this spy NOVEL will surely intrigue you.

c) You will probably like this spy NOVEL, if good plots intrigue you.

d) You might like this book, if a spy NOVEL usually intrigues you.

11. a) While the camera crew waited for the ACTRESS, she checked on the script.

b) While the whole camera crew waited, the ACTRESS checked over the script.

c) The whole camera crew waited for the ACTRESS, while she checked the script.

d) The whole camera crew waited, while the ACTRESS checked over the script.

12. a) Because the friendly baker gives cookies to the CHILDREN, they visit his shop every day.

b) Because the friendly baker gives out cookies, the CHILDREN visit his shop regularly.
c) The friendly baker gives away cookies to the CHILDREN, because they visit him daily.

d) The friendly baker gives out cookies, because the CHILDREN visit his shop regularly.

13. a) As Patricia was just sitting down for the CHURCH service, the choir began the third psalm.

b) As Pat was just sitting down in the pew, the CHURCH service began with the thirteenth psalm.

c) Patricia was just getting seated for the CHURCH service, as the choir sang the third psalm.

d) Pat was just sitting down in the pew, as the CHURCH service began with the thirteenth psalm.

14. a) Although the Sox were losing early in the GAME, the score was tied up by the seventh inning.

b) Although the Red Sox were losing at first, the GAME was tied by the end of the seventh inning.

c) The Sox were far behind by the end of the GAME, although the score was tied in the third inning.

d) The Sox were behind by the fourth, although the GAME was tied up in the top of the third inning.

15. a) Because New England Telephone lowered most of its NIGHT rates, its charges fell in line with federal rules.

b) Because the phone company lowered its charges, its NIGHT rates fell in line with the federal limits.

c) The New England telephone company lowered its NIGHT rates, because its charges topped federal limits.

d) The phone company lowered its charges, because its NIGHT rates had exceeded the federal limits.

16. a) While Mom rested in the living ROOM, the house was cleaned up by the maid.
b) While Mom was resting, the living ROOM was thoroughly cleaned by the maid.

c) Mom was resting in the living ROOM, while the house was cleaned by the maid.

d) Mom was resting, while the living ROOM was thoroughly cleaned by the maid.

17. a) Although the sudden storm surprised most of the CREW, the captain had expected rough weather.

b) Although the rainstorm surprised the captain, the CREW had expected some very rough weather.

c) The sudden thunder storm surprised most of the CREW, although the captain had expected rain.

d) The rainstorm surprised the captain, although the CREW had expected some very rough weather.

18. a) After you read the fine print on the LEASE, check the tax clause carefully.

b) After you have read the fine print, the LEASE should be checked for tax clauses.

c) You should read all the fine print on the LEASE, after you've checked the tax clause.

d) You should read the fine print, after the LEASE has been checked for tax clauses.

19. a) Because the artist hung up prints on the WALLS, his studio looked less empty.

b) Because the artist hung up paintings, the WALLS of his studio looked less bare.

c) The artist hung up his paintings on the WALLS, because his studio looked bare.

d) The artist hung up his prints, because the WALLS of his studio looked empty.

20. a) After several plumbers worked on the FAUCET, water still dripped for a whole week.
b) After the plumber fixed the leak, the FAUCET still dripped for an entire week.

c) Several plumbers finally worked on the FAUCET, after water dripped for a week.

d) The plumber fixed the leak, after the FAUCET had dripped for an entire week.

21. a) Because George has saved most of his MONEY, he now has a feeling of security.

b) Because George saves his earnings, his MONEY gives him a strong feeling of security.

c) George saves up almost all of his MONEY, because he likes a sense of security.

d) George saves his earnings, because his MONEY gives him a strong feeling of security.

22. a) Before the rainy season hits the SOUTH, the farmers should harvest the tobacco.

b) Before the rainy season comes, the SOUTH should harvest most of the tobacco crop.

c) The rainy season sometimes hits the SOUTH, before farmers can cut the tobacco.

d) Rainy weather might hit, before the SOUTH can harvest most of the tobacco crop.

23. a) After Ann planted shrubs in the GARDEN, the ground was drenched by heavy rain.

b) After Ann planted the shrubs, the GARDEN was drenched by a heavy rain.

c) Ann planted the shrubs in the GARDEN, after the ground was drenched by rain.

d) Ann planted shrubs, after the GARDEN was drenched by a heavy rain.

24. a) Because jungle tribes can send messages by DRUMS, visual contact is often redundant.
b) Because some jungle tribes must send messages, DRUMS sometimes can replace visual contact.

c) Many jungle tribes must send messages by DRUMS, because visual contact is difficult.

d) Jungle tribes can still send messages, because DRUMS completely replace visual contact.

25. a) Because England sent Biafra rations of FOOD, many hungry children could be fed.

b) Because England sent rations to Biafra, FOOD could be given to hungry children.

c) England sent Biafra some large rations of FOOD, because many children were starving.

d) England sent rations to Biafra, because FOOD was needed for the hungry children.

26. a) When your aunt arrived at the STATION, the platform was deserted.

b) When your great aunt arrived, the STATION was completely deserted.

c) Your great aunt arrived at the STATION, when the place was deserted.

d) Your great aunt arrived, when the STATION was entirely deserted.

27. a) After the angry students had insulted the JUDGE, they were fined for contempt of court.

b) After the angry students shouted insults, the JUDGE fined them all for contempt of court.

c) The angry students shouted out insults at the JUDGE, after they were fined for contempt.

d) The angry students shouted insults, after the JUDGE fined them all for contempt of court.

28. a) Because Margie was very careless with HOT grease, the broiler caused a small kitchen fire.
b) Because Marge was careless with the broiler, HOT grease caused a little fire in the kitchen.

c) Margie was especially careful with HOT grease, because the broiler had caused a fire.

d) Marge was careful with the broiler, because HOT grease had caused a small fire in the kitchen.

29. a) Before the whole team had finished in the SHOWERS, the hot water supply was turned off.

b) Before the entire team had washed, the SHOWERS were turned off in the small locker room.

c) Nearly all the team had finished in the SHOWERS, before the hot water was turned off.

d) Nearly all the team had washed, before the SHOWERS were turned off in the small locker room.

30. a) Because we sprayed disinfectant on all of our OLD blankets, they smelled rather pungent.

b) Because we sprayed disinfectant in the chest, our OLD blankets smelled extremely pungent.

c) We sprayed disinfectant on almost all of our OLD blankets, because they smelled pungent.

d) We sprayed disinfectant in the chest, because our OLD blankets smelled extremely pungent.

31. a) As Bob ran along the edge of the SMALL beach, the sand was being covered by the tide.

b) As Robert ran along the shore, the SMALL beach was being covered by the rising tide.

c) Robert ran along the edge of the SMALL beach, as it was being covered by the tide.

d) Robert ran along the shore, as the SMALL beach was being covered by the rising tide.

32. a) When nearly all of the noisy spectators get QUIET, it'll be time for the tightrope walker.
b) When all the spectators get seated, it'll be QUIET enough for the expert tightrope walker.

c) Every one of the noisy spectators must get QUIET, when it's time for the tightrope walker.

d) The spectators might see a good act, when it gets QUIET enough for the expert tightrope walker.

33. a) If the state would only build fast TRAINS, they would bring an end to big traffic jams.

b) If the state would build more rails, fast TRAINS would bring an end to major traffic jams.

c) The state government would build fast TRAINS, if they would bring an end to traffic jams.

d) The state would build railroads, if fast TRAINS would bring an end to major traffic jams.

34. a) After special robes were made for the CHOIR, they left for their national tour.

b) After some special robes were made, the CHOIR left town for their national tour.

c) Some special robes were ordered for the CHOIR, after they returned from their tour.

d) Special robes were ordered, after the CHOIR returned from their national tour.

35. a) After a new reservoir was built near the TOWN, the yearly water shortages ended.

b) After a new reservoir was built nearby, the TOWN had less severe water shortages.

c) A new reservoir was built near by the TOWN, after a water shortage arose.

d) A large new reservoir was built, after the TOWN had been through a bad water shortage.

36. a) Since you drank so many glasses of the COLD punch, you might get a hangover tomorrow.
b) Since you drank so much at the party, the COLD punch might give you a hangover tomorrow.

c) You should drink only a little of the COLD punch, since you might get a nasty hangover.

d) You should drink only a little, since the COLD punch might give you a hangover tomorrow.
APPENDIX II-B
DIFFERENCES IN THE EXPERIMENTAL PROCEDURE FOR EXP'S. I. AND II.

Some of the test procedures were changed slightly; e.g., a stimulus light was used in EXP. II. to signal subjects. At random intervals throughout the test session, the experimenter switched on a bulb, positioned directly above the screen. Subjects were instructed to write down the sentence immediately presented. This method was adopted because it took less time and was more controlled than the earlier method of the experimenter having to ask subjects for sentence repetitions several times throughout the test session.

The apparatus was also altered somewhat, as mentioned earlier. A diagram of the equipment for EXP. II appears below.

FIGURE A2.
APPARATUS FOR EXPERIMENT II.
APPENDIX II-C
ANOVA RESULTS

TABLE A-8
ABBREVIATIONS OF FACTORS IN ANOVA, EXP. II

<table>
<thead>
<tr>
<th>Number</th>
<th>Abbrev.</th>
<th>Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>CL</td>
<td>clause order</td>
</tr>
<tr>
<td>(2)</td>
<td>PP</td>
<td>probe position</td>
</tr>
<tr>
<td>(2) x (2)</td>
<td>PP x CL</td>
<td>kind of clause (interaction)</td>
</tr>
<tr>
<td>(36)</td>
<td>SE</td>
<td>sentence sets</td>
</tr>
<tr>
<td></td>
<td>Se*</td>
<td>pseudosentences (groups of sentences created by arbitrary groupings)</td>
</tr>
<tr>
<td>(9)</td>
<td>Tr</td>
<td>trials</td>
</tr>
<tr>
<td>(22)</td>
<td>Su</td>
<td>subjects</td>
</tr>
<tr>
<td></td>
<td>Su*</td>
<td>pseudosubjects</td>
</tr>
<tr>
<td>(4)</td>
<td>Gr</td>
<td>groups of subjects</td>
</tr>
</tbody>
</table>
TABLE A-9
RESULTS OF ANOVA TESTS, BY FACTORS

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Error Term</th>
<th>Factor</th>
<th>F</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CL x PP x GR 2 2 4</td>
<td>Tr x Su 9 22</td>
<td>CL</td>
<td>5.620</td>
<td>1/197</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PP</td>
<td>15.414</td>
<td>&quot;</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL x PP</td>
<td>8.373</td>
<td>&quot;</td>
<td>.005</td>
</tr>
<tr>
<td>2. CL x PP 2 2</td>
<td>Tr x Gr x Su 9 4 22</td>
<td>CL</td>
<td>5.125</td>
<td>1/791</td>
<td>.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PP</td>
<td>14.827</td>
<td>&quot;</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL x PP</td>
<td>7.401</td>
<td>&quot;</td>
<td>.01</td>
</tr>
<tr>
<td>3. CL x PP x TR</td>
<td>Real Su nested within Gr. = error term</td>
<td>CL</td>
<td>4.918</td>
<td>1/84</td>
<td>.03</td>
</tr>
<tr>
<td>(corrected for the mean)</td>
<td></td>
<td>PP</td>
<td>11.757</td>
<td>&quot;</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL x PP</td>
<td>6.215</td>
<td>&quot;</td>
<td>.02</td>
</tr>
<tr>
<td>4. CL x PP x SE</td>
<td>Su*</td>
<td>CL</td>
<td>6.292</td>
<td>1/21</td>
<td>.02</td>
</tr>
<tr>
<td>(corrected for the mean)</td>
<td></td>
<td>PP</td>
<td>14.234</td>
<td>&quot;</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL x PP</td>
<td>4.821</td>
<td>&quot;</td>
<td>.03</td>
</tr>
</tbody>
</table>
TABLE A-10

ANOVA TABLE, GROUP MEANS, EXP. II

<table>
<thead>
<tr>
<th>Group</th>
<th>RT</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>673</td>
</tr>
<tr>
<td>II</td>
<td>666</td>
</tr>
<tr>
<td>III</td>
<td>692</td>
</tr>
<tr>
<td>IV</td>
<td>656</td>
</tr>
</tbody>
</table>
### TABLE A-11

**COMPARISON OF GROUP DIFFERENCES**

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Error Term</th>
<th>Factor</th>
<th>F</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CL x PP x Gr</td>
<td>Tr x Su</td>
<td>Gr</td>
<td>3.095</td>
<td>3/591</td>
<td>&lt;.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PP x GR</td>
<td>0.139</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL x PP x GR</td>
<td>1.472</td>
<td>&quot;</td>
<td>&gt;.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>not significant</td>
</tr>
<tr>
<td>3. CL x PP x TR</td>
<td>Su within</td>
<td>Gr</td>
<td>1.694</td>
<td>3/84</td>
<td>&gt;.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gr x CL</td>
<td>0.798</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gr x PP</td>
<td>0.112</td>
<td>&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gr x CL x PP</td>
<td>1.281</td>
<td>&quot;</td>
<td>significant</td>
</tr>
<tr>
<td>Analysis</td>
<td>Error Term</td>
<td>Factor</td>
<td>F</td>
<td>d.f.</td>
<td>p</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------</td>
<td>--------</td>
<td>-----</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>4. CL x PP x SE</td>
<td>Su*</td>
<td>Se</td>
<td>8.496</td>
<td>35/735</td>
<td>&lt; .001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CL x SE</td>
<td>1.029</td>
<td>&quot;</td>
<td>&gt;&gt; .05</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PP x SE</td>
<td>1.736</td>
<td>&quot;</td>
<td>&lt; .020</td>
</tr>
</tbody>
</table>
APPENDIX II-D

EXPERIMENT II. POST-HOC TESTS

Preliminary analysis of the data in Exp. II raised several questions that need to be examined more closely; viz.,

1. Are our intuitions correct about the negligible msec. differences between conditions b, c, and d?

2. Are there any other factors that might have contributed to the increased latency on condition a? In particular, is there any correlation of RT and between-clause pause time?

3. What might be the reason(s) for the significant sentence effect that was obtained in analysis #4 (p.218)? i.e., Do the sentence sets show regular differences that were not being tested in the experiment—if so, which ones, and why should they affect RT?

Each of these questions will be taken up, in turn, in the sections below. Since each problem requires a different statistical technique, these will also be described in detail.
1. Comparison Between the Means
(ANOVA Results)

As expected, the 6 msec. difference between RT\(_{(c)}\) and RT\(_{(d)}\) was not significant at the 5% level, as shown by the results of a t-test on two of the analyses:

\( H_0: \) Null Hypothesis—i.e., no difference between
the means: \( \mu_{(c)} = \mu_{(d)} \)
\( \mu_{(c)} - \mu_{(d)} = 0 \)

\( H_A: \) two-tailed \( \{ \mu_{(c)} - \mu_{(d)} \neq 0 \} \) or \( \{ \mu_{(c)} > \mu_{(d)} ; \mu_{(c)} - \mu_{(d)} > 0 \} \)
Let \( \alpha = .05 \); reject \( H_0 \) if \( t_{\text{observed}} \)\;
\( \begin{cases} < t_{.025} \\ > t_{.975} \end{cases} \)

First, assume \( \sigma_c \neq \sigma_d \) and samples are independent;
\( n_c = n_d = 88 \) subjects.

a) \( \sigma_{\bar{x}_c - \bar{x}_d}^2 = \frac{\sigma_c^2}{n_c} + \frac{\sigma_d^2}{n_d} \)

b) \( t' = (\bar{x}_c - \bar{x}_d) - (\mu_c - \mu_d) / \sqrt{\frac{S_{\text{pool}}}{n_c} + \frac{S_{\text{pool}}}{n_d}} = s_{\text{pool}} \sqrt{n_c + n_d} \)

Under \( H_0, \mu_{(c)} - \mu_{(d)} = 0 \), and \( n_c = n_d = n \). Hence, the denominator in (b) above =

\( \sqrt{\frac{s^2_{\text{pool}}}{n}} \). By an approximation
due to Cochran, (1967), \( t' = t \) with \( (n-1) \) d.f. Then,
for 88 Subjects, d.f. = .87, and \( t = .360 \ll t_{.975} (87) = 1.988 \). Therefore, \( H_0 \) cannot be rejected.
(These figures come from the Tr x Su-within-groups analysis.) For the Se x Su* analysis, \( n_1 = n_2 = 36 \) sentences; d.f. = 35. For \( \alpha = .05 \), \( t_{\text{observed}} = .516 < t_{.05}(35) = 2.33 \). Hence, \( H_0 \) cannot be rejected at the 5% level.

2. Possible Factors Responsible for Increased RT to condition(a)

In the last chapter, between-clause intonation, or pausing, was mentioned as a likely source for greater RT to sentences with the order[[subordinate][main]], probe from first clause. Although Caplan's (1971) results suggest the opposite, there is still a chance that the increased latency in condition (a) was a function of greater pause time at the clause break for that version, but not for the other three. In order to test this possibility, we looked for a correlation between RT and absolute pause interval at the clause break. This determination required several steps:

First, each sentence of every stimulus tape was run through a polygraph to give a display of the sound envelope as a function of time. 1 sec. of speech time = 4 sec. tape time, and was represented as 100mm. on the graphic record. Thus, distance on the paper could be quickly converted to actual time in msec. Examples of polygraph charts appear below:
Using this method, a mean pause time was determined for each condition of every sentence, on each of the four stimulus tapes. Corresponding RT means were obtained from the results of the CL x PP x GR analysis. The chart on the following page summarizes these averages. The top number indicates pause time (msec.), and the lower number (in parentheses) shows mean RT.
<table>
<thead>
<tr>
<th>Tape (Group)</th>
<th>Conditions</th>
<th>RT Across Conditions (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a [X, \text{sub. main}]</td>
<td>b [X, \text{main}]</td>
</tr>
<tr>
<td>I.</td>
<td>174</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>(694)</td>
<td>(655)</td>
</tr>
<tr>
<td>II.</td>
<td>140</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>(686)</td>
<td>(650)</td>
</tr>
<tr>
<td>III.</td>
<td>86</td>
<td>118</td>
</tr>
<tr>
<td></td>
<td>(723)</td>
<td>(681)</td>
</tr>
<tr>
<td>IV.</td>
<td>102</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>(670)</td>
<td>(659)</td>
</tr>
<tr>
<td>Overall:</td>
<td>126</td>
<td>131</td>
</tr>
<tr>
<td></td>
<td>(693)</td>
<td>(661)</td>
</tr>
</tbody>
</table>
Thus, by inspection, there do not appear to be any correlations of RT with pause time, for any particular group, or across groups.

3. Possible Differences Between the Sentence Sets

Analysis #4, CL x PP x SE, showed a sentence effect (p < .001) and a PP x SE interaction (p < .02) (see Table A-9, p.215a). Although both effects were significant, they were not strong enough to mask the main effects of clause boundary and dominance. Nevertheless, the sentence influence was present, and must be explained.

There are at least four possible factors that might have caused the effect:

a) distance of target word from the end of the sentence; b) particular adverb used; c) syntactic category of target item wrt the rest of the sentence; and d) syntactic structure of the target itself.

Distance (a) is suspect, inasmuch as the targets across all 36 sentence sets ranged from 5 to 11 syllables from the end, although distance was constant for any given set. If RT is at least partially determined by the serial position of the target, probes with targets in different serial positions might have evoked different response times. The particular adverb (b) could also
have influenced RT, especially if listeners can determine its meaning, and the logical relations that it constrains in the sentence. For example, causal relations, specified by because or since, may be more difficult and take longer to figure out than temporal relations, specified by adverbs like before, after, or until. Syntactic category of the target (c) might likewise affect RT, given that distinctions like N, V, and Adj. can be made during initial perception of a sentence. Note that category distinctions must be made very early, according to Bever's strategies, which require an [N..V..(N)..] sequence to be segmented as a clause.

Finally, the syntactic structure of the target itself (d), might affect RT to probes. Target words that are constituents of an NP or AP would take longer to recognize than targets that occur as single terminal nodes in the phrase marker. The assumption here is that more complex structures, like phrases, take longer to search through than do simpler ones.

In short, all four of these factors could conceivably have caused the sentence effect. The last one, syntactic structure of the target, is the most plausible cause; this will become clear in the next section, where each of the four factors is examined in detail.
4. a) Distance

Recall that each sentence set was constructed so that the number of syllables from the end of the target word to the end of the sentence was constant in all four versions. The number of words after the target was also kept roughly constant, but allowed to vary by one word at most. Across all 36 sentence sets, however, distance from the end varied from 5 to 11 syllables. Each number over this range was represented by at least 3 sentence sets (with the exception of $D = 5$, which had 1 representative). Approximately 25% of the sets had $D \leq 7$; 33% had $D \leq 9$; and 45% had $D \geq 10$. Thus, the sentences did not show any obvious bias wrt $D$, as can be seen from the scattering of points in the following graph:
FIGURE A-3 EXPERIMENT II Post-Hoc Tests

Distance from end-of-target to end-of-sentence (syllables)

D = number of syllables immediately following target to end of sentence

Sentence number →

(See Appendix II A for complete list of sentences)
In order to test whether the different syllable lengths had any regular influence on mean RT, we used a linear regression model of RT on distance, \( D \).

In this analysis, the sample regression line is estimated as

\[
\hat{Y} = \frac{\Sigma Y}{n} + b \left( X - \frac{\Sigma X}{n} \right),
\]

where \( X = \) no. of syllables from the end of sentence;
\( Y = \bar{RT}/\text{sentence in msec.} = \) mean RT across all subjects on all conditions;
\( n = 36 \) sentence sets;
\( b = \) the \( Y \) intercept \( = \frac{\Sigma xy}{\Sigma x^2} \), \( \left( \frac{\Sigma x^2 = \Sigma X^2 - (\Sigma X)^2 / n}{\Sigma xy = \Sigma XY - \Sigma X \Sigma Y / n} \right) \)

Given RT means from the ANOVA results, the sample regression line was calculated as

\[
\hat{Y} = +7.21 \times + 609.
\]

The sample correlation coefficient, \( r \), is determined by the formula

\[
r = b \frac{s_x}{s_y}
\]

where \( s_x = \sqrt{\frac{\Sigma x^2}{n-1}} \) and \( s_y = \sqrt{\frac{\Sigma y^2}{n-1}} \).

For the above test, \( r \) was calculated as \( .2935 \), d.f. \( = n-2 = 34 \).

Under the null hypothesis, the actual correlation coefficient, \( \rho \), should be \( = 0 \). With \( \alpha = .05 \), the sample \( r \) must be \( \geq r_{.95} = .325 \), to be significant.

Since the observed value is less than this table value, we cannot reject \( H_0 \) at the 5% level. The observed value is significant at the 6% level,
however. This result means that the correlation was present, but was not sufficient in itself to cause the sentence effect. Other factors need to be considered.

b) Adverbial Conjunctions

Particular adverbs may have been a source of the effect, given the following assumptions:

a. The semantic relations between clauses are a function of the particular adverb used; e.g., because and since will constrain the logical relations of the two clauses wrt causality of events; whereas before, until, after affect the temporal sequence of events, etc.

b. Enough semantic processing occurs during initial sentence perception so that the listener can determine the semantic properties of the adverb.

The results of EXP's I and II argue that these assumptions are valid, just because the dominance effects did not reach significance until the semantics was made to "agree" with the syntax—i.e., until the logical relations in each clause were made more consistent with the syntactic structure of the sentence.

In order to discover any regularities between use of a particular adverb and mean RT, the sentences were first put in rank order, from slowest RT to
fastest (see Table A-14). The corresponding adverbials are listed in column 7 in the table. Quick inspection reveals no such regularities: the 13 causal adverbs (because, since) are scattered throughout the ranking, as are the 18 time adverbs (as, while, when, before, after). (The remaining 5 adverbs include if, even though, although, which are likewise distributed throughout the scale.) Hence, the particular adverb in a sentence set could not have caused the sentence effect.
<table>
<thead>
<tr>
<th>Test No.</th>
<th>Probe</th>
<th>Phrase Probe</th>
<th>Truth Value</th>
<th>Mean RT (Y)</th>
<th>Rank Order by RT</th>
<th>No. of Syllables from End (X)</th>
<th>Adverb</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>SMALL (beach)</td>
<td>Yes</td>
<td>Yes</td>
<td>785</td>
<td>35</td>
<td>11</td>
<td>as</td>
</tr>
<tr>
<td>28</td>
<td>HOT (grease)</td>
<td>Yes</td>
<td>Yes</td>
<td>765</td>
<td>34</td>
<td>10</td>
<td>because</td>
</tr>
<tr>
<td>30</td>
<td>OLD (blankets)</td>
<td>Yes</td>
<td>Yes</td>
<td>733</td>
<td>33</td>
<td>8</td>
<td>because</td>
</tr>
<tr>
<td>16</td>
<td>(living) ROOM</td>
<td>Yes</td>
<td>Yes</td>
<td>728</td>
<td>32</td>
<td>8</td>
<td>while</td>
</tr>
<tr>
<td>32</td>
<td>QUIET</td>
<td>No</td>
<td>No</td>
<td>716</td>
<td>31</td>
<td>10</td>
<td>when</td>
</tr>
<tr>
<td>13</td>
<td>CHURCH (service)</td>
<td>Yes</td>
<td>Yes</td>
<td>710</td>
<td>30</td>
<td>9</td>
<td>as</td>
</tr>
<tr>
<td>6</td>
<td>POLICE</td>
<td>No</td>
<td>No</td>
<td>709</td>
<td>29</td>
<td>11</td>
<td>even though</td>
</tr>
<tr>
<td>4</td>
<td>AMERICANS</td>
<td>No</td>
<td>No</td>
<td>708</td>
<td>28</td>
<td>11</td>
<td>before</td>
</tr>
<tr>
<td>15</td>
<td>NIGHT (rates)</td>
<td>Yes</td>
<td>Yes</td>
<td>694</td>
<td>27</td>
<td>11</td>
<td>because</td>
</tr>
<tr>
<td>19</td>
<td>WALLS</td>
<td>No</td>
<td>No</td>
<td>692</td>
<td>26</td>
<td>8</td>
<td>because</td>
</tr>
<tr>
<td>5</td>
<td>SALES</td>
<td>No</td>
<td>No</td>
<td>685</td>
<td>25</td>
<td>10</td>
<td>since</td>
</tr>
<tr>
<td>26</td>
<td>STATION</td>
<td>No</td>
<td>No</td>
<td>685</td>
<td>24</td>
<td>7</td>
<td>when</td>
</tr>
<tr>
<td>23</td>
<td>GARDEN</td>
<td>No</td>
<td>No</td>
<td>680</td>
<td>23</td>
<td>8</td>
<td>after</td>
</tr>
<tr>
<td>34</td>
<td>CHOIR</td>
<td>No</td>
<td>No</td>
<td>680</td>
<td>23</td>
<td>8</td>
<td>after</td>
</tr>
<tr>
<td>14</td>
<td>GAME</td>
<td>No</td>
<td>No</td>
<td>679</td>
<td>21</td>
<td>11</td>
<td>although</td>
</tr>
<tr>
<td>22</td>
<td>SOUTH</td>
<td>No</td>
<td>No</td>
<td>672</td>
<td>20</td>
<td>10</td>
<td>before</td>
</tr>
<tr>
<td>33</td>
<td>(fast) TRAINS</td>
<td>Yes</td>
<td>Yes</td>
<td>672</td>
<td>19</td>
<td>10</td>
<td>if</td>
</tr>
<tr>
<td>29</td>
<td>SHOWERS</td>
<td>No</td>
<td>No</td>
<td>666</td>
<td>18</td>
<td>9</td>
<td>before</td>
</tr>
<tr>
<td>10</td>
<td>(spy) NOVEL</td>
<td>Yes</td>
<td>Yes</td>
<td>663</td>
<td>17</td>
<td>6</td>
<td>if</td>
</tr>
<tr>
<td>35</td>
<td>TOWN</td>
<td>No</td>
<td>No</td>
<td>660</td>
<td>16</td>
<td>9</td>
<td>after</td>
</tr>
<tr>
<td>21</td>
<td>MONEY</td>
<td>No</td>
<td>No</td>
<td>658</td>
<td>15</td>
<td>11</td>
<td>because</td>
</tr>
<tr>
<td>18</td>
<td>LEASE</td>
<td>No</td>
<td>No</td>
<td>656</td>
<td>14</td>
<td>7</td>
<td>after</td>
</tr>
<tr>
<td>17</td>
<td>CREW</td>
<td>No</td>
<td>No</td>
<td>654</td>
<td>13</td>
<td>10</td>
<td>although</td>
</tr>
<tr>
<td>7</td>
<td>(instant) COFFEE</td>
<td>Yes</td>
<td>Yes</td>
<td>653</td>
<td>12</td>
<td>10</td>
<td>because</td>
</tr>
<tr>
<td>Test No.</td>
<td>Probe</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-----------</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>CLASS</td>
<td></td>
<td>No</td>
<td>650</td>
<td>11</td>
<td>6</td>
<td>when</td>
</tr>
<tr>
<td>12</td>
<td>CHILDREN</td>
<td></td>
<td>No</td>
<td>647</td>
<td>10</td>
<td>8</td>
<td>because</td>
</tr>
<tr>
<td>11</td>
<td>ACTRESS</td>
<td></td>
<td>No</td>
<td>645</td>
<td>9.5</td>
<td>5</td>
<td>while</td>
</tr>
<tr>
<td>20</td>
<td>FAUCET</td>
<td></td>
<td>No</td>
<td>645</td>
<td>9.5</td>
<td>8</td>
<td>after</td>
</tr>
<tr>
<td>3</td>
<td>SUNLIGHT</td>
<td></td>
<td>Yes</td>
<td>644</td>
<td>8</td>
<td>9</td>
<td>since</td>
</tr>
<tr>
<td>2</td>
<td>SPEAKER</td>
<td></td>
<td>No</td>
<td>641</td>
<td>7</td>
<td>7</td>
<td>while</td>
</tr>
<tr>
<td>24</td>
<td>DRUMS</td>
<td></td>
<td>No</td>
<td>630</td>
<td>6</td>
<td>10</td>
<td>because</td>
</tr>
<tr>
<td>9</td>
<td>BOOKS</td>
<td></td>
<td>No</td>
<td>623</td>
<td>5</td>
<td>9</td>
<td>when</td>
</tr>
<tr>
<td>25</td>
<td>FOOD</td>
<td></td>
<td>No</td>
<td>619</td>
<td>4</td>
<td>9</td>
<td>because</td>
</tr>
<tr>
<td>27</td>
<td>JUDGE</td>
<td></td>
<td>No</td>
<td>618</td>
<td>3</td>
<td>8</td>
<td>after</td>
</tr>
<tr>
<td>1</td>
<td>COLA</td>
<td></td>
<td>No</td>
<td>617</td>
<td>2</td>
<td>6</td>
<td>because</td>
</tr>
<tr>
<td>36</td>
<td>COLD (punch)</td>
<td>Yes</td>
<td>600</td>
<td>1</td>
<td>11</td>
<td>since</td>
<td></td>
</tr>
</tbody>
</table>
c) Syntactic Category of Probed Word
and d) Phrase Structure of Probe

All the probed items were either Adj. or N; this variation may have been responsible for significant differences between the sentence sets. On the other hand, we have argued above that the main effects should be a function of gross structural differences between clauses rather than between individual words. This hypothesis is supported by the results of Caplan's (1971) tests, which show that the clause boundary effect overrides any differences of syntactic category of the probed items. Because of these reasons, it seemed to be unnecessary to control for category in designing the original stimuli. Yet there is still the chance that N or Adj. status of the target word affected RT. The sentences were therefore placed in rank order by mean RT across conditions (Table A-14, p.231.). Quick inspection shows that 80% of the Adj. targets received the slowest responses. But since there were only 5 Adj. out of 36 target words, the finding is not conclusive.

What does emerge from inspection of Table A-14 is a potential correlation between RT and the (phrase) structure of the probed item; i.e., did the probe occur as an unmodified N, or was it an Adj. or N that was part of an Adj. phrase or NP? (The latter
will be referred to as a "phrase probe," and the former a "non-phrase probe." The table shows that 70% of the phrase probes (including compounds) received response times longer than the median RT (671). This percentage is large enough to warrant a statistical check on the potential correlation.

\[ \text{d (1). The Mann-Whitney } U \text{-Test} \]

This post-hoc test seemed suitable since it can be used with ordinal measures, and RT is an ordinal measure, at best. The hypotheses for this test are as follows:

\( H_0 \): There is no relation between RT and phrase structure of the target item.

\( H_A \): There is a relation; viz., sentences with +phrase targets evoked greater RT than did those with -phrase targets.

Let \( \alpha = .05; n_1 = 11 = \text{the number of sentences with +phrase targets} \)

\[ n_2 = 25 = \text{sentences with -phrase targets}. \]

Procedure

1. The sentences must be placed in rank order by RT, and rank numbers must be assigned, 1-36, in increasing order. Ties at the \( n^{th} \) level are given values = \( \frac{n + (n - 1)}{2} \).
2. Phrase targets are indicated by (+,)
nonphrase targets by (−).

3. The \( n_1 \) rank numbers in the group with the
smaller sum are added, giving the sum \( T_1 \). In this
case, the +phrase target group has the smaller sum.

4. \( T_2 \) is computed as \( n_1 (n_1 + n_2 + 1) - T_1 \)

5. The smaller value of \( T_1 \) and \( T_2 \) appears
as "T" in statistical tables.

For the example above, \( T_1 \) of \( n_1 = 249; \)
\[ T_2 = 158 \]

6. An observed \( z \) is computed as follows:
\[
z = \left( \frac{\mu - T}{\sqrt{n_1(n_1 + n_2 + 1)/2}} \right) \sqrt{n_2} \frac{\mu}{\sigma}
\]
In our case, \( z = 1.545 \)

The probability that values as extreme as this \( z \) occur
is found in tables of the normal deviate. The test
is 1-tail, and \( H_A \) predicts the direction of difference.
The rejection region includes all values of \( z \) which
are so extreme that \( p(H_0) \leq \alpha = .05. \)

For \( z = 1.545, p \leq .0614 \leq \alpha \) of .05. Hence, the null
hypothesis cannot be rejected. The test fails to
reach significance at the 5% level. It would be sig-
nificant at the 6% level; i.e., \( p(z \leq z_{1-\alpha}) = .94. \)
This result means that the correlation was present,
but was apparently not strong enough to be the sole
cause of the sentence effect.

As a further check on the phrase variable, another Mann-Whitney U test was performed, to see whether there was a correlation between phrase targets and distance D. The hypotheses are similar to the previous analysis:

H<sub>0</sub>: There is no relation between phrase targets and D, (as measured by the number of syllables from the end of target to end of sentence).

H<sub>A</sub>: There is a relation; viz. sentences with phrase targets had greater distances than did sentences without phrase targets.

Let α = .05; n<sub>1</sub> = 11, n<sub>2</sub> = 25; T<sub>1</sub> = rank number for phrase targets = 238.5

\[ T_2 = 168.5 = T \]
\[ = 203.5 \]
\[ = 29.118 \]
\[ z = 1.184 \]
\[ p = .1180 > \alpha \text{ of } .05. \]

Hence, H<sub>0</sub> cannot be rejected at the 5% level.

(To reject it, z must be >1.96.) Thus, there seems to be little correlation between phrase probes and greater distance.

The results of these tests suggest at least some influence of phrase structure on RT (although factors like distance seem to be confounded in the
phrase variable). Additional evidence for this conclusion appears in the graphs on the next few pages.
FIGURE A-4  Probe first vs. Probe second

\[ Y = \frac{(a + c)}{2} = \text{probe first (time in msec, corrected for decay)} \]

II.

NIGHT rates
80 POLICE
70 CHURCH service
60 SALES
50 AMERICANS
40 living ROOM
30 SHOWERS
20 GARDEN
10 TRAINS
0 STATION
-10 LEASE
-20 Spy NOVEL
-30 BOOKS
-40 instant COFFEE
-50 TOWN
-60 DRUMS
-70 CLASS
-80 MONEY
-90 ACTRESS
-100 CREW
-110 SUNLIGHT
-120 FAUCET
-130 FOOD
-140 COLA
-150 JUDGE
-160 no poison

III.

OLD blankets

IV.
FIGURE A.5  Probe Position
for a) vs b): subordinate clause first

\[ Y = \text{PROBE (a) in msec. (first clause)} \]

\[ X = \text{PROBE (b) (second clause)} \]

- HOT grease (because)
- SMALL beach (because)
- CHURCH service (before)
- POLICE (even though)
- OLD blankets (because)
- WALLS (because)
- AMERICANS (before)
- quiet (when)
- GARDEN (after)
- DRUMS (because)
- SOUTH (before)
- INSTANT COFFEE (because)
- LEASE (after)
- ACTRESS (while)
- my NOVEL (if)
- SUNLIGHT (since)
- GAME (although)
- CREW (although)
- FOOD (because)
- TOWN (after)
- COLA (because)
- FAUCET (after)
- COLD punch (since)
- JUDGE (after)

-80 -60 -40 -20 0 20 40 60 80 100
Figure A-6
Probe position for c) vs d): main clause first

\[ Y = \text{probe c} \]

II.
- HOT grease (because)
- SMALL beach (as)
- OLD blankets (because)
- CHURCH service (as)
- JUDGE (after)
- SALES since
- AMERICANS (before)
- QUIET (when)
- TOWN (after)
- GMEN (before)
- SOUTH (before)
- GAME (although)
- LEASE (after)
- COFFEE (when)
- CLASS (when)
- TRAVEL (before)
- SPEAKER (before)
- ACTRESS (after)
- DRUMS (because)
- FOOD (because)
- CHILDREN (because)
- COLD punch (since)

III.

IV.
**Figure 17**

Clause order by conditions, collapsed across PP. Probed words are given by each point. Adverb appears in ( ).

<table>
<thead>
<tr>
<th>II</th>
<th>80</th>
<th><img src="" alt="Conditions" /></th>
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<td></td>
<td><img src="" alt="Subordinate" /></td>
<td><img src="" alt="Main" /></td>
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<td><img src="" alt="Even though" /></td>
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<td><img src="" alt="Quiet" /></td>
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<td><img src="" alt="Shower" /></td>
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<td><img src="" alt="Crew" /></td>
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<td><img src="" alt="Station" /></td>
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<td><img src="" alt="Food" /></td>
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<td><img src="" alt="Instant" /></td>
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<td><img src="" alt="Cold punch" /></td>
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<td><img src="" alt="Judge" /></td>
<td><img src="" alt="After" /></td>
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</table>
Figures A4-7 show the results of plotting mean RT scores on different combinations of conditions (a-d). Individual sentences appear as points, scattered over four quadrants; some values are negative because the raw scores were corrected for the mean.

Figure A4 represents the probe position effect—first clause probe values are plotted on the y-axis, and second clause probes on the x-axis. Quadrants I. and II contain sentences where the effect was strongest, i.e., \( RT_{1st \, clause} \) was longer than \( RT_{2nd \, clause} \). The important thing to notice is the clustering of sentence points: quadrant I. sentences received the extreme RT values (long responses) and these are just the sentences having +phrase targets; whereas quadrant III. sentences received faster RT's and had predominantly -phrase targets.

Figures A5 and 6 illustrate how the PP effect varied as a function of clause order. Although the

---

*For a given condition on a sentence, the overall mean for that condition was subtracted from the raw score; e.g., where the overall mean for \((b + d)\), probe 2nd clause = 662; and the mean for \((b + d)\) on sentence n = 645, the corrected score is \( 645 - 662 = -17 \).
sentence points lie in roughly the same relative position as in Figure A4, there is a slight shift of points from quadrants III. to II. for the subordinate-first order. This shift is expected; it represents the fact that the probe position effect was enhanced in conditions a) and b) (subordinate-first).

Figure A7 shows clause order. Conditions (a + b) appear on the y-axis, and (c + d) on the x. Again, the sentence points maintain the same relative positions as on the previous graphs, so that the sentences with +phrase targets cluster in quadrants I. and II. Because RT means for +phrase targets are inversely related to RT's for the -phrase targets on the graphs, and because this relationship is nearly consistent on plots of both PP and CL, the +phrase factor appears to have had an independent effect on response latency. In particular, the presence of a +phrase target in a sentence increased the mean RT to probes. It also seems to have enhanced the main effects of clause boundary and dominance, as can be seen by the clustering of points in Figures A8 and A9. Figure A8 shows that the kind of clause effect (RT_{sub} > RT_{main}) was strongest for just those sentences with +phrase probes. Similarly, Figure A9 shows nearly the same distribution of sentence points in the
first two quadrants—an indication that the +phrase targets brought out the clause boundary effect as well. Notice also the influence of clause order; viz., over 75% of the points are in quadrants I and II on Figure A9; in these quadrants \( \text{RT}_a - \text{RT}_b \) is positive, and (a) and (b) are the conditions with subordinate-first.
FIGURE A.8 "Dominance Effect"

2nd Quadrant
- sub > main, probe first
- sub < main, probe second

1st Quadrant
- sub > main, probe first
- sub > main, probe second

\[ Y = (a-c)(\text{Probe subordinate - Probe main}) \]

3rd Quadrant
- sub < main, probe first
- sub < main, probe second

4th Quadrant
- sub < main, probe first
- sub < main, probe second

\[ X = (d-b)(\text{_probe subordinate - Probe main})\text{second clause} \]
**FIGURE A9. Boundary Effect**

\[ Y = (a + b) = \text{probe first - probe second} \]

- **JUDGE** (after)
- **HOT grease** (because)
- **DRUMS** (because)
- **POLICE** (even though)
- **SHOWER** (before)
- **SALES** (since)
- **OLD blankets** (because)
- **CHOIR** (after)
- **living ROOM** (because)
- **SOUTH** (before)
- **ACTRESS** (while)
- **FAST TRAINS** (before)
- **small town** (after)
- **LEASE** (after)
- **towel** (after)
- **FOOD** (while)
- **spicy NOVEL** (before)
- **GARDEN** (after)
- **STATION** (when)
- **WALLS** (since)
- **CHILDREN** (because)
- **SUNLIGHT** (since)
- **MONEY** (because)
- **GAIN** (although)
- **QUIET** (when)
- **FAUCET** (after)
- **SPEAKER** (since)

\[ X = (c - d) = \text{main clause first} \]

- **COLA** (because)

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d) (2) Implications of the Phrase Target Effect

In general, a +phrase target made the sentence more difficult to process. Subjects were apparently forced to compute more structure and to search through more structure for +phrase targets than for -phrase targets. Both processes should have taken longer and would have shown up as increased latency to +phrase probes. The fact that mean RT's were longer for these probes can be explained if NP's, compound N, and AP's are analyzed as (perceptual) units, and are represented as such in computed structures. It follows that there should be confusion when a listener is forced to split up a structural unit, in responding to one item from a syntactic phrase.

Subjects had particular difficulty with two-word compounds, like

living-room (probe = ROOM)
three-fourths (probe = THREE)

In the first experiment, they averaged 750 msec. RT to these probes, as compared to a sentence median of 651 and a range of 570-750 across sentences. Also, among the few errors that were made on the complete test battery, more than half were made on probes like ROOM and THREE. This finding suggests that words
from compounds are in some sense more difficult to retrieve from the computed structure than are N and Adj. from other phrase types.

Differences in the way phrase types are processed may be a function of syntactic distinctions between compounds and other NP. One such distinction is boundedness of a lexical item in a phrase, which is defined by its movement possibilities in the sentence and by its underlying source. Single lexical N are the least bound (and they appear as terminal nodes in the phrase marker); N or Adj. in phrases are "loosely bound," and N or Adj. in compound N are "tightly bound." Consider the example below:

1) N: book, house, woman

2) AP: red book, white house, old woman

3) (AP near-idioms: willing accomplice, mere fool)

4) pure compounds: White house, blackboard...

What we are calling AP idioms should fall somewhere in-between AP and pure compounds wrt boundedness, insofar as they are not as restricted as adjectives in compounds, and can occur with other NP heads:

a willing girl

a mere boy
But they are nevertheless more tightly bound than are adjectives in regular NP, like a pretty girl, a clever boy. The following evidence illustrates those syntactic differences between the four kinds of expressions that are related to the boundedness of adjectives to the phrase head:

1. Movement restrictions

Most compounds and many idioms are restricted wrt movement of adjectives.

a) no questioning

What house did you see?
*The White one.

Which fool did you make love to?
*The mere one. {notice}

b) no conjoining

*The mere and rakish fool.
*The White and garrish house.
*The scrub and old woman.

But members of NP or single N can be questioned and conjoined:

Which book did you see? What did you see?
The red one. The book.

Which fool did you notice? Whom did you notice?
The crazy one. The fool.

Which house did you see? (etc.)
The White one.

conjoined: The book and the pencil.

The old and wrinkled woman.
2. Derivations

Pure compounds and most idioms* cannot be derived from relative clauses, but "regular" adjective + noun phrases can:

White house ≠ house which is white
mere fool ≠ fool that is mere
but clever boy = boy who is clever.

Since pure compounds seem to be most restricted syntactically, words from these expressions should be hardest to recognize; whereas words from AP idioms should be easier, and words from adjective-noun phrases should be easiest of all.

These predictions are summarized below:

**Unmodified probe word.** Faster RT. Relatively "easy" for S to perceive and access lexical item because it is perceived as a unit.

\[
e.g., [[] \text{ house}]]
\]
\[
\text{NP N}
\]

**Probe from adjective phrase.** Slower RT. "Harder" to perceive and access probed word because more structure must be recovered; search time is therefore longer.

\[
e.g., [[] \text{ a [light] [house]}]]
\]
\[
\text{Det. Adj. N}
\]
\[
\text{ADJ.P.}
\]

*By definition, the semantic reading of an idiom is not a compositional function of the individual meanings of each element.
Probe from compound expression. Slowest RT. Hardest to perceive and access. Internal structure of compounds must be recovered, and this adds to RT latency. S is forced to break up a perceptual unit.

lighthouse keeper

underlying structure

\[ N \left[ \text{Adj.} \left[ N \left[ \text{A light} \right] \text{N} \left[ \text{house} \right] \text{Adj} \right] \text{N} \left[ \text{keeper} \right] \right] \text{N} \]

surface realization

\[ N \left[ \text{lighthouse} \right] \text{N} \left[ \text{keeper} \right] \text{N} \]

If further research confirms these predictions, it would mean that listeners do a considerable amount of clause-internal analysis by the time the sentence has ended. It also suggests that syntactic boundedness is psychologically "real," in the sense that boundedness distinctions in the grammar would have specific effects on performance.

Interestingly enough, this hypothesis provides another reason for the contrasting results of EXP's I. and II., and for the interaction of the boundary and dominance effects. The argument goes as follows:

Assume boundedness applies to subordinate clause types as well as to phrases (as will be shown below); the adverbial clauses in EXP.'s I. and II. are all loosely attached to the matrix in the phrase marker;
and that dominance distinctions are weakest for loosely bound clauses.

There should be little or no effect of dominance for two-clause sentences with adverbials (since they are loosely bound to the matrix-S); but there should be sizable effects with relative clauses and complements (since they are more tightly bound to a sentence constituent, as well as being more deeply embedded than adverbial clauses).

These predictions are to be tested with the probe-latency paradigm, as adopted for EXP.'s I. and II. This new study (EXP. III) involves a comparison of RT's for recognizing a probe word from different clause types, including adverbials, complements, and coordinate clauses. The latter will serve as control material, since sentences which are linked by the coordinating conjunctions (and, but, or) do not exhibit dominance differences in clause structure. The relevant comparisons thus range over three types of clause structures, as diagrammed below:

Coordinate structures: no effect of dominance. \( \text{RT}_{S_1} = \text{RT}_{S_2} \). No difference in boundedness properties of \( S_1 \) and \( S_2 \).
Adverbial structures: little or no effect of dominance.

\[ \text{RT}_{S_1} = \text{RT}_{S_2} \]

No difference in boundedness properties of \( S_1 \) and \( S_2 \).

Adverbial structures: little or no effect of dominance.

\[ \text{RT} \not\equiv \text{RT} \]

Adv. main clause

Adverbial clause is loosely bound to the matrix.

Relatives and complements: strong dominance effect.

\[ \text{RT}_{\text{subordinate}} \neq \text{RT}_{\text{main}} \]
\[ \text{RT}_{\text{subordinate}} \succ \text{RT}_{\text{main}} \]

The subordinate clause is tightly bound.

These predictions, if valid, would explain why the dominance effect reached significance in EXP. II., but not in EXP. I. Because adverbial clauses were used in both experiments, there should only have been
a slight difference in recognizing probes from adverbials as opposed to main clauses. Hence, the effect should have been weaker than other factors, like clause boundary position. Dominance differences could therefore have been easily obscured (as in EXP. I.). When other grammatical properties reinforce syntactic dominance, the effect should be revealed. This is probably what happened in EXP. II., since the semantic dependencies between clauses were enhanced.

In making the above predictions, we are assuming that the differences between clause types can be defined by the formalism, and that main clauses can be distinguished from subordinates by variables like depth-of-embedding, a geometrical property of tree structures. It is important to realize, however, that such formal distinctions are motivated by the syntactic, semantic, and phonological behavior of different clause types. Consider the evidence below:

1. Movement properties

   Most adverbials can move around freely, but complements and relatives cannot. E.g.,

   Adv. Because the man stared at panty hose all day, he was the topic of the women's meeting.

   or: The man was the topic of the women's meeting because he stared at panty hose all day.
Compare restrictive relatives:

The man staring at panty hose all day was the topic of the women's meeting.

*The man was the topic of the women's meeting staring at panty hose all day.

*Staring at panty hose all day the man was the topic of the women's meeting.

2. Selection

Verbs in the matrix-S are subcategorized for the kinds of complements which can occur in embeddings. There are fewer restrictions, however, on the verb wrt what kind of adverbials can occur. E.g.,

Infinitival clauses (purpose):
?The man squinted (in order) to look at panty hose all day.

VP complements:
The man squinted *that he was looking at panty hose all day.

The man squinted *his looking at panty hose all day.

Adverbials:
o.k. The man squinted because he looked at panty hose all day.

3. Intonation

Adverbial clauses are normally separated from the main clause by pausing (comma intonation), but restrictive relatives and complements are not. In fact, if pausing separates a relative clause from its head, the interpretation cannot be restrictive (see sentence (b) below).
a) Adv.: Because the man stared at panty hose all day, he was the topic of the women's meeting.

b) Rel.: The man--staring at panty hose all day--was the topic of the women's meeting.

c) Inf.: The man stared--to see the panty hose.

4. Summary and Conclusions

Noticing the influence of +phrase targets on RT provided a way of explaining the sentence effect, and forced us to look closely at the phrase structure of the probed items. This inquiry revealed differences in boundedness properties of the target words, which led to a discussion of boundedness in clause types as well.

It may be that a general processing principle is involved in the analysis of phrasal and clausal relations by listeners; viz., more complex grammatical structures are harder to perceive, or harder to access, or both. "Complexity," in this sense, would depend on depth-of-embedding and boundedness for clause structure; and degree-of-modification for phrases. If this general principle turns out to be correct, we would have reason to refine our linguistic analysis to bring out the similarities of phrase and clause structures in the grammar.
APPENDICES TO CHAPTER III
APPENDIX III-A
STIMULUS MATERIAL

Sentence #1. LAND 21 syllables 13 before/8 after

COMP

1. The fact that the greedy rancher purchased lots of land made farms more scarce in Pratt county.

2. The fact that the rancher purchased lots of farms made land more scarce in most of Pratt county.

3. The greedy rancher's sudden purchase of lots of land meant that farms would become more scarce.

4. The old rancer's purchase of lots of farms meant that land would become scarce in Pratt county.

ADV.

1. When the very greedy rancher purchased lots of land, farms became scarce in Pratt county.

2. When the greedy old rancher purchased lots of farms, land became quite scarce in Pratt county.

3. The very greedy old rancher purchased lots of land when farms were becoming quite scarce in Pratt county.

4. The greedy old rancher purchased lots of farms when land became quite scarce in Pratt county.

COORDINATE

1. The very greedy old rancher purchased lots of land and farms were scarce in Pratt county.

2. The greedy old rancher purchased lots of farms and land became quite scarce in Pratt county.
RELATIVES

1. The year that the greedy rancher purchased lots of land, farms became scarce in Pratt county.
2. The year that the old rancher purchased lots of farms land became more scarce in Pratt county.
3. The very greedy old rancher purchased lots of land the year that farms became more scarce.
4. The old rancher purchased lots of farms the year that land became more scarce in Pratt county.

Sentence #2. CAR 25 syllables 15 before/10 after COMP.

1. For a skilled mechanic to have worked a long time on the car would have put the engine in condition.
2. For a mechanic to work on the engine would put the car into very good running condition.
3. The highly-skilled mechanic worked just long enough on the car for the engine to be in condition.
4. The highly skilled mechanic worked just long enough for the car to be back in good running condition.

ADV.

1. Since a highly-skilled mechanic worked a long time on the car, the engine was back in good condition.
2. Since a highly-skilled mechanic worked on the engine, the car was in very good running condition.
3. The skilled mechanic worked for a very long time on the car since the engine was in bad condition.
4. The mechanic worked a long time on the engine since the car was in very bad running condition.
COORDINATE

1. A highly skilled mechanic worked for a long time on the car, and the engine was put in condition.

2. The mechanic worked a long time on the engine, and the car was put back in good running condition.

RELATIVE

1. The highly skilled mechanic that worked a long time on the car put the engine back in good condition.

2. The skillful mechanic that worked on the engine put the car back in very good running condition.

3. The very skillful mechanic did a tune-up on the car that put the engine in good condition.

4. The highly skilled mechanic did a tune up that put the car into very good running condition.

Sentence #3. TIME 23 syllables 14 before/9 after

COMP.

1. For you to prepare a large meal well ahead of time would allow a rest before dinner.

2. For you to prepare the meal ahead would allow time for a short rest right before dinner.

3. Your preparation of the meal well ahead of time would let you rest right before dinner.

4. Preparation of meals ahead would let you take time for a short rest right before dinner.

ADV.

1. If you can only prepare the meal ahead of time you can take a rest before dinner.
2. If you can prepare the meal ahead, you can take time for a short rest right before dinner.

3. You surely could prepare the meal well ahead of time if you want a rest before dinner.

4. You could prepare the meal well ahead, if you want time for a short rest right before dinner.

COORDINATE

1. You surely could prepare the meal well ahead of time and take a short rest before dinner.

2. You surely could prepare the meal ahead and take time for a short rest right before dinner.

RELATIVE

1. Any meal that you can prepare well ahead of time will allow a rest before dinner.

2. Any meal that you prepare ahead will allow time for a short rest right before dinner.

3. You certainly could prepare meals well ahead of time that allow a rest before dinner.

4. You certainly could prepare meals that allow you time for a short rest right before dinner.

Sentence #4. JUDGE

COMP.

1. For our lawyer to be so rude in front of the judge of the case would make us angry.

2. For our lawyer to be rude in court could make the judge of the case extremely angry.

3. Our lawyer's rudeness directly in front of the judge made us get extremely angry.
4. Our lawyer's rudeness in the courtroom had made the judge of the case get very angry.

ADV.

1. Because our lawyer was so rude in front of the judge, we were quite angry.

2. Because our lawyer was very rude in court, the judge of the case became quite angry.

3. Our lawyer should have been less rude in front of the judge because he became quite angry.

4. Our lawyer should have been much less rude because the judge of the court became quite angry.

COORDINATE

1. The lawyers were extremely rude in front of the judge and he became very angry.

2. The lawyers were extremely rude in court and the judge of the case became quite angry.

RELATIVE

1. The lawyers who were extremely rude to the judge of the case made him quite angry.

2. The lawyers who were very rude in court made the judge of the case extremely angry.

3. The rude lawyers made some remarks in front of the judge that got him extremely angry.

4. The rude lawyers made several remarks that got the judge of the case extremely angry.

Sentence #5. FARMERS 26 syllables 12 before/14 after

COMP.

1. The fact that feed costs increased so much for farmers made people aware of problems in the economy.
2. The fact that feed costs increased so much made farmers aware of serious problems in the economy.

3. The enormous increase in feed costs made farmers aware that there were some problems in the economy.

4. Increased food costs made people aware that farmers were having rather serious economic problems.

COORDINATE

1. Most feed costs increased greatly last year for farmers, and now there are other problems in the economy.

2. Most feed costs increased greatly last year, and farmers now are having other serious economic problems.

ADV.

1. Ever since feed costs increased greatly for farmers, there have been serious problems in the economy.

2. Ever since feed costs have increased greatly, farmers have had many other serious economic problems.

RELATIVE

1. The feed costs that increased so much last year for farmers made people aware of problems in the economy.

2. Feed costs that increased so much last year made farmers aware of serious problems in the economy.

3. Most feed costs increased enormously for farmers the year that there were serious economic problems.

4. Food costs had increased greatly the year that farmers became aware of serious economic problems.
Sentence #6. DIAMONDS  25 syllables  14 before/
11 after

COMP.

1. For the collector to allow the sale of the diamonds would put many rare gems back on the market.

2. For the collector to sell his gems would put the diamonds right back onto the open market again.

3. The extremely famous collector of all the diamonds allowed his gems to be sold on the market.

4. The collector of many rare gems allowed the diamonds to be sold on the open market again.

ADV.

1. If the collector will allow the sale of the diamonds, many rare gems will be back on the market.

2. If the collector can sell many rare gems, the diamonds will be back on the open market again.

3. The extremely famous collector would sell the diamonds, if gems become rare on the open market.

4. The famous collector would sell many gems, if diamonds suddenly become quite rare in the market.

COORDINATE

1. The famous collector allowed the sale of the diamonds, and many rare gems were back on the market.

2. The famous collector sold many gems and the diamonds suddenly were back on the open market.
RELATIVE

1. The extremely famous collector who sold the diamonds put many rare gems on the open market.

2. The collector who sold many rare gems put the diamonds right back onto the open market again.

3. The extremely famous collector of all the diamonds held a sale that put rare gems on the market.

4. The famous collector held a sale that put the diamonds right back onto the open market again.

Sentence #7. PLANTS 25 syllables 13 before/12 after

COMP.

1. Using special kinds of insect spray on all the plants may keep the leaves safe from aphids in the summer.

2. Using special kinds of insect spray may keep the plants safe from attacks of aphids during the summer.

3. The use of special kinds of insect spray on the plants may keep the leaves from being attacked by aphids.

4. Insect spray may keep aphids from attacking the plants during the very early part of the summer.

COORDINATE

1. We've used special kinds of insect spray on all the plants, but the leaves are still attacked by tiny aphids.

2. We've used insect spray on all of the leaves, but the plants are still attacked by small aphids in the summer.
ADV.

1. Ever since we used special insect spray on the plants, the leaves have been safe from attacks of small aphids.

2. Ever since we used insect spray on the leaves, the plants have been safe from most attacks of tiny aphids.

3. We have used special kinds of insect spray on the plants ever since the leaves were attacked by small aphids.

4. We've used insect spray on the leaves ever since the plants were attacked by several kinds of tiny aphids.

RELATIVE

1. The special insect spray that we use on all the plants keeps the leaves safe from aphids during the summer.

2. The insect spray that we use on the leaves keeps the plants safe from attacks of aphids during the summer.

3. We use a special kind of insect spray on the plants that keeps the leaves safe from aphids in the summer.

4. We use an insect spray on the leaves that keeps the plants safe from attacks of aphids during the summer.

Sentence #8. PARKWAYS 23 syllables 11 before/ 12 after

COMP.

1. Starting such massive repairs on the parkways might really jam up traffic during the rush hour.
2. Starting road repairs might jam up the parkways with extra heavy traffic during the rush hour.

3. Some of the massive repairs on the parkways might start jamming up traffic during the rush hour.

4. Road repairs might start jamming up the parkways with extra heavy traffic during the rush hour.

**ADV.**

1. Because repairs were started on the parkways, heavy traffic was jammed up during the rush hour.

2. Because road repairs were started, the parkways jammed up with heavy traffic during the rush hour.

3. Some of the repairs were stopped on the parkways because traffic was jammed up during the rush hour.

4. Some road repairs were stopped because the parkways jammed up with heavy traffic during the rush hour.

**RELATIVE**

1. The repairs that were started on the parkways might really jam up traffic during the rush hour.

2. The repairs that were started jammed the parkways with extra heavy traffic during the rush hour.

3. Some repairs were just started on the parkways that might jam the road with traffic during rush hours.

4. Road repairs were started that jammed the parkways with extra heavy traffic during the rush hour.

**COORDINATE**

1. Massive repairs were started on the parkways and heavy traffic jammed up during the rush hour.

2. Massive road repairs started, and the parkways jammed up with heavy traffic during the rush hour.
Sentence #9. CHIEF 23 syllables 15 before/8 after

COMP.

1. That the officer would give a false report to the chief upset all the men on the police force.

2. That the officer would give a false report upset the chief of the city police force very much.

3. The new officer personally reported to the chief that the men on the force were upset.

4. The new officer personally reported that the chief of the police force was very upset.

ADV.

1. Because the new officer gave a false report to the chief, the men on the police force were upset.

2. Because the new police officer gave a false report, the chief of the force was very much upset.

3. The new officer personally reported to the chief, because the entire force was upset.

4. The officer reported personally because the chief of the police force was very upset.

COORDINATE

1. The new officer had given a false report to the chief and the men on the force were upset.

2. The new officer had given a false report and the chief of the police force was very upset.

RELATIVES

1. The officer who had given a false report to the chief upset all the men on the police force.
2. The new officer who gave a false report upset the chief of the city police force very much.

3. The new police officer had personally given the chief a report that upset the whole force.

4. The officer had given a report that upset the chief of the city police force very much.

Sentence # 10. SQUAD 25 syllables 13 before/12 after

COMP.
1. That the sergeant would give such quick orders to the squad surprised every man at battalion headquarters.

2. That the sergeant would give such orders surprised the squad at the main headquarters of the third battalion.

3. The experienced sergeant gave orders to the squad that they should surprise the enemy battalion.

4. The experienced sergeant gave orders that the squad should surprise the battalion of the enemy.

COORDINATE
1. The old sergeant had given quick orders to the squad, yet the men were still surprised by the enemy.

2. The old sergeant had given quick orders, yet the squad was still surprised by the enemy battalion.

ADV.
1. After the sergeant had given orders to the squad, the men were surprised by the enemy battalion.

2. After the sergeant had given his orders, the squad was surprised by every enemy battalion.
3. The old sergeant gave several quick orders to the squad, after the men were surprised by the battalions.

4. The sergeant gave several quick orders after the squad was surprised by every enemy battalion.

RELATIVES

1. The sergeant that had given quick orders to the squad surprised every man at battalion headquarters.

2. The sergeant that gave such quick orders surprised the squad at the main headquarters of the third battalion.

3. The experienced old sergeant had given the squad orders that surprised every man at headquarters.

4. The sergeant had given orders that surprised the squad at the main headquarters of the third battalion.

Sentence #11. FAMILY 24 syllables 14 before/10 after

COMP.

1. Promptly ordering some reserve tickets for the family will assure good seats at the symphony.

2. Promptly ordering some tickets will assure the family of good seats at the symphony concert.

3. A prompt order of some reserve tickets for the family will assure your getting good concert seats.

4. Reserve tickets will assure you of getting the family some good seats at the symphony concert.

COORDINATE

1. Promptly order several reserve tickets for the family and be assured of seats at the concert.
2. Promptly order reserve tickets and assure the family of good seats at the symphony concert.

ADV.
1. When you promptly order reserve tickets for the family, you can be assured of good concert seats.
2. When you promptly order tickets, you'll assure the family of good seats at the symphony concert.
3. You should promptly order reserve tickets for the family when you want assurance of concert seats.
4. You should promptly order tickets, when the family wants assurance some good concert seats.

RELATIVES
1. The tickets that you (ha)'ve promptly ordered for the family will assure good seats at the symphony.
2. Tickets that you've promptly ordered will assure the family of good seats at the symphony concert.
3. You should have promptly ordered some tickets for the family that will assure them of good concert seats.
4. You should have ordered tickets that will assure the family of good seats at the symphony concert.

Sentence #12. WIDOW 27 syllables 16 before/ 11 after

COMP.
1. Becoming involved in an extended affair with the widow convinced the man of marriage in the future.
2. Being involved in an extended affair convinced the widow of a possible marriage in the future.
3. Involvement in a rather extended affair with the widow possibly convinced the man of marrying her. (mar-ing)

4. An extended affair convinced the man of marrying the widow quite possibly in the very near future.

COORDINATE

1. That man was involved in an extended affair with the widow, but she finally convinced him of marriage.

2. That man was involved in an extended affair, but the widow finally had convinced him of a marriage.

ADV.

1. Before the man could even begin an affair with the widow, she convinced him of a possible marriage.

2. Before the man could even begin a long affair, the widow had convinced him of a possible marriage.

3. The man began a rather extended affair with the widow before she could convince him of a marriage.

4. The man began an extended affair that convinced the widow of a possible marriage in the future.

RELATIVES

1. The man who had become involved in an affair with the widow might be convinced of marriage in the future.

2. The man who had been involved in an affair convinced the widow of a possible marriage in the future.

3. The man had become quite seriously involved with the widow in an affair that convinced him of marriage.

4. The man became involved in an affair that convinced the widow of a possible marriage in the future.
1. That the movie producer would send a cable to the actress raised the agent's expectations of a contract.

2. That the producer sent a cable raised the hopes of the actress for a generous movie contract very soon.

3. The important movie producer had cabled to the actress that a contract could be expected very soon.

4. The movie producer cabled to the agent that the actress could expect a generous contract very soon.

COORDINATE

1. The movie producer had sent a long cable to the actress, and the agent raised his hopes for a film contract.

2. The producer sent a cable to the agent, and the actress raised her expectations of a movie contract.

ADV.

1. Because the movie producer sent a cable to the actress, the agent soon raised his hopes for a film contract.

2. Because the producer sent the agent a cable, the actress raised her hopes for a generous movie contract.

3. The movie producer had sent a long cable to the actress, because the agent had hopes for a film contract.

4. The producer sent the agent a cable because the actress had hopes for a very generous film contract.
RELATIVES

1. The movie producer who had sent a cable to the actress raised the agent's expectations of a contract.

2. The producer who sent a cable raised the hopes of the actress for a generous movie contract very soon.

3. The movie producer had sent a long cable to the actress that raised the hopes of the agent for a contract.

4. The producer sent a cable that raised the hopes of the actress for a generous movie contract very soon.

Sentence #14. SINGER 26 syllables 14 before/12 after

COMP.

1. Arguing violently with the band about the singer provoked the director during most rehearsals.

2. Arguing violently with the band provoked the singer during almost every one of the rehearsals.

3. Arguments with members of the band about the singer provoked the director into firing her. (fi-er-ing)

4. Arguments provoked the director into firing the singer during almost every one of the rehearsals.

COORDINATE

1. The band got into violent arguments with the singer, and the director was provoked at rehearsals.

2. The band got into violent arguments, and the singer became more and more provoked at the rehearsals.
ADV.

1. After the band had many arguments with the singer, she was finally fired by the director. (fi-erd)

2. After the band had too many arguments, the singer was finally fired by the director himself.

3. The whole band had many arguments about the singer, after she was fired by the director himself.

4. The whole band had many arguments, after the singer was finally fired by the director himself.

RELATIVES

1. The arguments that the band got into about the singer provoked the director during most rehearsals.

2. Arguments that the band got into provoked the singer during almost every one of the rehearsals.

3. Almost every member of the band had got the singer into arguments that provoked the director.

4. The band got into arguments that provoked the singer during almost every one of the rehearsals.

Sentence #15. CLASS 24 syllables 11 before 13 after

COMP.

1. The fact that there was so much noise from the class got the teacher into trouble with the principal.

2. The fact that there was so much noise got the class in really serious trouble with the principal.

3. There was constantly so much noise from the class that the teacher got in trouble with the principal.

4. There was so much noise from the room that the class got into serious trouble with the principal.
ADV.

1. Because there's always so much noise from the class, the teacher could get in trouble with the principal.

2. Because there's so much noise from the room, the class could get in serious trouble with the principal.

3. There should really be much less noise from the class, because the teacher could get in serious trouble.

4. There should really be less noise, because the class could get in serious trouble with the principal.

COORDINATE

1. There must really be much less noise from the class, or the teacher will get into serious trouble.

2. There must be less noise from the room, or the class will get in serious trouble with the principal.

RELATIVES

1. All the noise that constantly comes from the class could get the teacher in trouble with the principal.

2. The noise that comes from the room could get the class in really serious trouble with the principal.

3. All of the noise constantly comes from the class in the room which got in trouble with the principal.

4. All the noise comes from the room in which the class got into serious trouble with the principal.
1. That lazy caretaker's ignoring most of the grounds turned the yard into a heap of weeds.

2. That caretaker's ignoring the yard had turned the grounds into a big heap of ugly weeds.

3. That lazy caretaker of nearly all of the grounds ignored the yard's turning into weeds.

4. That lazy caretaker of the yard ignored the grounds turning into a big heap of weeds.

COORDINATE

1. That lazy caretaker ignored most of the grounds, and the yard turned into ugly weeds.

2. That lazy caretaker ignored the yard and the grounds turned into a heap of ugly weeds.

ADV.

1. Because that lazy caretaker had ignored the grounds, the yard turned into a heap of weeds.

2. Because the caretaker had ignored the yard, the grounds turned into a heap of ugly weeds.

3. That lazy old caretaker ignored most of the grounds, because the yard had turned into weeds.

4. That old caretaker ignored the yard because the grounds had turned into a big heap of weeds.

RELATIVES

1. The caretaker who ignored nearly all of the grounds turned the yard into a heap of weeds.

2. The caretaker who ignored the man's yard turned the grounds into a big heap of ugly weeds.
3. The caretaker ignored nearly all of the grounds of the man whose yard had turned to weeds.

4. The caretaker ignored the yard of the man whose grounds had turned into a big heap of weeds.

Sentence #17. BOOKS 24 syllables

COMP.

1. The efficient clerk's auditing of some of the books keeps accounts of the company up to date.

2. The clerk's auditing of all the accounts keeps the books of the company completely up to date.

3. The clerk can efficiently audit some of the books by keeping accounts completely up to date.

4. The clerk can audit the accounts by keeping the books of the company completely up to date.

COORDINATE

1. The clerk can efficiently audit some of the books and keep the company's accounts up to date.

2. The clerk audits some of the accounts, and keeps the books of the company completely up to date.

ADV.

1. Now that the efficient clerk has audited the books, the company's accounts are kept up to date.

2. Now that the clerk has audited the accounts, the books of the company are all kept up to date.

3. The clerk can efficiently audit some of the books, now that the accounts are all kept up to date.

4. The clerk audits more efficiently now that the books of the company are all kept up to date.
RELATIVES

1. Any clerk who can efficiently audit the books can keep the company's accounts up to date.

2. Any clerk who can audit accounts can keep the books of the company completely up to date.

3. Any clerk can most efficiently audit the books of accounts that are completely up to date.

4. Any clerk can audit for a company whose books are most always kept completely up to date.

Sentence #18. HOUSE 17 syllables 9 before/
8 after

COMP.

1. To put up some new screens on the house would keep the rooms free of insects.

2. To put up new screens would keep the house free from many kinds of insects.

3. All of the new screens up on the house are to keep the rooms insect-free.

4. All the new screens are to keep the house free from many kinds of insects.

ADV.

1. If you'll only put screens on the house, the rooms will be free of insects.

2. If you'll only put up screens, the house will be mostly free of insects.

3. You might put up new screens on the house if the rooms are full of insects.

4. You might put up new screens if the house is full of most kinds of insects.
COORDINATE

1. Put all of the new screens on the house and the rooms will be insect free.

2. Put up all the new screens and the house will be free of many insects.

RELATIVES

1. The new screens that you put on the house keep the rooms free of most insects.

2. The screens that you put up keep the house free from many kinds of insects.

3. Put up screens on those rooms of the house that get the most insects in them.

4. Put up screens at the time that the house gets the most insects in the rooms.

Sentence #19. WALLS 21 syllables

COMP.

1. For the nurse to hang up pictures on the walls might cheer up the new patient in the room.

2. For the nurse to hang up prints might make the walls cheerful for the new patient in the room.

3. The nurse wanted the bright pictures on the walls to cheer up the new patient in the room.

4. The nurse wanted the pictures to make the walls cheerful for the new patient in the room.

COORDINATE

1. The nurse hung up some bright pictures on the walls, and the rooms looked more cheerful to patients.

2. The nurse hung pictures in the rooms, and the walls looked much more cheerful to the new patients.
ADV.

1. Because the nurse hung bright pictures on the walls, the rooms looked more cheerful to the patients.

2. Because the nurse hung up bright pictures, the walls of the rooms looked more cheerful to patients.

3. The nurse hung up some bright pictures on the walls because the rooms would look much more cheerful.

4. The nurse hung up bright pictures, because the walls of the rooms would look cheerful to patients.

RELATIVES

1. The pictures that the nurse hung up on the walls made the room more cheerful for the patient.

2. The pictures that the nurse hung up made the walls more cheerful for the patient in the room.

3. The nurse hung up some bright pictures on the walls of the room that the new patient was in.

4. The nurse hung up some pictures that made the walls of the room more cheerful for the patient.

Sentence #20. COFFEE 23 syllables 13 before/10 after

COMP.

1. The fact that retail prices were so high for coffee made tea a bargain by comparison.

2. The fact that prices were so high for tea made coffee a real bargain by comparison.

3. Retail prices have been getting so high for coffee that tea is really quite a bargain now.
4. Prices have been getting so high for tea that coffee is quite a bargain by comparison.

COORDINATE

1. Retail prices have been getting higher for coffee, but tea is really quite a bargain now.

2. Prices have been getting higher for tea, but coffee is quite a bargain by comparison.

ADV.

1. Although retail prices are very high for coffee, tea is a bargain by comparison.

2. Although most retail prices are high for tea, coffee is quite a bargain by comparison.

3. Many retail prices are very high for coffee, although tea is really quite a bargain.

4. Most prices are very high for tea, although coffee is quite a bargain by comparison.

RELATIVE

1. The very high prices that have been charged for coffee make tea a bargain by comparison.

2. The high prices that have been charged for tea make coffee a real bargain by comparison.

3. Higher prices have been charged for the types of coffee that compare with tea in retail (re-ta-ul) trade.

4. High prices have been charged for types of tea that coffee can be compared with in retail (re-ta-ul) trade.
Sentence #21. SHOWERS 23 syllables 14 before/9 after

COMP.

1. For each of those swimmers in the gym to use the showers would deplete the hot water supply.

2. For those swimmers to use the gym would deplete the showers' supply of hot water completely.

3. Too many of the swimmers in the gym used the showers for there to be much hot water left.

4. Too many of the swimmers used the gym for the showers to have very much hot water left.

COORDINATE

1. Every one of the swimmers in the gym used the showers, and the hot water was depleted.

2. Every one of the swimmers used the gym, and the showers' supply of water was depleted.

ADV.

1. Before many swimmers in the gym had used the showers, there was a large supply of hot water.

2. Before too many swimmers had used the gym, the showers had a large supply of hot water.

3. Every one of the swimmers in the gym used the showers before the water was depleted.

4. Each one of the swimmers used the gym before the showers' hot water supply was depleted.

RELATIVES

1. Many of the swimmers who had been using the showers depleted the hot water supply.

2. The swimmers who had used the gym depleted the showers' supply of hot water completely.
3. Too many of the swimmers had been using the showers in the gym which was short of water.

4. Too many swimmers had been using the gym whose showers were already short of hot water.

Sentence #22. COEDS 27 syllables 15 before/ 12 after

COMP.

1. For the dean to respond to a few demands of the coeds would almost satisfy the dorm committee.

2. For the dean to respond at all would satisfy the coeds from the committee on women's dormitories.

3. The dean's favorable response to the demands of the coeds seemed to satisfy the dormitory council.

4. The dean's favorable response seemed to satisfy the coeds from the committee on women's dormitories.

COORDINATE

1. The dean responded to some of the demands of the coeds, and the dorm committee was almost satisfied.

2. The dean responded to some of the demands, and the coeds of the dorm committee were almost satisfied.

ADV.

1. Even though the dean might respond to demands of the coeds, the dorm. committee will hardly be satisfied.

2. Even though the dean might respond to the demands, the coeds of the dorm council will hardly be satisfied.

3. The dean should at least respond to the demands of the coeds, even though the dorm will hardly be satisfied.
4. The dean should respond to the demands, even though the coeds of the dorm council will hardly be satisfied.

RELATIVES

1. The dean that responded to a few demands of the coeds almost satisfied the dormitory council.

2. The dean that responded favorably satisfied the coeds from the committee on women's dormitories.

3. The office of the dean had given a few of the coeds a response that satisfied the dorm committee.

4. The dean's office gave a response that satisfied the coeds from the committee on women's dormitories.

Sentence #23. MATCH 27 syllables 14 before/
13 after

COMP.

1. Your tennis partner's being so confident of the match won you a spot in the national tournament.

2. Your tennis partner's being so confident won the match for you both in the international tournament.

3. Your partner in the very early stages of the match was confident of winning the tennis tournament.

4. Your first partner was confident of your winning the match easily in the national tennis tournament.

COORDINATE

1. Your tennis partner was very confident of the match, and you both won the international tournament.

2. Your partner was quite confident, and you both won the match easily at the national tennis tournament.
ADV.

1. After your partner was much more confident of the match you both won a spot in the national tournament.

2. After your partner was more confident, you won the match easily at the national tennis tournament.

3. Your tennis partner was much more confident of the match after you won the international tournament.

4. Your partner was more confident after you won the match easily in the national tennis tournament.

RELATIVES

1. A partner that would have had more confidence in the match could have won you a spot at the tennis tournament.

2. A partner that had more confidence could have won the match for you both at the national tennis tournament.

3. Your partner in the very early stages of the match had the kind of confidence that wins a tournament.

4. Your partner had the kind of confidence that wins the match at every international tennis tournament.

Sentence #24. PLOT 28 syllables 16 before/12 after

COMP.

1. The fact that quite a few politicians knew details of the plot brought the watergate case to public attention.

2. The fact that politicians knew details of the case brought the plot of the watergate to the public's attention.

3. A few of the more intelligent politicians in the plot knew that watergate would get public attention.
4. A few intelligent politicians should have known that the plot of the Watergate would get public attention.

COORDINATE

1. A few politicians have known all along about the plot but the facts on Watergate have just been made public.

2. Some politicians knew all along about the case but the plot of Watergate is just now being made public.

ADV.

1. Even before a few politicians knew details of the plot, Watergate was brought to the public's attention.

2. Even before the politicians knew all the details, the plot of Watergate was brought to public attention.

3. Quite a few politicians knew about the details of the plot even before the Watergate was made public.

4. Politicians knew details of the case even before the plot of Watergate was brought to public attention.

RELATIVES

1. The politicians that knew details of the plot brought the Watergate case to public attention.

2. The politicians that knew the details of the case brought the plot of the Watergate to the public's attention.

3. Some of the politicians knew only those facts about the plot that were being brought to the public's attention.

4. Some of the politicians knew all the facts that had brought the plot of the Watergate case to public attention.
APPENDIX III-B

TABLE A-15

ASSIGNMENT OF SENTENCES TO SUBJECTS, EXP. III

<table>
<thead>
<tr>
<th>Group</th>
<th>Clause Type</th>
<th>Sentence Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,5</td>
<td>Coordinates</td>
<td>1-12</td>
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<tr>
<td></td>
<td>Relatives</td>
<td></td>
</tr>
<tr>
<td>2,6</td>
<td>Coordinates</td>
<td>13-24</td>
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<td></td>
<td>Complements</td>
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<tr>
<td>3,7</td>
<td>Adverbials</td>
<td>13-24</td>
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<tr>
<td>4,8</td>
<td>Adverbials</td>
<td>1-12</td>
</tr>
<tr>
<td></td>
<td>Complements</td>
<td>13-24</td>
</tr>
</tbody>
</table>
APPENDIX III-C

TABLE A16
EXP.III.: ASSIGNMENT OF SENTENCES TO SUBJECTS,
BY CONDITIONS

Group I. Coordinates (Sentence sets 1-12)
Relatives (Sentence sets 13-24)

24 Sets

12 Coordinates (1-12)

12 Relatives (13-24)

6 Probe 1st
6 Probe 2nd

3 S,M
3 M,S
3 S,M
3 M,S

1st 64 Subjects (1-6)
(7-12)

(a) Probe 1st
(b) 2nd
(c) Probe 1st
(d) 2nd
(13-15)
(16-18)
(19-21)
(22-24)

2nd 64 Subjects (7-12)
(1-6)

(19-21)
(22-24)
(13-15)
(16-18)
TABLE A16—continued

ASSIGNMENT OF SENTENCES TO SUBJECTS, BY CONDITIONS

Group II. Coordinates (13-24)
Complements (1-12)

<table>
<thead>
<tr>
<th>24 Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 Coordinates (13-24)</td>
</tr>
<tr>
<td>6 Probe 1st</td>
</tr>
<tr>
<td>1st 64: (13-18)</td>
</tr>
<tr>
<td>6 Probe 2nd</td>
</tr>
<tr>
<td>(19-24)</td>
</tr>
<tr>
<td>12 Complements (1-12)</td>
</tr>
<tr>
<td>3 S,M</td>
</tr>
<tr>
<td>(a) Probe 1st</td>
</tr>
<tr>
<td>(1-3)</td>
</tr>
<tr>
<td>3 M,S</td>
</tr>
<tr>
<td>(c) Probe 1st</td>
</tr>
<tr>
<td>(4-6)</td>
</tr>
<tr>
<td>3 S,M</td>
</tr>
<tr>
<td>(b) 2nd</td>
</tr>
<tr>
<td>(7-9)</td>
</tr>
<tr>
<td>3 M,S</td>
</tr>
<tr>
<td>(d) 2nd</td>
</tr>
<tr>
<td>(10-12)</td>
</tr>
</tbody>
</table>

| 1st 64: (13-18) |
| 6 Probe 2nd |
| (19-24) |
| 2nd 64: (19-24) |
| 3 S,M |
| (a) Probe 1st |
| (1-3) |
| 3 M,S |
| (c) Probe 1st |
| (4-6) |
| 3 S,M |
| (b) 2nd |
| (7-9) |
| 3 M,S |
| (d) 2nd |
| (10-12) |
TABLE A16—continued

Group III. Adverbials (13-24)
Relatives (1-12)

24 Sets

12 Adverbials (13-24)
6 Probe 1st
3 S,M
(a)
(13-15)

6 Probe 2nd
3 S,M
(b)
(19-21)

3 M,S
(c)
(16-18)

3 M,S
(d)
(22-24)

1st 64 subjects

12 Relatives (1-12)
6 Probe 1st
3 S,M
(a)
(1-3)

6 Probe 2nd
3 M,S
(b)
(4-6)

3 S,M
(c)
(7-9)

3 M,S
(d)
(10-12)

2nd 64 subjects

(13-15)

(16-18)

(19-21)

(22-24)
TABLE A16—continued

Group IV. Adverbials (1-12)
Complements (13-24)

24 Sets

12 Adverbials (13-24)
6 Probe 1st
3 S,M
(a) (1-3)
6 Probe 2nd
3 S,M
(b) (7-9)
3M,S
(c) (4-6)
3M,S
(d) (10-12)

12 Complements (1-12)
6 Probe 1st
3S,M
(a) (13-15)
6 Probe 2nd
3M,S
(b) (16-18)
3S,M
(c) (19-21)
3M,S
(d) (22-24)

1st 64 Subjects

2nd 64 Subjects
APPENDIX III-D

FILLER MATERIAL. OUT-PROBES

1-Clause Sentences

1. Six housing units are especially designed for handicapped persons. SILLY

2. First priority for residents in the new complex will go to senior citizens. SCOUR

3. Any coach fare ticket on that particular airline can save you money. STOVE

4. The last survivor had left an account of the ordeal in the Arctic camp. TERRAIN

5. The new treasurer of the club should be honest enough for everyone's satisfaction. LOW

6. The rather grimy individual in the back seat of the old Plymouth was drunk. DUSTY

7. Dining room tables of dark mahogany are now being sold at fantastic prices. LISTEN

8. The spokesman for the reporters requested an interview at the end of the press conference. BOX

9. Nationwide tests show some improvement in mail service over the past fifteen months. KNOW

10. The rise of the steam ship changed the character of plantation life. EXPLAIN

20--2-clause sentences

comp: ("M"=main, 1st or 2nd clause order)

M1-1) Several people forced the foreign students to leave the hotel. SORT

M1-2) Jim ordered his young brother to wash the dirty dishes. FLAKED

M2-3) Seeing the executive at the rock concert astounded the workers. FORTUNATE
M2-4) The report that the foghorn was going constantly in the nearby harbor upset my uncle. OPTION

M2-5) To sight UFO's in the backyard would startle my parents. DENTAL

ADVERBS

Main 1st

M1-6) The soldiers were very tired because the battle had lasted ten hours. BIRD

M1-7) George paused for a few moments before he crossed the street. BLUE

M1-8) Customers complained to the manager when lettuce went up to forty cents a head. HEAVY

Main 2nd

M2-9) When a nineteen-year-old youth was shot, women marchers protested the killing. YIELD.

M2-10) Since the crowd was disorderly and noisy in the town hall, they were arrested. TENDER

COORDINATE

11) Either Jack failed completely, or I have been deceived. BUILD

12) An hour ago the man called from the garage, and he was rather angry. PILL

13) The mailman knocked quite loudly, but everyone was away from home. TIGHT

14) Frank has a beautiful baritone voice and he will do a good job on the aria. TELL

15) Please yell, or press the button by your bedside. RIPE
RELATIVES

Main 1st

M1-16) The drama club could surely have found someone who was tall enough for the part. TISSUE

M1-17) Most of the people ignored the girl who was sitting in a corner. FLACCID

M1-18) A few of those magazines come from the stack given to me by my aunt. MAGNETIC

Main 2nd

M2-19) The man giving the sports roundup only had a few scores from last night's game. BLACKSMITH

M2-20) Some of the letters which were stolen from the office were important. CONCERNS

3-Clause Sentences

COMP

Main 1st

1. The usher warned the audience to quit smoking during the movie. GREEN

Main 2nd? or 3rd?

2. Finding a gold ring in the attic convinced the woman to look more thoroughly in the debris. SIP

3. The fact that the commander worried about handling the crew was no surprise. TWIJS

4. To make tasty Chinese soup, it's necessary to use saki. AFFECT

ADVERBIALS

Main 1st

1. The librarian had been reading before the shelves fell over and distracted her. KITCHEN
Main 2nd--3rd

2. Because England sent rations of food to Biafra, many children could be fed and thus avoid starvation. SELF

3. When the dignitary arrived at the station, everyone who was on the platform waved. CERTAIN

4. After the plumber fixed the leak, the faucet still dripped and caused extensive damage. WORSE

COORDINATE

1. The new bridge saves time but there's a heavy toll charge, so it may not be used by many people. PEAR

2. The carpenter must do a good job, or we will hire someone else, and get the work done properly. SULK

3. A major source of this city's pollution is the nearby river, but the factories also contribute, and so do the cars. DYE

RELATIVES

Main 1st

1. The soldier shot the sniper who had injured several persons on the walk which bordered the park. BLAST

Main 2nd--3rd

2. The dictator the people despised spent his fortune on a woman who was breathtaking. FOOL

3. The bundle which was left here was tied with a ribbon that had polka-dots on it. SEAS

4. The cheese that's in the refrigerator should be wrapped in the foil that's in the drawer. BULB
23 Clauses+Mid.

1.b. After a large demonstration, a mob is hard to disperse quickly. MOB

2.(6.a). A recent institute-wide survey shows that secretaries are unable to push into administraive positions. SECRETARIES

3.c) When grass is scarce in the Southwest, cattle are likely to feed on prickly pear cactus. CATTLE

4.a) In an emergency strangers are reluctant to send help. STRANGERS

5.b) Some marriage counselors believe that wives are easy to control in the home. WIVES

6.c) African game wardens believe that elephants are likely to move to new ranges only in the spring. ELEPHANTS

7.(8.c) Management consultants agree that corporations are unlikely to divide into smaller companies. CORPORATIONS

8.a) As every parent knows, a boy is reluctant to clean up at dinner time. BOY

9.b) Some psychologists argue that children are simple to dress in hand-me-down clothes. CHILDREN

(10.b) According to Esquire magazine bachelors are impossible to entertain at home. BACHELORS

11.b) Modern military theory holds that a recruit is tough to train for all eventualities. RECRUIT

12.(11.c) After a year of independent study, a student is wrong to teach the following year. STUDENT

13.a) After an undisputed victory, generals are wise to retire on a pension. GENERALS
14.c) When recovering from the flu, convalescents are right to keep indoors on cold days. CONVALESCENTS

15.b) Some radical students claim that universities are difficult to change from within. UNIVERSITIES

16.a) In good times and in bad friends are eager to please in little ways. FRIENDS

17.b) Even in the seventh grade some girls are easy to date regularly. GIRLS

(18.c) Because clear water permits a real spotting, submarines are right to hide during the day. SUBMARINES

6 IN, +Phrase, +Mid.

Compounds

1. 2cl, Comp, M1, probe 1st clause, 1st member

   The illustrious musicians in the string quartet wanted to give a special performance of baroque works. STRING

2. 3-cl, R., main 2nd, probe 2nd, and 2nd member

   The man who was in charge of apparatus described the digital timer that was to be used in the test. TIMER

3. 3-cl, Co, probe 3rd cl, probe 1st member

   In the writer's workshop, some people wrote sonnets, others wrote blank verse, and the rest tackled short stories. BLANK

Adj. & NP

4. 3cl, adv. main 2nd, probe 3rd cl, P-2nd member

   After it rained last week, the sky finally cleared, and the normal level of pollution went down a bit. LEVEL
5. 3-clause, comp, main 1st, P2nd cl, P-1st member

The prophet asked his disciples to find young people who were very dedicated. YOUNG

6. 2cl, R., M2, P-1st cl, P-2nd Member

Anyone who is even properly trained has a problem in the job market now. TRAINED

In-Fillers (32, +Phrase)

Probe toward end of sentence:

Adj. phrase, probe 2nd member:

1. C, 3-cl, M 1st, P 3rd cl, 2nd member

John thought that the circus bear could continue balancing the tiny ball on his nose. BALL

2. R., 2-cl main 2nd, P 2nd cl.

A psychiatrist who treats hundreds of cases a year needs a long vacation every few months. VACATION

3. Co, 2 Clause, main 1st, probe 1st cl, 2nd member

The van will definitely come in early afternoon, and then we can move. AFTERNOON

4. ADV., 2-cl, main 2nd, probe 2nd clause

Long after all of the guests had left the hall, the tired hosts were still cleaning. HOSTS

Adj. phrase, probe 1st member:

5. Comp., main second, P 2.

Jerry's drawing the picture so rapidly impressed his doting mother. DOTING

6. Rel., 3 cl, main 1st, p-l

The departmental secretary is getting in touch with the unfortunate students who have an advisor who never comes to school. UNFORTUNATE
7. Co, 2 cl, probe 2nd cl.
   His aunt was a peasant woman, but his uncle was a renowned scholar in his own right. RENOWNED

8. Adv, 2-cl, main 1st, probe 1st cl, 1st member
   The collie ran along the edge of the small beach, as the tide was going out. SMALL

End probe

Compound, probe 2nd member

1. 2 cl, main 1st, probe 1st cl., Comp.
   The chairman of the socialist group invited the day laborer to speak at the next meeting. LABORER

2. Rel., 2 cl, main 2nd, probe 2nd
   The natives we saw depended on a medicine man for nearly everything. MAN

3. co, 3-clause, probe 2nd cl.
   The tenor was in fine condition, and he got a standing ovation, but the opera itself was dull. OVATION

4. adv., 2 cl, main 2nd, probe 2nd
   Ever since the lake was opened to the public, summer cottages have been popular. COTTAGES

Compound, probe 1st member

5. comp, main 2nd, probe 2nd cl.
   For the audience to give the speaker strong apple..se would please the toastmaster at the banquet. TOAST

6. rel, 2 clause, main 1st, probe 1st
   Overnight guests in the old hotel should summon a bellboy who can assist them. BELL
7. co, probe 2nd clause, 2 clauses

The boy wanted a job as a welder, but he was afraid of blow torches in the shop. BLOW

8. adv, 3-clause, main 1st, probe 3rd

The star player will be excused from further games, since his knee gave out after the kick-off was made. KICK

In-fillers, 16 start-of-sentence-probes

adj. phrase, probe 2nd member

1. comp, 3-clause, main 1st, probe 1st

The wholesaler warned the timid merchant that the strike would continue to increase the cost of the goods. MERCHANT

2. rel, 2 cl, m2, p2

A man who smokes might be a bad choice for a woman with many allergies. CHOICE

3. co, 2cl, m2, p1

The new bride is a fine cook, and she's also quite a seamstress. BRIDE

4. adv, 2cl, m2, p2

Before my mother came home, the efficient maid had done a thorough job in all of the rooms. MAID

adj. phrase, probe 1st member

5. comp, 2 cl, m2, p2

Falling down would make a shy debutante unhappy at her coming-out party. SHY

6. rel, 3 clause, main 1st, p2

This wrench may reach the bolts that the stupid repairman put underneath the shelf that's in the basement. STUPID
7. co, 2-cl, m2, p2
Climb up and find the loose wire on that antique chandelier from Aunt Sally's apartment. LOOSE

8. adv, 2-cl, m1, p1
Our loud stereo bothers the neighbors, although we only turn it on once in a while. LOUD

**Compounds, probe 1st member, starts.**

1. comp, 2-cl, m1, p1
All the tenants of the townhouse asked the commission to check into the legal rent. TOWN

**Fillers, in-probes, starts, compounds, 1st member**

2. r2, m2, p2
The gardener we hired left the power mower on in the middle of the yard out of sheer neglect. POWER

3. co-3, pl
Buy the foreign car now, or the dealer will get edgy and sell it to someone else. FOREIGN

4. 2-cl, adv, m2, p2
When we came back, the blackboard was full of graffiti. BLACK

5. compound, probe 2nd member
comp, 2-cl, m2, p2
The lady asked that the cab driver take the shortest possible route to the airport. DRIVER

6. rel 2, m1, p2
The origin of the Yankee Clipper is a mystery to people who know little about New England. CLIPPER

7. co, 2, m2, p2
The chicken looked done but the white meat was still a little too pink for my family's tastes. MEAT
8. adv, 3cl, ml, pl

You might like this spy novel, if good plots intrigue you, and you have a far-out imagination.
NOVEL
APPENDIX III-E

EQUIPMENT FOR EXP. III

The following changes were made in the test apparatus in order to insure that the equipment would work reliably for all 128 subjects: since the opening and closing of the shutter caused a large inductive kick, the start signal had to be conditioned. A monostable circuit was built and inserted between the shutter switch and the timer start terminals. The output of this circuit was normally high. When the shutter opened, the shutter switch closed and Q went low for 4 seconds and then high again. During those 4 seconds, the timers were protected against false restarts. They were also protected from false zeroing from the subject's RT key through a bounce-eliminator circuit.

The last problem left was an occasional false restarting of the 10-second timers. It was traced to the MagneCORD tape recorder and the voice key. A Tandberg recorder was then substituted and the voice key circuit was modified. Figure A-10 on the next page illustrates these changes.
FIGURE A10
Equipment for EXP. III

a) Initial set-up

b) Zener Diode Protection Circuit
BIBLIOGRAPHY
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(Includes Supplemental Material)


VITA

The author, Judith R. Kornfeld, was born July 31, 1948, in Oklahoma City, Oklahoma, where she lived until 1953, when she and her family moved to Wichita, Kansas. There, she attended elementary and secondary schools, and graduated from Wichita High School Southeast in 1966. From 1961 through 1966, Ms. Kornfeld focused her interests on the physical sciences and the Classics. She participated in local, state, and national competitions in each of these areas, and received honors in both Science Fairs and Latin contests. During the same period, she studied piano with Dr. Robert Steinbauer at Wichita State University, and was active in local and regional piano auditions.

In 1966, she accepted a four-year academic scholarship at the University of Chicago, which she attended until 1969. Although she concentrated on linguistics and humanities at Chicago, she also maintained her interest in music, and studied with Felix Ganz at the Roosevelt Conservatory in Chicago. In 1969, she received a B.A. in Linguistics, with Honors in Humanities, and was elected to Phi Beta Kappa of Illinois. The following year, she entered the graduate
program in linguistics at M.I.T. and was awarded an NSF graduate fellowship. She was an NSF Fellow for two years, and an NIMH Fellow and teaching assistant thereafter, until her graduation in 1974.

While at M.I.T., she extended her work in linguistic theory to the areas of acoustic phonetics, speech recognition, language acquisition, and psycholinguistics, the latter being her field of concentration. Reports of her research have appeared in the Quarterly Progress Reports of M.I.T.'s Research Laboratory of Electronics, and the Proceedings of the annual meetings of the Chicago Linguistics Society.

Ms. Kornfeld is currently an Assistant Professor of Speech in the Department of Speech at Temple University, in Philadelphia. She is teaching linguistics and humanities courses there, and continuing her research in sentence processing and child language acquisition.