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Parsing Routines in Syntactic Processing: The Effect of Expected Word Order on Sentence Comprehension

Ann Dibella Jablon
Graduate Center, City University of New York

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Jablon, Ann DiBella

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PARSING ROUTINES IN SYNTACTIC PROCESSING:
THE EFFECT OF EXPECTED WORD ORDER
ON SENTENCE COMPREHENSION

by

ANN DiBELLA JABLON

A dissertation submitted to the Graduate Faculty in Speech and Hearing Sciences in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

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Date

Chair of Examining Committee

[signature]

4/18/86

Date

Executive Officer

Robert W. Fiengo

Michael Studdert-Kennedy

Supervisory Committee

The City University of New York

Abstract

PARSING ROUTINES IN SYNTACTIC PROCESSING:
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ON SENTENCE COMPREHENSION

by

Ann DiBella Jablon

Advisor: Professor Helen Smith Cairns

Two experiments were conducted to test the SVO Expectancy Hypothesis. This hypothesis embodies three claims: (a) the syntactic parsing device has an initial expectation for the SVO (syntactically defined) structure, (b) the parser reads or tracks the syntactic information in the utterance to confirm or adjust its predictions, and (c) the parser has the ability to make on-line revisions based on the syntactic information contained within the utterance.

In the first experiments using tachistoscopic presentation, 75 sentences representing 15 different sentence types were read by subjects. Each type varied in structure and in the clarity of markers used to indicate interruptions or deviations from SVO structure. Comprehension time was measured. The results supported the hypothesis that the parser initially expects (predicts) an SVO structure. Furthermore, there was some tentative support for the claim that syntactic information which unambiguously marks the SVO interruptions or deviations facilitates parsing.

The second experiment employed the phoneme monitor task to test both the expectancy and the marker claims on-line. Sentences containing embedded subject and object relative clauses were presented auditorily to subjects. In addition, sentences containing object complements with and without selection restrictions and pragmatic constraints violated were presented to determine the level of processing at which semantic information is used. Experiment 2 failed to yield conclusive results. The failure was attributed to the inappropriate use of a nonmodular task to tap an informationally encapsulated system (parsing). Furthermore, an unanticipated materials effect may have contributed to the failure of the second experiment. Error data and follow-up probe tasks provided support for the SVO effect. In addition, these data suggested that selectional information is not read by the parser but subcategorization information is.

It was concluded that the results of Experiments 1 and 2 support the SVO Expectancy Hypothesis. It was suggested that future research focus on the marking system and the revision process.

For my mother.

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There is a myth about the loneliness of the dissertation writer. In fact, however, this writer, while apparently alone at her desk, was constantly crowded by the presence of legions of teachers, colleagues, and friends. These gentle Furies have dogged my heels over the years driving me to the completion of this task. To each and every one for his and her very real contribution to this work, I am grateful beyond words. To a very small, select few of this army I offer the following expressions of gratitude in the hope that all will read behind the lines.

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For my husband, Kenneth, who offered his love and his shoulder many, many years ago, there are no words, no expressions that can be garnered to convey my feelings. His constancy has been the source of my strength.

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CHAPTER ONE

Language Comprehension: Three Central Issues

What is human language? It is the goal of any number of scientific theories to provide an answer to this question. For example, linguistic theory has as its goal the description and explanation of the universal (and particular) formal properties of language. Psycholinguistics takes as its goal the explanation of how these formal properties are realized in the processes of comprehension and production. An explanation of how these two systems are acquired is the goal of research in developmental psycholinguistics; while physiological explanations are sought within the neurosciences. This is not an exhaustive list; however, these theories are the basic blocks upon which an understanding of the nature of human language can be built. The deepest understanding of human language will be achieved when the relationship among the diverse explanatory theories is illuminated as well. To that end, this study represents one very small fragment of the work to be done in human language research. However, in the necessary single-minded pursuit of each theoretical fragment, the larger goal of a cohesive theory must be kept in sight. To lose sight of this goal will result in the development of limited explanations destined to be abandoned. It would be incorrect to interpret the above comments as ultimately favoring a strict reductionist accounting of the language faculty. Rather, it is assumed that the theoretical claims from each scientific domain will converge in such a way that a unified model of human language will emerge.

The scientific domain within which one seeks to answer the questions of language will dictate the form of the questions posed, as well as the methods employed in conducting the research. This study continues the line of investigation into language comprehension. In particular, the focus of this study is the mechanism by which the structural description of an utterance is derived. The nature of this line of investigation has changed since research into syntactic processing began. However, the specification of the syntactic processing system, as well as the definition of the role syntactic knowledge plays in processing continues to be one of the central challenges in psycholinguistics.

Because perceptual systems presumably all evolved to organize incoming information into manageable, interpretable units, there should be identifiable basic principles which guide all processing. The acquisition of knowledge can be broadly thought of as learning to recognize the regularities of the world and, thus, learning to recognize the absence of these. Therefore, in developing perceptual theories, what must be developed are perceptual routines which detect regularity, along with a red flag system signalling the lapses, which serve to organize the encountered stimuli. We can postulate that a basic perceptual operation is "segment" and that like other perceptual processors, the syntactic processor learns particular segmentation routines based on its acquired knowledge of linguistic regularities. Additionally, it learns to search the incoming lexical string for the syntactic information which will engage a given routine. It may also learn when to shift into another routine and/or to abort routines inappropriately begun. It may be the case that it does not possess an abort function; but, rather, when faced with irreconcilable discrepancies between the data and the expected analysis, it plods along the original course. It then may send the problem phrase off to a second stage processor for resolution.[1] This perspective (of the no-abort function) derives from the often reported response to sentences in which syntactic illusions have been created (e.g., the classic "The horse raced past the barn fell.") Listeners have great difficulty interpreting these sentences. Indeed, some listeners fail to interpet these as grammatically well-formed sentences. (See, for example, Limber, 1976; and Experiment 1, this paper.)

Although functions such as segmentation are often said to be "cognitively impenetrable" (Pylyshyn, 1981), the actual segmentation routines that the processor employs may be data dependent. That is, the processor may segment all incoming information, but the kind of information may determine how segmentation is accomplished. The segmentation routines used by the syntactic processor should be extremely limited, and thus affected by the data in that the processor can shift to an alternate existing routine or two, but then must resort to some interpretative stage in processing. The segmentation routines are early-learned, language-particular routines which are cognitively impenetrable. Thus the system which employs the segmentation routines will not be affected by the input beyond a predetermined and limited use of it. That is, the input information will serve to identify, verify, or contraindicate the use of a given segmentation routine. However, the information cannot engender a routine not previously a part of the system; nor sidestep the segmentation process by appealing to another level of processing. This is presumably different from changes in response to context, mood, gender, etc. Those variables suggest a cognitively penetrable system which is characteristically in constant flux. As Pylshyn (1981) noted, there is a certain amount of neurological malleability. The syntactic processor, it is being claimed, is not penetrable, at least at some initial level.

The view of the syntactic processing stage of comprehension presented here is one which contains a level of processing based on functions such as "segment." Such functions guide the knowledge acqusition process. In the case of syntactic knowledge, these functions guide the acquisition of the formal properties of a particular language. They also guide the acquisition of the processing routines which will enable the listener to categorize input structures according to her grammar.

Thus, it is being claimed that the predisposition to organize language guides the child in learning his language. That is, perceptual functions and cognitive capacities guide the acquisition process along its course. Thus the child learns, among other things, the units of language and the appropriate ways for the units of language to be combined. He learns which sequences of linguistic units frequently, hence predictably, occur. These predictable sequences will mature into parsing routines that the adult depends upon during language comprehension. In addition, along the way, the child learns about his environment--the "real world." He formulates different kinds of knowledge schemes and expectancies based on his growing experiences. It would be surprising if this growing collection of information changes, in any significant way, his knowledge of the linguistic units and their allowable combinations. Within his own language, he will learn new words (but not new sounds or new sound patterns): he will learn to violate allowable combinations to create metaphor and poetry; he will learn that person A frequently uses this pattern, phrase, etc. This knowledge will influence his interpretation of the speech signal, but it is inconceivable that it will cause him to segment differently, or to any regular extent, circumvent the parsing routines.

The immediate challenge in constructing a theory of syntactic processing is (a) to identify the basic perceptual functions which underlie syntactic processing, and (b) to identify the processing routines which realize those functions. This study was an investigation of a syntactic processing routine which is hypothesized to derive from the perceptual function to impose order on the stimuli to be understood. It is hypothesized that the "impose order" function is a perceptual universal that governs some processing routine in every human language. Investigating the existence and universality of the "impose order" function is well outside the domain of this thesis. However, evidence for the existence of the syntactic processing routine in English, which is based on the proposed order function will constitute tentative as well as limited evidence for the function. The syntactic processing routine investigated in this research wil be described and explicated in chapters 2 and 4.

One of the pitfalls encountered in constructing theories of syntactic processing is the problem of developing appropriate methods for testing syntactic hypotheses. There are few, if any, tasks which have been employed which directly tap the early syntactic parsing stage. Even on-line tasks are no doubt tapping the output of a later interpretative state, as the early stage is, by hypothesis, rapid and automatic, and most likely not directly accessible. The failure to take this problem into account has led to proposals that cognitively penetrable functions (e.g. context) operate in syntactic parsing. It is suggested that these theories are based on spurious nonsyntactic effects which result from the inaccessibility of the early syntactic parsing stage. While the methodology which circumvents this problem has not been forthcoming, the awareness of the necessary distinction that must be made with regard to early and late processing variables can inform the interpretation of the data. The methodological issue, at least with regard to the results of this study, will be addressed in chapters 3 and 4.

There are three issues which are central to any discussion of syntactic processing. They are: (a) the relationship between linguistic competence and linguistic performance, (b) modularity or autonomy in syntactic processing, and (c) the limitation of short term memory (STM) and its effects on syntactic processing.

In the following sections I will discuss each of these issues. While I have chosen to treat these issues as separate and separable, it is clear to me that they are more integrally related than this format suggests. While this format might create some redundancy among the sections, I believe it is important to highlight the fundamental assumptions upon which parsing theories are built.

The Competence/Performance Distinction

Since the inception of contemporary linguistic thought (Chomsky, 1957), there has been debate regarding the relationship between linguistic competence and linguistic performance. Distilled to its essence, linguistic theory claimed that there existed a systematic relationship among various individual sentence types. These relationships could be understood in terms of a syntactic component comprised of a deep level of language which was related to a surface level of language through a system of rules. The rules described the changes which could lawfully apply to a basic structure in a language. Thus by invoking this description of human language the nature of the relationship between pairs of sentences was captured. For example,

(1) The mother kissed the baby.

(2) The baby was kissed by the mother.

one's intuitive sense of the structural relatedness of this pair is described by the derivations for each member.

The implications of this characterization of knowledge for a theory of language use were widely recognized; but not wholly accepted. One central issue was whether to introduce nonobservable variables into the scientific study of (language) behavior. Psycholinguistics was born in the rush of enthusiasm to demonstrate that indeed the mind was worthy of study. It is clear from the vantage point of time that Chomsky's claims filled a need in psychology. For the behaviorist paradigm, initiated as a methodological revolution to secure psychology's standing as a natural science, had devoided psychological theory of much of its content. The linguistic theory that Chomsky proposed paved the way for more substantive research in the area of language.

Thus, what began as psychological investigations regarding the reality of the linguistic constructs proposed by Chomsky has become the competence-performance issue. Essentially what researchers have sought to define is the relationship that exists between linguistic knowledge and linguistic use. The relationship has been variously defined. The earliest studies in psycholinguistics proclaimed support for an isomorphic relationship between proposed syntactic rules and the mental operations performed during comprehension (for example, Savin and Perchonock, 1965). While this view is no longer influential in the development of psychological models, there is currently research which assumes and supports a direct relationship between knowledge and use (e.g. Bresnan, 1978). At the other end of the spectrum, there are theories which deny that any relationship exists (for example, Clark and Haviland, 1974; Marslen-Wilson and Tyler, 1980), and that language processing is nonlinguistic in nature. There is a third view which proposes an inter-dependent relationship between the two components. Thus, it is claimed that certain linguistic rules exist to accommodate the processing system, just as certain processing operations exist because of the structure of language (for example, see Langendoen and Bever, 1976). There is also the perspective first articulated by Fodor and Garrett (1966) that the relationship between performance and competence exists; however, it is an indirect relationship. Processing operations are not said to mimic the linguistic rules; however, a structural description is assigned by the processing operations. How the processor has been proposed to accomplish this assignment will be discussed in chapter 2.

The strongest interpretation of the psychological reality condition, i.e., the claim of isomorphism, was articulated in the form of the Derivational Theory of Complexity (DTC). There are several reasons why DTC has been rejected as a theory of language performance. Among the most important are (a) that its initial success was limited to a very narrow range of linguistic phenomena; (b) that it failed to take into account STM constraints; (c) that many of the linguistic assumptions upon which DTC was predicated have subsequently been rejected. Whatever naivete has since been attributed to DTC, it is clear that all subsequent important claims in psycholinguistic theory have roots in the early research which the theory generated. The set of theories which can be categorized as "strategy" models (e.g., Fodor, Bever, and Garrett, 1974; Kimball, 1973; Frazier and Fodor, 1978) derive from the early findings which supported the reality of a level of structural representation. More direct ties to the DTC thesis can be seen in the current literature which has returned to a stronger interpretation of "realizable" (e.g. Bresnan, 1978; Crain and Fodor, 1984; Ford, Kaplan and Bresnan, 1982; Wanner and Maratsos, 1978). An additional perspective on this view has been contributed by Berwick and Weinberg (1983). While they make no substantive claims with regard to a processing model, their reinterpretation of the realization condition deserves consideration. I will summarize their perspective first; follow with a brief summary of Bresnan's position; and conclude with the Fodor, Bever, and Garrett view in an effort to explicate the current status of the competence/performance relationship. I will not discuss the interdependent perspective of the competence/performance distinction as the claims embodied in this view, while not incompatible, are beyond the scope of this thesis. Additionally, I will not discuss the research which takes as its assertion that the competence/performance distinction is at the least questionable, if not nonexisting. The processing theory being developed in this paper assumes some relationship between knowledge and use such that a structural representation is posited for every utterance during language comprehension. Thus, a discussion of the relative merit of a purely psychological account of processing is considered to be beyond the scope of this paper as well. (See Valian, 1979, for a review and discussion of the competence/performance distinction.)

The rejection of DTC resulted in the corresponding rejection of the isomorphic relationship between competence and performance, and for some, the rejection of Transformational Grammar as a theory of competence. In a consideration of the DTC failure, Berwick and Weinberg (1983) call these conclusions into question. They present a model of syntactic processing which reinterprets the DTC claims rejected. In doing so, they reject instead another assumption upon which most current models of syntactic processing are based.

Berwick and Weinberg have analyzed the claims of DTC as follows.

(1) Transformational Generative Grammar (TGG) is an appropriate theory of linguistic knowledge.

(2) This grammar is a component of the syntactic processing system whose parsing operations are isomorphically related to the transformation rules.

(3) The parsing operations are performed linearly and serially.

In re-examining these claims, they noted that the failure to demonstrate the psychological reality of the transformational rules has been attributed to the faulty nature of Assumption 1 (e.g., Bresnan, 1978), or of Assumption 2 (e.g., Fodor, Bever, and Garrett, 1974). They have proposed a different accounting. By varying the form of the parser (Assumption 3), Berwick and Weinberg have argued, it is possible to claim a direct role for TGG in parsing. Citing recent research in visual processing and motor control theories as a basis of support, they suggested that syntactic processing is a synchronous parallel process. This claim amounts to increasing the computational capacity of the parser by suggesting that it can perform several operations at one time. The net effect is a "speedup" of the processing of certain transformational rules (local dependency rules) which are precisely the rules which have not been "realistically captured" by TGG. Thus, they argued that if Assumption 3 is regarded as faulty both TGG and the isomorphic condition remain unchallenged.

A second challenge to the purported failure of TGG and its realization is raised by Berwick and Weinberg's suggested re-interpretation of the realization condition. Specifically, they have invoked the concept of a cover grammar from programming languages to justify a relaxation of this condition. If two grammars are related such that they both generate the same language, and the parses of one (G_1) can be recovered from the parses of the other (G_2) through some homomorphic recovery, then G_2 is said to cover G_1. The utility in the concept of a cover grammar is that it does not require an isomorphic recovery, thus we are free to propose a computationally expedient grammar which can be determined by the structure of the parser. However, the homomorphic relationship serves to limit the parsing algorithms to those which comport with the competence grammar. The realization condition is thus relaxed, while the competence grammar still maintains a central role in parsing.

While there currently exists no direct experimental evidence for either of Berwick and Weinberg's proposals, and, it is unclear at this time how these claims might be critically tested, they present a challenge to any pat solutions to the competence/performance issue. Their message is simply and rightly that there is no a priori reason to prefer a particular parser structure, or to insist on isomorphism as the only test of a realizable grammar. However, the Berwick and Weinberg view does represent a departure from the thinking upon which most research in performance has been predicated. The serial, linear model has been assumed, and isomorphism has been regarded as the only interpretation of realizable. Given these assumptions, two lines of thinking have evolved as a response to the failure of DTC.

Bresnan (1978, 1982) has argued for a strict interpretation of the realizable condition.[2] She has proposed that the failure to confirm the reality of certain transformational rules is a function of a faulty theory of the grammar (Assumption 1). Thus she has proposed a linguistic model which comports with the psycholinguistic data, and avails itself of the information which is stored in the lexicon. Lexical-Functional Grammar (LFG) is purely a model of linguistic knowledge which, Bresnan (1978) claimed, can be compatible with any type of parsing model (providing that it complies with Assumption 2 above). Ford, Kaplan, and Bresnan (1982) have presented a parsing model which is based directly on the properties of LFG; however, Bresnan (1978) has also shown that other models of processing (augmented transition network [ATN] models, for example) are compatible with an LFG theory of the grammar.

The main point to consider in reviewing the perspectives of Berwick and Weinberg and Bresnan is that the failure to demonstrate the reality of particular linguistic phenomena can no longer be regarded as a falsification of the reality hypothesis. In constructing a theory of parsing, one must carefully consider where the preponderance of the data lie with regard to the basic assumptions of performance theory. Does the evidence militate for a reconstruction of the grammar theory; a reconstruction of the parsing theory or parser structure; or is the more traditional view expressed in the work of Bever, Fodor, and Garrett still the research strategy that will prove most fruitful?

The Fodor, Bever, and Garrett perspective (see Fodor, Bever, and Garrett, 1974 for a full explanation) was derived basically from the rejection of Assumption 2. They postulated that a theory of performance could best be constructed when the distinction between performance and competence was clear. They proposed that there existed an abstract relationship between the grammar and the parser, and that the parsing operations could be thought of as heuristic strategies which the language user learned during the developmental period. Thus, psycholinguistic theory was endowed, in this view, with its own subject matter. Fodor, et al.'s work has been criticized for the arbitrary nature of the strategies proposed. For example, Frazier and Fodor (1978) have criticized the "ad hoc" nature of the strategies with regard to the architecture of the parser. They, instead, proposed strategies which derive directly from the limits and capacities of their two-stage parser. Wanner and Maratsos (1978) have criticized the arbitrariness of the strategies with regard to the loss of "linguistically significant generalizations" suffered when the grammar is not directly incorporated into the parsing system.

The issue remains so largely unresolved, for the sciences which define each of the mental components under discussion are young and the theories are yet subject to much testing and revision. The perspective on the relationship that holds between performance and competence which informs this thesis might best be described as tempered Fodor, Bever, and Garrett (henceforth FBG). In essence, FBG have called for a separation of levels of description in order to achieve greater explanatory adequacy. There is no doubt that most researchers currently addressing the issues in linguistics and psycholinguistics (adult and developmental) expect the points at which the performance and competence theories converge (isomorphically? homomorphically?) to be revealed at some time. It is this expected serendipity that keeps the separation between competence and performance from becoming wildly divergent. All thought in these disciplines should be guided by that expectation.

It is difficult to assess whether Berwick and Weinberg's notion of a cover grammar is merely a notational variation of FBG's heuristic strategy model. Clearly, there is conceptual superiority in calling for principled strategies as Frazier and Fodor have. What the guiding principles are or should be for research purposes perhaps are two different questions. Certainly, two different answers have been proposed, i.e., a direct or indirect role of the grammar in the comprehension process. This investigation favors a relaxed interpretation of the reality condition such that parsing principles must be sensitive to linguistic constructs; however, they derive from the hypothesized constraints and capacities of the parser. Whether this results in a theory of performance which relates homomorphically to a theory of competence remains to be seen. I do not see the specification of the homomorphism as an immediate goal. Nor does it make good research sense to write a theory of the grammar which is tailored to the parsing constraints. Isn't this, after all, a parsing grammar? For now, the conservative choice of a strict separation of performance and competence seems to be the most productive position, with one added condition. The one condition of systematically related strategies needs to apply in order for the theory of parsing to gain full theoretical status.

Summary

There are currently three views of the performance-competence relationship which underlie the major research models in language comprehension. Bresnan (1978, 1982) favored assigning a direct and transparent role to the competence grammar during the comprehension process. To this end, she has called for a revision of the competence grammar. The revision--LFG--Bresnan has offered is based on facts about the language (linguistic evidence) as well as the facts about the language user (psycholinguistic evidence).

Berwick and Weinberg (1983) also favored a direct role assignment for the competence grammar. However, they have called for a relaxation of the transparency condition and/or a reformulation of the assumed structural properties of the parser to account for the psycholinguistic evidence which contradicts TGG.

FBG (1974) favored an indirect, opaque relationship between performance and competence. They have retained the TGG model of the competence grammar and have called for a separation of performance theory from competence theory. In order to account for the psycholinguistic evidence they have postulated various parsing strategies which function to recover the deep sentoid underlying each surface clausal unit. These strategies have been criticized by Frazier and Fodor (1978) as well as by Wanner and Maratsos (1978) for their ad hoc nature.

The FBG view of performance/competence was the guiding influence for this study. However, the main thesis of this investigation is the related, and nonarbitrary nature of the parsing heuristics (see chapter 2). This perspective preserves the distinction between competence theory and performance theory, and captures the significant psycholinguistic generalizations which the data have revealed.

Autonomy in Processing

The assumption of a transparent relationship between linguistic theory and psycholinguistic theory carried with it the assumption of syntactic autonomy. The autonomy of syntax hypothesis refers to the existence of a syntactic component of the grammar which is only described in terms of syntactic primitives. Translated to processing, autonomy has come to mean that syntactic processing is initiated by a sub-processor which only refers to the syntactic properties of a sentence in its input, in its internal operations, and in its output.

When, in the mid-sixties, the perspective on the isomorphic relationship between competence and performance began to shift (see Fodor and Garrett, 1966), previous proposals of strictly autonomous processes gave way to proposals of interactive processing operations. Results regarding the apparent facilitating nature of semantic variables (for example, Slobin, 1966), as well as the generative semantics movement in linguistics (for example, Lakoff, 1971) militated for the assignment of a more powerful role to the semantic component in both theories. While this view is no longer among the dominant in linguistic theory (although, see Bresnan, 1978, 1982), psycholinguistic theory still bears its mark. Thus, what had been implicit under a DTC framework, i.e., the assumption of autonomy, now needs independent motivation.

It is easy to see why a theory of sentence comprehension would be susceptible to the introduction of semantic and real world knowledge variables as processing operations. The comprehension process is, by definition, one of recovering the meaning of the sentence. However, the question regarding autonomy in processing is not whether semantic and pragmatic variables operate during sentence comprehension. Rather, the question is how do they operate; and further, what, if any, is the nature of the interaction between syntactic and semantic/pragmatic variables. The proponents of non-autonomous theories assert that the influence is pervasive and that semantic/pragmatic variables can direct or override syntactic analyses. The proponents of autonomous processing models suggest that the semantic information from the lexicon or semantic information and real world knowledge from a context do not exert influence on the performance of a syntactic analysis. Rather, semantic and pragmatic information is employed at higher cognitive levels to effect choices or perhaps facilitate the assembly of the parsed units. On this view, syntactic complexity would be determined by the structural properties of a sentence, and semantic variables would not lessen the difficulty of the parse.

In this section I will attempt to provide the answers to the following two questions for purposes of motivating the autonomy principle. The questions are: (a) Is there reason to prefer autonomous models to more global models of processing?, and (b) is there evidence in favor of a processing mechanism that operates only on syntactic variables in order to determine the structural representation of a sentence? In addition, a third question to be considered is what problems will be encountered in testing the autonomy hypothesis. Are the problems methodological or are they indicative of the theoretical weakness of autonomy theories?

There are several a priori reasons to claim autonomy in syntactic processing. To begin with, psycholinguistic theory can be regarded as the interface between linguistic theory and neural theory (Cairns, 1980). Since both linguistic theory and neural theory are "two highly constrained, autonomous theories (p. 4)," it is a coherent position to take. This does not imply a return to the strong form of the transparency thesis with regard to linguistic theory. Nor does this view require a strict reductionist perspective with regard to neural theory. It simply states that the psychological theory of language should be compatible with linguistic theory and neural theory in its framework, though not necessarily in its details, if explanatory adequacy is to be achieved.

Beyond compatibility and coherence lies the issue of constraints. In general, constraints in science are far from limiting. The greater the constraints, the more falsifiable the data, thus we can have greater confidence that the data represent the facts. With regard to sentence processing, Forster (Forster and Olbrei, 1973; Forster, 1979) has argued that there is no hope for discovering the true nature of the syntactic processor unless we propose a constrained thus falsifiable theory. The autonomy hypothesis is able to make specific claims regarding syntactic processing. It is a highly constrained theory with strong, easily falsifiable claims. Interactionist theories endow the perceptual processes with so much power that perception is virtually all.[3] It is difficult to falsify the claims of the inter active theories, for as Fodor (1985) has noted, real world knowledge has an effect on comprehension on any view of processing. Thus evidence in support of interactive processing does not constitute evidence against an autonomous level of processing. However, evidence supporting the autonomy hypothesis does cast doubt on the interactive model. Hence the autonomy model is a stronger research model as it allows for choosing between the two theories.

Perhaps the most compelling reason to prefer the autonomy theory is that the human language system exhibits an amazing amount of regularity. And interestingly enough, human language learners seem to rely rather heavily on the regularities of the system. It would, in the face of these observations, seem somewhat contrary to propose that adult listeners (and speakers) fail to take advantage of syntax--the "economical packaging" (Limber, 1976) of the language system; and would, instead, rely on more idiosyncratic and often arbitrary contextual factors. A more reasonable hypothesis does seem to be one which states that for every instance of sentence comprehension there is a level at which some known structural description is advanced by the listener as a part of the utterance meaning. It seems clear that context effects are real and must be accounted for within a theory of language comprehension. The autonomy claim does not preclude such a statement. Nor does it demand a purely sequential model of processing. As stated above, the claim entails the postulation of a processing stage which is purely syntactic. At this stage we can hypothesize that the listener taps her linguistic knowledge by way of highly learned processing routines that are automatically deployed. These routines can be characterized as cognitively impenetrable operations (Pylyshyn, 1981). Thus, by definition, they are impervious to context. Context, in this view, will exert its influence in a less constrained stage.

While it can be concluded that there are several a priori reasons for preferring an autonomous language processing model, these reasons do not constitute evidence for its existence. The second question to be addressed is, therefore, what evidence does exist in support of an autonomous or modular model of the perceptual system. The data which directly support the autonomy hypothesis are limited. The evidence in favor of an autonomous stage during lexical processing is more firmly established. However, there does exist some support for the autonomy of a syntactic parsing stage.

Forster and Olbrei (1973) demonstrated in a series of experiments using decision latency and rapid serial visual presentation (RSVP) tasks that the difference in processing time between active and passive sentences obtained whether the sentence version was reversible or irreversible. In the same paper, using the decision latency task, Forster and Olbrei reported that variations in plausibility did not affect "the time required to analyze a particular syntactic structure" (p. 329). This confirmed an earlier result (Forster and Ryder, 1971) which employed the RSVP task on essentially the same materials. In total, these results were interpreted to indicate the presence of a "constant" processing time for a structural type regardless of the semantic properties of the sentence. This constant time was taken as evidence for a level at which a syntactic analysis is performed without benefit of semantic and pragmatic cues, which is the autonomy (or constancy, as Forster and Olbrei called it) claim.

Additional experiments employing recall tasks and sentence classification tasks (reported in Forster, 1979) investigated the effects of plausibility on sentences containing order errors. Order effects were found to remain constant despite the plausibility version in which the order errors were embedded. Thus, the main results of these investigations indicated that the locus of the plausibility effects was not within the syntactic processor.

More recently, Rayner, Carlson, and Frazier (1983) conducted two experiments in which they measured eye-movements while subjects read structurally ambiguous sentences. The sentences were constructed so that they varied with regard to plausibility. Reyner, et al. found that subjects selected a particular syntactic analysis without regard to the plausibility of the reading. Furthermore, they found that semantic and plausibility factors only affect the "ultimate" analysis of a sentence, not the initial structural analysis. They concluded that there is a separate and independent mechanism which computes the structural analysis of a sentence during comprehension.

Cowart and Cairns (1984, fully described in chapter 4) used a next word naming task to investigate the effects of structural, selectional, and pragmatic anomalies on syntactic processing. They concluded from their data that only the structural anomaly was successful in blocking an inappropriate analysis. Neither the selectional nor pragmatic anomalies were observed to block this incorrect structural analysis.

They conclude that these results accord with the modularity view of processing.

While these authors proposed somewhat different accounts of the language comprehension system, they have all concluded that there exists a stage at which a structural analysis is computed unaided by semantic or pragmatic factors. It is true that there is a limited amount of data which has been accrued in support of the autonomy hypothesis. However, these data are the results of carefully controlled studies (see Cowart, 1983) which employ measures apparently sensitive to syntactic variables. I will comment briefly at this time on the question of methodological problems in the study of syntactic parsing. This theme will be addressed in subsequent chapters of this thesis.

Much of the initial evidence for on-line interactive theories was derived from studies using post-sentential measures to support on-line semantic and pragmatic effects. That these variables affect sentence processing is not disputed. The autonomy issue is centered around developing the appropriate cognitive architecture of the processing model. Thus autonomous models predict different loci for linguistic and nonlinguistic effects than interactive models do. (As a result, they claim different degrees of cognitive penetrability for the perceptual system.) The more recent use of on-line measures in syntactic processing research has provided support for the claim that a structural level of processing exists. However, not all on-line measures are equally sensitive to syntactic variables (for example, see the discussion of the results of Experiment 2, this paper). The rapid, automatic, and unconscious nature of syntactic parsing makes it difficult to develop tasks which tap these early processes. Furthermore, semantic and pragmatic effects occur so rapidly within comprehension (for example, see Cairns and Kamerman, 1975), that nearly any response required of a subject occurs beyond the time frame of the unaided parse. Finally, linguistic theory is not currently thought to provide specific guidelines for predicting psycholinguistic complexity. Thus, the selection of what to measure in order to tap syntactic effects is no longer constrained by a theory independent from psycholinguistic theory.

All of these methodological problems make the interpretion of the data difficult, and the evaluation of the competing theories more so. However, the results of the studies cited above provide promise for testing the autonomy hypothesis. Perfecting these methodologies, and employing careful controls will provide some insurance against a false rejection of the autonomy hypothesis.

Summary

To claim autonomy in syntactic processing is to claim that there is a stage of sentence comprehension during which a syntactic analysis is performed on an input by consulting the immediately available syntactic elements of that input string. This hypothesis stands in opposition to those which claim that semantic factors can facilitate syntactic processing. While the research supporting the autonomy hypothesis for syntactic processing has been limited, the results have been replicated across several tasks. In addition, the research supporting the autonomy of the retrieval stage in lexical processing has been more extensive and conclusive (see Cairns, 1980 for an extensive review of the autonomy issue). It would seem odd indeed to have a partially autonomous processing model that was not autonomous in the syntactic component, given the current form of the linguistic theory to which processing theory is presumably linked.

The autonomy in syntactic processing claim is assumed in this work for various reasons. The most important with regard to this current investigation is that it is the most constrained theory of processing, and is, therefore, the most fruitful research strategy.

Short Term Memory and Syntactic Processing

The last issue to be discussed as having influence on parsing theory construction is the capacity of the processing mechanism. My preliminary remarks will draw on the insights provided by Miller (1956), for these insights form the foundation upon which models of sentence perception have been built. While the ostensible span of immediate memory seems to correspond to the span of absolute judgment (i.e., seven categories wide), Miller has made another suggestion, namely that recoding plays a very important part in perception (of language). The concept of recoding, borrowed from information theory, refers to the transformation of information during transmission. In the case of language comprehension, the recoding process serves to reduce the burden on STM by creating chunks of information comprising increasingly larger numbers of bits and chunks. Thus, while STM capacity is constant, recoding enables large amounts of information to be operated on by a funneling process, so to speak. In the face of the severe restriction on STM, along with the sizable burden placed on it by the time demands of comprehension, added to the complex nature of even the simplest utterance, recoding becomes a useful concept.

It is easy to see why the early psycholinguistic research embraced Transformational Grammar. In the form of transformational rules, TG provided the description of the recoding operations, while the concept of deep structure provided the description of the information after recoding took place. There is appeal in this wedding as the recoding process was a psychological operation in search of detail. That linguistic theory provided the detail seemed fortuitous, to say the least. The outcome of the early research is not so important as is the fact that Miller's notions of recoding and chunking in language use as they were described in that 1956 paper have influenced the construction of many subsequent significant models of processing.

Despite overt differences in the proposed architecture of the mechanisms, current processing models generally reflect the "recode into chunks" principle of economy. Kimball (1973) proposed a two-stage model of syntactic processing in which the first stage parses and packs phrases which are then shunted to a second stage where the entire phrase marker is assembled. Similarly, Frazier and Fodor (1978) proposed a two-stage model which operates on approximately seven lexical items at a time. Completed parcels are shunted when there are no longer attachment possibilities within the current phrase being constructed. The STM constraints are thus explicitly handled in these models by first-stage parsers which formulate syntactic chunks on the basis of some predetermined operating routines. These chunks are more or less formulated without consulting information other than that available within the parser. However, both models allow for a limited "look ahead" function to avoid constant premature shunting. As Frazier and Fodor (1978) pointed out, the utility of a two-stage syntactic processor is that each stage does as much as it can. STM is relieved of extreme burdens by virtue of early, automatic chunking which allows more complex decisions to be made at the later stage.

The FBG (1974) model was also a two-stage operation with a similar distribution of functions between the two stages. The early parsing routines, upon which FBG focus, operate to recover the "deep sentoid." In this view, the packaging unit is clausal in nature. Thus, once the clause has been segmented and its internal relationships specified, it is shunted to the second stage where the clauses will be assembled into the appropriate sentence marker. Unlike Kimball (1973), and Frazier and Fodor (1978), FBG do not detail the relationship between the two stages. Likewise, the parsing routines they propose are not intrinsically related to the "two-stagedness" of their model which distinguishes it from the others.

While not expressed in a two-stage structure, ATNs (e.g. Wanner and Maratsos, 1978) take advantage of the recoding and chunking hypothesis. Thus, there are networks which package and store phrases with their assigned function until the end of the phrase is reached, and the syntactic analysis is completed. Since the recoding concept does not entail a specific architecture, we can ask if there is any reason to prefer one type of structure.

While there seems no direct evidence in support of a two-stage model, there does seem to be merit in the claim. To begin with, consider the lexical processing stage. There is evidence which points to an autonomous retrieval stage followed by a decision making stage in which the appropriate reading is selected (see Cairns, 1984 for a full discussion.) The retrieval stage has been characterized as an automatic, unattended stage of processing (Yates, 1978). While there is not a perfect analogy between lexical processing and syntactic processing, it does seem that if we claim autonomy in syntactic processing, we are led to a similar two-stage model. Thus, by analogy, the syntactic processor is a two-stage processor. The first stage is an autonomous, automatic and unattended stage which recodes the input utterance. Recoding reduces the amount of information that the second stage, the decision stage, must contend with.

Secondly, the two-stage models which have been proposed make specific claims about the nature of the operations which perform the initial parse. Kimball (1973) identified seven parsing strategies, six of which were first-stage routines while the seventh described the transfer of information to the second stage of the processor. Frazier and Fodor (1978) discussed two strategies which are a by-product of the structure of their mechanism. FBG (1974) have proposed several heuristic strategies which were widely investigated throughout the seventies. On the other hand, we find, at least at this time, ATNs to be very flexible models of processing. A change in schedule can handle one criticism (see, for example, Wanner, 1980), an additional loop can handle another, etc. Until ATNs are further specified, i.e., more constrained, they fall into the same empirical trap that nonautonomous, interactive models do. They remain essentially unfalsifiable, and, therefore, increase the risks that the true nature of the mechanism will remain obscured. This does not imply that ATNs, or other one-stage syntactic processors can never be adequate research models. Rather, under the current specifications ATNs do not allow for critical tests of the structure of the mechanism. And, to my knowledge, there are no other one-stage autonomous models of syntactic processing which have made testable claims (see Berwick and Weinberg, 1983, discussed above).

The two-stage models touched upon in this section distinguish themselves primarily on the basis of what each claims to be the parsing unit. Kimball (1973) proposed the phrase as the unit of parsing; while FBG (1974) held that the surface clause is what is operated on by the parser. In contrast to these linguistically specified units, Frazier and Fodor (1978) argued that length is the determiner of the parsing unit.

Specification of the parsing unit and the operations performed by the parser derive from yet another facet of the immediate memory constraints and their effects on syntactic processing. That is, the notion of syntactic complexity in processing is the psychological result of burdens placed on STM. These burdens arise when structures violate, in some way, the normal operations of the parser. This causes, perhaps, subroutines to be engaged; reprocessing to take place; phrases to be held beyond the allotted time; etc. This aspect of syntactic processing will be discussed in chapter 2. Specifically, I will consider the proposals that have been made to account for processing complexity post-DTC.

Chapter 2 will conclude with a discussion of a parsing strategy which, I will claim, can account for many of the observations discussed.

Summary

Recoding as a solution to the problem of the known restrictions on STM was discussed. Several models which make use of the recoding concept were reviewed.

It was concluded that two-stage models of syntactic processing make stronger predictions with regard to the nature of the syntactic processing mechanism. In addition, to the extent that unity is a desirable trait of a psychological theory, it was noted that lexical processing is a two-stage procedure. These two facts underlie the selection of a two-stage processing model as the structure of the mechanism investigated in this study.

Notes for Chapter One

[1]It has been observed (personal communication, M.S. Chodorow, March 18, 1986) that "abort" may take precisely this form. That is, the parser encountering "fell" cannot revise the structural analysis which it has performed. The inability to revise arises from the absence of markers, as far as the parser can determine, contraindicating the original analysis. Thus "abort" can possibly be defined as an unrevised (unrevisable) incorrect structural analysis which is sent to higher cognitive levels for further processing.

[2]Crain and Fodor (1984) have taken a position which is conceptually similar to Bresnan. They suggested that the parser has direct access to the rules of the grammar which are directly available for parsing application. They have argued here (and elsewhere) for a generalized phrase structure grammar (GPSG), and for a GPSG parsing model as a strong theory of language knowledge and use.

[3]Fodor (1985) has argued against effacing the distinction between perception and cognition. Perception is a fast, here-and-now process; while cognition is a slow, long-term process. Fodor argued that the architecture of the two systems must reflect their differences. Fodor has proposed that perception is an "informationally encapsulated system," i.e., an autonomous, rigid, constrained system--a psychological module. In contrast, cognition is a nonencapsulated, holistic system, hence it is not modular.

CHAPTER TWO

Syntactic Processing: Theories of Parsing

The theories of syntactic processing which have been proposed over the past 25 years are superficially diverse. The observed diversity basically derives from the particular position each researcher has adopted with regard to linguistic theory (e.g., a transformational-generative grammar, a phrase structure grammar, a lexical-functional grammar, etc.); the relationship between linguistic and psycholinguistic theories (i.e., direct or indirect); and the autonomous (or nonautonomous) nature of processing. It is the purpose of this chapter to examine a representative set of psycholinguistic theories in order to identify areas of convergence among the various processing theories. The theories selected for investigation all assume that a structural analysis is computed during the comprehension process, and they all propose a set of strategies or routines which are deployed to accomplish the analysis. It will be suggested that the identified common properties among these models are those properties which best reveal the nature and operations of the syntactic processing mechanism.

The Task of the Parser

The task of the syntactic processor is to provide a structural analysis of the input such that the internal relations among the words of a clause, as well as the relationship among the clauses of an utterance, are specified. It is generally agreed that the processor performs this analysis left-to-right in real-time. On some views there is an initial stage in which the processor makes on-line decisions consulting only the syntactic elements of the input and the rules of the grammar to which it has access, ignoring until a later stage semantic and contextual information. The initial stage of syntactic processing is the focus of this paper. This stage will be referred to as the parsing stage, and the device which performs the analysis will be referred to as the parser.

The syntactic processor makes errors. These errors derive, by hypothesis, from the strength of the first order strategies that the parser applies in performing its analysis. While some errors apparently pass through the entire system undetected, other errors are detected and changed. Thus the syntactic processor must be capable of reprocessing; however, it must be sufficiently confident in its original analyses that reprocessing, which is costly on any view of comprehension, is kept to a minimum. There has been controversy as to whether the parser produces a number of alternative analyses when local (structural) ambiguities are encountered. If so, then a decision stage needs to be postulated; if not, then a "revision" mechanism which operates on-line (see Frazier, 1978) should be proposed.

Short Term Memory and the Unit of Perception

The limitations of STM have posed one of the most interesting challenges to psycholinguists. Namely, how does the mechanism operate on a rapidly arriving, rapidly decaying signal in a 'space' which is not capacious? This dilemma gave rise to the concept of a unit of perception, that is, a piece of the signal which was segmented out of the incoming information, recoded, and cleared from working memory, thus freeing memory for the next segment. By far, the most influential proposal of the syntactic perceptual unit of choice was the clause.

The exact nature of this clausal processing unit has been controversial. There are data which suggest that the underlying "sentoid" is the unit of segmentation (e.g. Bever, Lackner, and Kirk, 1969); as well as data which point to the surface clause as the segmentation unit (e.g., Chapin, Smith, and Abrahamson, 1972). Additional research has suggested that the notion of clause should be modified to include a range of clause and clause-like structures which all function as clauses within the sentence structure (Tanenhaus and Carroll, 1975). The semantically complete "functional clauses", on this view, were hypothesized to serve as the segmentation unit. In general, these studies of segmentation relied on extraneous noise location methods. Known collectively as the "click" studies, this research was conducted primarily by Bever, Fodor, and Garrett along with several others. Given the phenomenon of perceptual closure, it was hypothesized that errors in locating noise bursts placed within sentences revealed the nature of the perceptual unit. Both recall and recognition tasks were observed to produce the same result, i.e., displacement to a boundary location. Using an on-line modification of the click paradigm, Holmes and Forster (1970) measured reaction times (RTs) to clicks placed within a clause or adjacent to the boundary. The boundary effect was confirmed, as RTs to the boundary-adjacent clicks were faster. Thus, the general finding that breaks between (roughly) clausal units attracted clicks indicated the perceptual integrity of these units. At least some of the conflicting claims regarding the nature of the clause (e.g., deep or surface) have been obviated by current linguistic theory.

Other paradigms, however, were also employed to test the clause processing theory. In the main, a strong "clause boundary effect" has been supported. This has been taken as support for the clausal theory of processing. For example, probe studies have indicated that an occurrence of a clause boundary causes a decline in the subjects' performance on an otherwise identical sequence. Caplan (1972) presented pairs of two-clause sentences which differed in two ways: (a) the initial portion of the first clause, and (b) the location of the clause boundary. Subjects were to indicate whether a single word heard after the sentence had actually occurred within the sentence. For each sentence pair the probe word was identical and was drawn from the same position in the sentence. The manipulated variable was whether the boundary preceded or followed the probe word. Recognition latencies were as predicted on clausal theory, longer when the probe word preceded the clause boundary.

The deletion of clause boundary cues was shown to increase sentence complexity. For example, Fodor and Garrett (1967) used double-center-embedded sentences presented with and without the relative pronoun. Using a paraphrase task, they found that the deletion of the cue to the embedded relative clause affected the subject's ability to accurately paraphrase the sentence. Hakes and Cairns (1970) used an on-line measure, the phoneme monitor task, to test these sentences. In those versions from which the relative pronoun had been deleted, the phoneme monitor latencies were longer for target sounds contained in the second verb which followed a clause boundary.

The clausal processing theory was also tested with a sentence completion paradigm. For example, Bever, Garrett, and Hurtig, 1973; and Hurtig, 1975 presented subjects with sentence fragments which were structurally ambiguous or non-ambiguous forms of complete or incomplete clauses. Bever, et al. used visual presentation; Hurtig presented the sentences auditorily. The results of both studies indicated that the structurally ambiguous, incomplete clauses took significantly longer to complete than the nonambiguous or clausally complete fragments. These results were taken as supportive of the clausal processing hypotheses, as the ambiguity effect was no longer detectable once the clauses boundary had intervened.

The clausal theory was widely held from the late sixties to, at least, the mid-seventies. However, other proposals for the unit of segmentation were considered, although not as widely investigated. In an influential paper, Kimball (1973) proposed that the unit of segmentation was the phrase. In Kimball's model, completed phrasal packages were cleared from STM and assembled into a completed phrase marker at a later stage in syntactic processing.

Limber (1976) suggested that listeners expect (and package) alternating patterns of NPs and VPs. Expectancy was defined in terms of an evaluation template. The notion of an alternating order is appealing in its allusion to the alternating acoustic structure of consonant vowel syllables. This aspect of Limber's proposal for syntactic processing procedures will be discussed in a later section. However, the main point here is that while clausal theory has dominated the syntactic processing literature, there are alternatives to this approach which account for the observed data but suggest a quite different mechanism.

A radically different perspective was contributed by Frazier and Fodor (1978). They proposed that there exists no unit of segmentation in syntactic terms. Instead, they have suggested that the mechanism has a "narrow viewing window" which severely limits the number of items which can be processed at one time. (They have suggested that this number is approximately seven items in length.) Thus, length is the variable which selects the unit of perception during syntactic processing.

In response to Frazier and Fodor's (1978) proposed length constraint on syntactic processing, Milsark (1983) has, in effect, resurrected the essence of the clausal processing theory. He claimed that "the parser is upward bounded by S" (p. 133). His hypothesis comports with the clause processing literature in general, as well as some interesting observations of the main-subordinate clause relationship. For example, the paradoxical findings that the main-subordinate order is facilitating in comprehension (Holmes, 1973), while the subordinate-main order facilitates verbatim recall and recognition (Jarvella and Herman, 1972; Cairns and Jablon, 1976) can be explained by a processing device which is constructing an S phrase marker.

This observation cannot be as readily accounted for by Frazier and Fodor's claim with regard to length as the operating variable in sentence segmentation. Frazier and Fodor wanted to appeal explicitly to STM limits with regard to the local attachment preferences their subjects expressed. However, in building the limits directly into the design of their model, they lose the ability to account for those times when the view is expanded to include longer stretches of the utterance. The amount of information available in STM seems to be determined by the syntactic properties of the utterance (e.g., subordinate-main clause order--perhaps clausal relationships, in general), which Frazier and Fodor are obliged to ignore, at least at first stage processing.

The identification or explanation of segmentation units has been motivated by the acknowledged limits of STM and the time pressure that the conversational process exerts on the parser. In accordance with the recoding principle (Miller, 1956), many researchers have proposed that smaller pieces of the utterance are preselected by the parser as recoding units. With the exception of Kimball's (1973) phrasal unit, the unit of segmentation seems to be a clause-like or clause-sized unit. Whether it is syntactically or functionally defined, or whether it is an accident of length, is an empirical question. While Frazier and Fodor's length variable does not speak against the autonomy principle, as Milsark has criticized it seems too "quirky" to appeal to a nonsyntactic parameter when an explicitly syntactic hypothesis can account for the same data and also explain some curious exceptions to Frazier and Fodor's predictions as well.

Milsark's "locality principle" is parallel to the claim for "structurally governed locality" in the grammar; thus it indirectly expresses a link between the performance and competence systems. These types of links between the performance routines employed by the language user and the grammar are highly desirable. They are facts about use which derive from the same source as the facts about knowledge do, i.e., language, itself, and, indeed, the human mind which encompasses it.

Milsark's notion of the importance of the sentence boundary in syntactic processing (see also, Cairns and Jablon, 1976) is a unifying concept which accounts for the clause processing research as well as Frazier and Fodor's data; however, it is in conflict with Kimball's theory of phrasal packaging.

There is evidence for the phrase as a perceptual unit to be found in the click literature. It was demonstrated that phrase boundaries exhibited some of the same attraction tendencies as the clause boundary. However, these tendencies were not stable or strong, most likely confirming the hypothesis that phrasal units are recognized as having integrity, but not necessarily supporting the phrasal segmentation hypothesis. While clearing phrases as soon as they are determined as such might have some appeal as a concession to STM capacity, it is probably in the long run a less efficient system than one in which larger units are analyzed and assembled in the initial stage. A lot of little packages are as clumsy to handle as a large unwieldy one is. Furthermore, a phrase-shunting device will need to rely on a look ahead function and will frequently find exceptions to its shunting procedures. It seems more desirable to propose procedures which will be upheld rather than excepted most of the time.

The Structure of the Parser

The acceptance of the segmentation hypothesis leads naturally to the postulation of a two-stage model of syntactic processing. FBG (1974), Kimball (1973), and Frazier and Fodor (1978), all have proposed variations on the two-stage model in order to accommodate their views on segmentation.

On the FBG view, the parser seeks the clause boundary, segments out this clausal unit and provides a structural analysis of the clause-internal relationships. When the structural description has been provided for this segment, the processed clause is sent to some holding area which will provide a description of the relationships among the clauses of an utterance once all the information has been collected. Essentially, their first stage processor is a segmenter, as well as an analyzer of the grammatical relations. The second stage is an assembler.

Kimball has expressed the same view of the division of labor for his syntactic processing model. Kimball asserted that the parser packages each phrase as it is completed and sends each package along with pointers for its location within the phrase markers to the Processing Unit. Here the entire phrase marker is assembled. Kimball's use of the phrasal unit allows this process to proceed uniformly for simple as well as complex sentences. In the FBG model it is not clear how the second stage handles simple sentences. For example, how long is a clause retained before it is judged independent from subsequent incoming clausal structures? That material might be held unnecessarily seems to be an inefficient statement of processing. The second stage of the FBG model, rather than being an integral part of the structure of the processing device is, instead, a clumsy ad hoc supplement in acknowledgment of STM constraints. Similar criticisms have been made of the strategies proposed by FBG which will be discussed in the next section. In contrast, in Kimball's model the second stage provided the motivation for the parsing routines employed by the first stage parser. Again, these strategies will be discussed subsequently. Where FBG and Kimball are in agreement is in the postulation of a parser/assembler processing device.

Frazier and Fodor (1978) have also accepted this division as the appropriate characterization of the syntactic processor. The first stage, the sausage machine, provides the phrase marker for whatever appears in its narrow window; however, it is unable to keep track of what was previously constructed. Thus, again the second stage is characterized as an executive division that is responsible for the assembly of the entire phrase marker. Both Kimball's model and Frazier and Fodor's model do not allow the second stage to guide the analyses performed by the first stage parser. Thus even though the second-stage has access to information about previously parsed items, the parser relies only on the strategies it routinely employs in accomplishing its task. FBG's model also functions in this way; however, it is of no significant interest in their model as the clause is completely processed before it is shunted. Presumably, their second stage would provide little, if any, guidance for accomplishing the first-stage analysis.

Despite the proposed variations in the relationship between the two stages in syntactic processing, there is agreement that the actual parse is performed during the early stage of processing and the reconstruction of the entire input takes place later in the process. In compliance with this conception of syntactic processing for the remainder of this paper the first stage of syntactic processing will be referred to as the parsing stage, and the device as the parser. The second stage will be referred to as the processing stage and the device as the processor.[1]

The question regarding the nature of the second stage remains open. To date, there are no data which supports the characterization of this stage as either perceptual or cognitive. (See Fodor, 1985; also chapter 1, Note 1). Frazier and Fodor (1978) claimed that their model is a two-stage parsing model which performed its analyses and assembled the phrases without reference to semantic information. This places their model in the perceptual system within an apparently modular architecture. On the other hand, Kimball (1973) allowed that semantic information was possibly utilized during the second stage (processing), linking the processing stage to cognition. It is not clear at this time if a two-stage perceptual model yields a clear advantage with regard to overcoming STM constraints during language comprehension. Furthermore, it is not clear how the second stage would be (could be) tested in order to determine whether it was perceptual or cognitive. How one views this stage at this time seems more related to how one believes the processing system should be constrained. There are certainly data which indicate that semantic effects are facilitative in processing (e.g., irreversible passives). In light of these findings, it is possible that the proposal of an autonomous second stage in syntactic processing is not theoretically justified.

It is generally agreed upon within the two-stage framework that reprocessing effects take place in the processor. The parser constructs its analyses and forwards these to the processor. The processor is sometimes unable to construct a coherent assembly of the items it receives. For example, the perceptual illusion created by the ambiguous morphology in the following sentence causes an incorrect parse to occur leaving the processor with an unattached lexical item.

(1) The horse raced past the barn fell.

Both the Kimball and the FBG models, as well as the literature on reprocessing effects, assume that reparsing takes place, and this is what accounts for the observed complexity of these sentences (and other Garden Path types). However, in a departure from this definition of reprocessing, Frazier (1978) claimed that once a parse is begun it will not be reanalyzed by the processor unless the processor cannot plausibly interpret the packages that it receives. Similarly, Frazier and Fodor (1978) claimed that the parser exhibits the same tenacity and employs "revision as a last resort" strategy. This view of reprocessing as opposed to a more traditional notion, reflects the flexibility that the device routinely exhibits during normal conversation. Fragments, ungrammatical sequences, and the like are frequently assigned a meaning. If, assuming the autonomy of syntactic processing hypothesis is correct, one wishes to account for this fact then the concept of reprocessing needs to be relaxed. A syntactic device which reprocessed violations and deviations would be an inefficient device. The analysis of a given utterance could theoretically last indefinitely. In order to account for the fact that processing does seem to proceed rapidly despite the traps a speaker sets for the mechanism, the reprocessing response would have to be subject to some constraints, if it were not limited in the way that Frazier (1978; with Fodor, 1978; with Clifton and Randall, 1983) has suggested. That is, the parser makes on-line routine revisions, if necessary; and the processor reanalyzes only as a last resort.

The Operations

The centerpiece of syntactic processing theories is the specification of the operations that give rise to the syntactic analysis. I will discuss these operations in two sections. In the first section, I will describe the actual parsing routines and strategies that have been proposed. In the second section I will discuss the role that has been ascribed to the lexicon within the parsing stage.

Parsing Routines/Syntactic Strategies

The concept of a strategy model was initially most clearly and thoroughly developed by Bever (1970). Bever hypothesized that sentence comprehension was a perceptual process; and that the sentence processing strategies to be identified had strong links to general perceptual strategies and weak links to the actual rules of the grammar. Bever's claims were made against the backdrop of DTC research and thus constituted a bold departure (which had begun in the late sixties) from this theory of sentence comprehension.

The two most interesting strategies with respect to the existing sentence processing data and subsequently proposed parsing models are Bever's Strategy A and Strategy B. Strategy A directed the parser to "segment together any sequence x..y, in which the members could be related by primary internal structural relations, 'actor, action, object ...modifier'" (p. 290). Strategy B elaborated, "The first n...V..(n)...clause (isolated by Strategy A) is the main clause, unless the verb is marked as subordinate" (p. 291). Strategies A and B formed the foundation of the clausal processing theory, and surfaced in a later work (FBG, 1974) as the Canonical Sentoid Strategy. Canonical Sentoid Strategy was defined as follows: "Whenever one encounters a surface sequence NP V (NP), assume that these items are, respectively, subject, verb, and object of a deep sentoid" (p. 345). In accordance with their clausal processing view, FBG asserted that the clause is assembled or segmented before the internal relations are interpreted. Thus they claimed that "the stages in processing appear to be to first reduce the input to the form NP V (NP)...and then apply canonical order strategy" (p. 347).

A variation on the Bever and FBG claims could be a reversal of the order. Thus one could claim that the internal relations, subject verb object, are identified first and that this sequence NP V (N) is then packaged as a clause (Frazier, 1978). The data need to be evaluated in order to determine whether these claims can be differentiated. That is, do they make different predictions and are either set of predictions supported by the data. Along these lines, Frazier (1978) described the operating strategies of a parser as constructing a surface structure phrase marker (which is similar to Kimball's claim). Her position was that the internal relations were identified prior to segmentation. Specifically she proposed the Late Closure Strategy to account for this. Late Closure instructs the parser to attach incoming information into the current clause. There is no postulated clause boundary search and subsequent segmentation; rather there is a constructed phrase marker which states the grammatical relations and is resistant to closure or segmentation.

An alternative accounting of syntactic closure was offered by Ford, Bresnan, and Kaplan (1982). Specifically, they proposed that two principles and their defaults can account for the observed closure effects during parsing. At the center of their closure theory lies the claim that "lexical items govern the closure properties of phrases" (p. 743). This claim is expressed in the principle of <u>Lexical Preference</u>. The <u>Lexical Preference</u> principle is based on the <u>Coherence</u> condition on well-formedness in Lexical Functional Grammar. It states that given a structural choice the parser opts for the analysis that is "coherent with the strongest form of the predicate" (p. 747). If the <u>Lexical Preference</u> principle cannot direct the parser in its choice, the default principle, <u>Syntactic Preference</u> applies. The order of priority under <u>Syntactic Preference</u> is based on the strength of the alternative categories in question. The principle of Final Arguments determines when the phrase selected by the preference principles is closed. Final Arguments is, in effect, a late closure principle. It instructs the parser to delay attaching the final argument (or any elements subsequent to the final argument) of the strongest form of the phrase under construction. If the phrase to be attached is not the final argument of the strongest lexical form, then the default principle Invoked Attachment applies. It instructs the parser to opt for attaching the phrase under consideration to the partial constituent which gave rise to the phrase. Ford, et al. contended that, taken together, these principles account for the parsing preferences exhibited in a wide variety of sentence structures. This claim will be discussed in a subsequent section of this chapter. It should be noted that the Ford, et al. model constitutes a departure from the other models under discussion. Theirs is a competence-based parsing theory which directly incorporates the grammar (LFG) in the processing component. In addition, the Ford et al. model is not a two-stage operation. Thus, the parsing principles do not arise from the architecture of the comprehension mechanism; but rather, they arise directly from the grammatical constraints.

Two parsing strategies (see Frazier and Fodor, 1978, Fodor and Frazier, 1980) which derive from the two-stage architecture of the parsing mechanism and predict the preferred parses are Minimal Attachment and Local Association. Minimal Attachment expresses the parser's preference for incorporating new information into the existing (open) structure with as few nodes as possible. This is the simplest way to parse. In addition, the revision process becomes simplified as the operation will always be to add new nodes. In cases where Minimal Attachment is precluded by closure, the principle of Local Association governs the attachment. Local Association will cause the parser to group adjacent words into a single structure. While Frazier and Fodor's Local Association principle makes similar predictions to Kimball's Right Association, it appears to be more broadly applicable as it has no height or direction preference but only favors immediate attachment. Unlike Right Association, Local Association is a bottom-up or data-driven procedure which is directly due to the limited capacity of the parser (Fodor and Frazier, 1980). Bever's (1970) Strategy A is a specific statement of the Local Association Principle, as is the FBG (1974) Canonical Sentoid Strategy.

As discussed above, Milsark (1983) has proposed a parser which is sensitive to sentence boundaries. With regard to Frazier and Fodor's data, and in support of his own claim Milsark noted that "all cases [in Frazier and Fodor's sentences] where there is a local attachment preference have structures where a sentence boundary intervenes between the local and distant attachment sites...where no such preference exists [there is] no boundary in the analogous position" (p. 133). Milsark has cited the clause boundary literature as lending support to his parsing theory. For example, it is of interest to note that Cairns and Jablon (1976) found that subjects retained more information across the clause boundary for subordinate-main structures than for main-main-structures. Specifically, Cairns and Jablon auditorily presented three-clause paragraphs to subjects. At the end of each paragraph the second clause was re-presented either verbatim or in a syntactically altered form. Subjects were asked to indicate whether the probe sentence exactly matched a sentence in the paragraph. A Yes or No response as well as a confidence level for the response was recorded by each subject after each trial in a response booklet. In this study, both syntactic type and clause type were varied. Of interest here is the data regarding clause type. "For each syntactic type, more information is retained when the sentence boundary precedes Clause 2 than when it follows Clause 2, if Clause 2 is subordinate..." (p. 116). The difference prevailed in only three of the five types, and, furthermore, these differences were not significant, when Clause 2 was coordinate. Finally, when the sentence boundary preceded Clause 2, subordinate Clause 2 showed more information retention than coordinate Clause 2 for four of the five syntactic types. If length (which gives rise to the Local Attachment Principle) were the operating variable, we would expect no effect of clause type (i.e., main vs. subordinate) on information retention in the Cairns and Jablon study as length of the second clause was controlled. These data are supportive of a sentence boundary effect. In addition, Milsark noted that cyclical rule application and the Subjacency Condition express grammatical preferences for "structurally governed locality" (p. 133). Thus the sentence boundary strategy provides the type of indirect link between competence and performance that ideally should independently emerge between the two theories.

Claiming similar links to the competence theory, Fodor (1979) proposed Superstrategy as the parsing routine of choice. She defined this strategy as the recovery of a well-formed deep structure. Thus the job of the parser is to reposition the elements of the received input into an appropriate deep structure configuration. In order to accomplish this recovery, the parser utilizes both phrase structure rules as well as the information contained in the lexicon to construct the deep structure phrase marker. The parser is also aware of the conditions which apply within the language such as the "Nested Dependency Constraint" which forbids intersecting filler-gap dependencies; and "The XX Extraction Principle" which governs the movement of elements within the structure. The parse is thereby accomplished by using linguistic knowledge to reconstruct the most probable deep structure of an utterance.

Limber (1976) proposed that each listener has a "canonical order sentence template" (p. 166). For English, Limber has suggested that the listener expects "alternating patterns of NPs and VPs" (p. 175). Violations of the pattern as well as the occurrence of particular lexical items will signal the listener to amend her expectancies in some alternatively predictable way. Extreme violations may not be perceived as such, and the processor might function as a "normalizer" in these instances. For example, Limber recorded sentences such as

(2) The player kicked the ball kicked him.

at a "slow to normal" rate. Subjects were asked to paraphrase the sentence and indicate their confidence in the paraphrase. Limber's subjects fabricated conjoined or relative sentences as responses. A similar result was obtained in Experiment 1 (this paper). On a rating task of various sentence types, subjects rejected sentences such as (2) in the presented form. Instead, they primarily interpreted these sentences as subject relatives supplying the missing elements. This perception persisted despite the explanation of the structure given by the experimenter. (See chapter 3 for a discussion of the result.)

This is a rather interesting observation. The normalization of less than ideal stimuli is, by hypothesis, one of the main functions of the speech perception mechanism. It would be surprising, indeed, if the syntactic processing device failed to take advantage of this mental capacity. This view does presuppose an expectancy model. However, nearly all models which invoke reliance on the rules of the grammar during processing (but not the type of reliancy suggested in DTC) are expectancy models. Frazier and Fodor (1978) and Kimball (1973), for example, both recognized that efficient parsing was dependent upon the predictability of the following structure. Returning to sentence (2) above, Limber attributed its complexity to the lack of structural predictability within the sentence. Specifically, the reduction of the relative clause and the ambiguity of the past/passive verb eliminated the structural signals.

Frazier (1978) has made related observations. She has argued that if the processor received incorrectly packaged phrases containing no overt errors, it will accept these analyses. She reasoned further that if the second stage processor "cannot achieve a plausible reanalysis, it will do its best to interpret the phrasal packages constructed" (p. 125). This is precisely what Limber's data (and the current data) show.

What conclusion does this lead to? There seems to be a strong sense of "sentencehood" that pervades the above considered segmentation proposals. Again and again, researchers find their thinking and their data pivoting around units such as the clause (FBG, 1974), alternating NP/VP segments (Limber, 1976), seven-item segments (Frazier and Fodor, 1978), well-formed deep structures (Fodor, 1978), functional structures (Ford, et al., 1982), S (Milsark, 1983). Within these proposals several researchers have alluded to the parser's use of the Phrase Structure rules (e.g., Frazier, 1978; Fodor, 1979). One interesting interpretation would be to propose that the listener expects an SVO structure, assuming that this structure is the one the phrase structure rules of English bias the listener toward. That is, SVO is being syntactically defined as follows. NP_1 is the NP immediately dominated by S; NP_2 is the NP immediately dominated by VP, and to the right of V. Consider Frazier's (1978) comments on the strategies the human parsing mechanism adopts. She reasoned that the strategy of choice is "successful...more frequently than competing strategies" (p. 9); and that the "analysis [it provides] is the simplest to compute" (p. 10). She also noted that the "parser assumes it is processing an untransformed sentence..." unless contradictory information is received (p. 142). If the parser does access the phrase structure rules and begins its parse, as it encounters each new sentence, with S along with its predictable nodes (unless the utterance is otherwise marked), then the SVO expectancy model is the most natural expression of that process. In accordance with Frazier's conditions, the SVO strategy reflects the parser's assumption of an untransformed structure; it would be the simplest (i.e., least effortful); and as a starting point, the most successful strategy if we roughly define the strategy as follows:

Expect each structure to contain a subject, verb and optionally an object in that order unless marked otherwise.

This strategy reflects some facts of Universal Grammar (see, for example, Greenberg, 1963; Chomsky, 1982). It also exploits the same sensibility as Limber's template model. The SVO strategy differs from superficially similar strategies, such as Limber's template model, FBG's Canonical Sentoid Strategy, and Bever's Strategy A (1970), in two ways. The first distinguishing characteristic is the parser's prediction of, rather than its search for, the SVO structure. The second is the claim that the parser tracks syntactic information as it moves through the utterance verifying or adjusting its predictions. Additionally, it differs from segmentation strategies such as Bever's and FBG's in that segmentation is a result of the SVO assignment, not a precondition to it.[2]

<u>SVO expectancy as a parsing routine</u>. How, specifically, does a parser that expects a particular structure proceed? The following is a brief sketch of the proposed process.

When the listener receives the input:

(3) The boy eats lunch.

she is expecting an SVO structure or a set of SVO structures. The SVO roles in the input are verified by the parser. The verification process would be tantamount to a scan for exceptions. If there are no apparent exceptions, the phrase is appropriately labelled and packaged as an SVO unit, cleared from STM, and sent to the next stage of processing. At the next stage, other variables contribute to a fuller processing of the unit. Thus, context, pragmatic factors, etc. would exert influence at this stage (see note 1).

If the input, on the other hand, deviated from the unmarked structure, as illustrated in the sentence below, the parse would then follow a different course.

(4) The boy eating his lunch likes Mary.

In this example, the first verb serves as a marker which instructs the parser to alter the analysis. Upon receipt of the unexpected element (the relative clause verb), the assigned portion of the structure (i.e., the subject) would be 'held' until that parse could continue, i.e., until the matrix verb is received.

The "HOLD" function is a procedure associated with and described in the ATN literature (see Wanner and Maratsos, 1978 for a full description). One criticism which has been raised (Fodor and Frazier, 1980) regarding HOLD is the unavailability of the information in HOLD for use in the subsequent parse, which increases processing complexity by the removal of possibly crucial information.

HOLD in the SVO expectancy model being discussed would similarly suspend the current parse to begin another parse (presuming that the parser cannot accomplish the two simultaneously). However, it is proposed that the material in HOLD would be accessible to the parser throughout the subsequent parse expressly for the purposes of achieving a syntactic coherence by providing the parser with access to elements which may be part of the parse in progress.

Another contributing factor (perhaps the primary one) to the complexity of the parse is the predictability of the subsequent nodes of a structure once a parse has been begun. While Fodor (1978); Frazier (1978); Ford, et al. (1982); Frazier, Clifton, and Randall (1983); among others, have all expressed the importance of predictability in syntactic processing, it is a particularly crucial aspect of the SVO expectancy model. Within this model some deviations such as relative clauses would be routine, i.e., highly predictable. It can be hypothesized that these routine deviations will have a minor effect on parsing complexity despite the invocation of the HOLD function. Essentially the claim can be stated in terms of predictability. The SVO model suggests that SVO structures are completely predictable, therefore the least complex to process. It is suggested, further, that there are a variety of non-SVO structures which have explicit markers (sometimes several markers) associated with them. The appearance of these markers causes the parser to suspend the SVO parse it had begun to comply with the instructions conveyed by the markers. This claim leads to the hypothesis that all non-SVO structures are more complex; however, the complexity is attenuated by the appearance of the markers which redirect the parse in an efficient manner. An examination of the literature on non-SVO structures reveals various results with regard to the marked deviations from SVO. For example, the passive construction has exhibited greater processing complexity than its active counterpart (e.g. Foster and Olbrei, 1973); as well as equal complexity, or non-complexity (e.g., Slobin, 1966) depending upon the method employed. These conflicting findings are compatible with the model being proposed. We would expect very different results depending on how and where the complexity was being tested since the claim is that the increase in complexity is local and quickly resolved.

In addition, the finding that ambiguous markers increase processing complexity can be taken as further support for this view. Consider, for example, Bever's (1970) classic "perceptual-illusion" type sentence, The horse raced past the barn fell. The parser scanning the sentence for deviations is fully satisfied that none occur. This derives from the legitimate deletion of the relative clause marker "who" plus the auxiliary verb "was"; and is compounded by the loss of information due to the ambiguous morphology of the verb "race." That the parser does not pause to consider options at "raced" I believe supports the claim that the parser's job is to scan the input rapidly with the expectation of an SVO construction. While I am claiming it notes marked, routine exceptions, it would be an inefficient parser, indeed, which cataloged every possible deviation that can legitimately occur. Both informal as well as formal assessment (see Experiment 1, this paper) indicate that the parser packages this sentence type as an SVO unit, leaving the second stage processor with the problem of resolving the extra element "fell." This claim is supported by the resolutions reported by my subjects (also see Limber, 1976) which range from rejection of the utterance as unacceptable to the insertion of "who" between "horse" and "raced," or "and" between "barn" and "fell." All of these were conscious post-hoc solutions (at least for my subjects) which reflect the fact that the SVO parse has not been challenged; but rather the formal properties of the sentence are judged as odd, unacceptable, insufficient, etc., by the processor.

In summary, I am claiming that the literature in syntactic processing strategies points to the SVO unit as the expected structure for parsing purposes. This would be an altogether simplistic notion if it were not claimed further that the parser can easily recognize routine deviations from this structure by scanning the input for "expected" markers. The occurrence of the marker will cause the parser to suspend the parse in progress to accommodate the new information. This procedure places a burden on STM as it must store a partially parsed phrase and begin a new parse simultaneously. An important facet of this claim is the suggestion that the markers supply the parser with enough information so that the revised set of predictions replace the original parsing scheme. Once the revised expectancies are established, the parse proceeds as rapidly as before. Thus clearly marked, routine deviations from SVO pose a minor problem for the parser in that it is momentarily delayed while it reads the instructions and accesses the new plan. Once the plan is accessed, there are no longer any differences in parsing complexity. Thus the parser's ability to predict future information, whether initially or at a point later in the parse, will determine the complexity of that parse.

The Role of the Lexicon in Syntactic Parsing

That the lexicon provides the parser with critical information regarding the syntactic properties of the input is not disputed. What is controversial is the extent to which the lexicon is tapped during this process. In the following section I will briefly consider some of the claims regarding the parser's use of selection restrictions and sub-categorization properties of the verb. I will conclude with a discussion of the processing model proposed by Ford, Bresnan, and Kaplan (1982) which is based on the Lexical-Functional Grammar.

Selection restrictions. That the parser uses selection restrictions to determine the internal grammatical relationships within each clause was initially suggested by some findings reported by Slobin (1966). Namely, Slobin's data indicated that the use of irreversible subject/object nouns in the passive construction facilitated its processing. It should be noted that the picture verification task used by Slobin has been discredited for use in syntactic processing studies (Gough, 1966). However, the semantic effect has been demonstrated in subsequent studies using various methodologies, thus Slobin's conclusions regarding the effect still appear to be valid.

Bever (1970) advanced this interactive hypothesis as Strategy C in which it was stated that "constituents are functionally related internally according to semantic constraints" (p. 296). Bever cited a variety of research results which supported this view and concluded that knowledge of individual and groups of lexical items rather than linguistic knowledge was employed by the listener during sentence comprehension.

As discussed in the previous chapter, this type of parallel processing model (i.e., syntactic and semantic) was opposed by Forster. Forster claimed that the comprehension process was a serial, autonomous process. Using on-line measures to test this hypothesis Forster found that the active-passive difference in processing was preserved despite the irreversibility of the nouns. Forster additionally demonstrated that subjects performed acceptable syntactic analyses on anomalous sentences without recourse to special procedures. These findings led Forster to claim that the parser admits syntactic information only. Specifically, Forster (1979) stated that "selection restrictions do not operate at the level of lexical insertions" (p. 47); arguing for autonomy in the grammar and linking that claim to the processor which, he asserted, is constructed from the grammar.

We are left, then, with a question regarding the level at which selection restrictions are utilized during the comprehension process. Slobin (1966), and others since claimed that this lexical information can and does direct the assignment of the grammatical relationships. Forster and Olbrei (1973) and others have claimed that more sensitive measures reveal "constant" effects of the syntactic properties despite the presence of the purported facilitating lexical items. The SVO claim is that selection restrictions do not operate at the level of parsing. Rather, semantic (and pragmatic) variables are said to affect the processing stage. It is the processor's job to evaluate the parser's decisions and to determine the meaning of the sentence. Thus it seems that a more powerful second stage mechanism must be postulated to account for these capabilities.

Subcategorization information. The effect of subcategorization on syntactic parsing was first addressed by Fodor, Garrett, and Bever (1968). Fodor, et al. claimed that complex verbs increase comprehension difficulty by causing the parser to hypothesize more possible subsequent structures than a simple verb would. Thus as a listener receives a verb, she will use the subcategorization properties of that verb immediately to predict the subsequent structural properties of the predicate. Fodor, et al. used post-sentential measures such as paraphrase and anagram tasks to test this hypothesis. Their results indicated that the presence of a complex verb decreased the accuracy and speed of response, confirming the predictions.

Hakes (1973) was critical of this work on two counts. One, he found the claim--that a listener predicts predicate structures while hearing the verb despite the fact that specific information would soon be available--to be "implausible." Two, given the claim, he criticized the use of post-sentential measures to detect purportedly on-line effects. Using phoneme monitor and paraphrase tasks to test the verb complexity hypothesis, Hakes obtained a curious set of results. The paraphrase task consistently confirmed the verb complexity hypothesis, the phoneme monitor task failed in all cases to confirm the predictions. Hakes (1971, 1972, 1973) used a variety of constructions and monitor positions in an attempt to locate the site of the effect to no avail. Hakes (1973) claimed that these data weakened the support for active, on-line comprehension theories in general. However, he conceded that the paraphrase task had been shown in other research contexts to "reflect comprehension processing effects" (p. 2). Thus the data do not rule out the verb complexity hypothesis; however, they do present a "puzzle" with regard to the locus of the effect.

In his theory of structural determinacy, Chodorow (1979) proposed that a listener decides on a structural analysis relatively soon after receiving the input, or alternatively at some later point depending on her ability to determine the structure of the input. On this view, complex verbs would cause the listener to postpone making an early structural decision[3] which would increase the processing complexity of the sentence. Chodorow tested this hypothesis using time-compressed vs. normal presentation rates for sentences containing unreduced "that" complements, reduced "that" complements, verb phrase complements, as well as sentences containing simple verbs contrasted with complex verbs with direct objects. Following a silent interval which was either a short or long pause, subjects heard a word list. Subjects were to first recall the sentence, then the word list. Recall of the sentence was considered a measure of the listener's performance "inside" the sentence; recall of the word list was considered an "outside" measure. The findings supported the structural determinacy hypothesis. Essentially, in the compressed speech condition, indeterminate structures (reduced NP complements, VP complements, complex verbs with Direct Objects) were more poorly recalled than the determinate structures (unreduced NP complements and simple verbs). The length of pause affected recall of the word list. Recall decrements occurred when indeterminate structures were presented in the short pause condition for both normal and compressed rates. Thus both measures indicated that indeterminate structures required more processing time.

According to the structural determinacy hypothesis, the increase in complexity is due to the decision lag; while according to the SVO hypothesis it is due to the on-line revision process. Data reported by Chodorow on selected substrings of the complex indeterminate structures for two of the conditions indicated that the recall decrement was greatest at the verb. These data can be interpreted as providing support for admission of subcategorization information during parsing if the recall decrement is assumed to reflect the parser's response to this information.

While as Chodorow has noted, it is difficult to choose among various processing models on the basis of these data, there is sufficient evidence for the claim that the occurence of a complex verb in any sentential frame slows down the comprehension process. This claim is in accordance with the findings of Fodor, et al. (1968) which indicated an overall increase in processing complexity. Furthermore, in light of Chodorow's results, Hakes' data seem less puzzling. In particular, consider the data on the verb phrase complements and the reduced NP complements. Chodorow found that the complex verb itself showed the greatest recall decrement when compared with words in the three surrounding positions, i.e., the matrix subject, the complement subject, and the complement verb. Hakes monitored a variety of positions--all following the matrix verb. Chodorow's results and Hakes' results exhibit the same pattern. That is, there is no detectable complexity in a given position following the complex verb; however, processing of the material beyond the verb is affected in a more general way.

These data can be interpreted as supportive of several models of processing. However, they are compatible with the SVO expectancy model sketched above. Furthermore, the results point to the admission of subcategorization information by the parser. How the parser utilizes this information is an empirical question. The SVO claim is that the parser reads the subcategorization information in the same way that it reads a more explicit marker. The parser will upon encountering a complex verb, invoke the HOLD function. The structural determinacy hypothesis follows directly from the SVO model. That is, as Hakes pointed out, a slight decision lag will provide sufficient information (under most circumstances) regarding the specification of the predicate structure. The structural determinacy hypothesis predicts the lag. The SVO model explains the mechanism which causes it.

The decision lag does not ensure the correct analysis, as various studies have indicated. One question which arises with regard to that fact is how long does the parser wait before it regards the structure as determinate. The clause processing literature suggested that the decision is postponed until the boundary is reached. Frazier (1978) proposed a late closure strategy which is compatible with the end of clause view. The SVO model does not necessarily predict the postponement of the decision until the clause boundary has been reached. Rather, it has been implied in the model outlined above that the parser revises its plan on-line as soon as the instructions are received in the following way. The complex verb signals the parser to remain open (via a HOLD) until it receives a set of instructions, i.e., until it encounters an explicit marker. If the marker fails to appear in the predicted position/positions, then the parser resumes its SVO analysis. Studies investigating structures from which markers had been deleted (e.g., Hakes and Cairns, 1970; Hakes, 1972) have generally pointed to increased processing complexity. Thus, the assertion that the parser relies on these markers is fully compatible with the data. Furthermore, the data on the processing of perceptual illusions (see the discussion of sentence (1) above) have indicated that in the perceived total absence of the marker the parser resumes its SVO analysis prior to the end of the clause leaving the listener with an unattached and unattachable final element.

Taken together, these findings are supportive of the marker vs. clause boundary locus of decision hypothesis. However, this matter is yet to be resolved. While the current study was not designed to test this hypothesis, a variety of complex constructions in the reduced and unreduced versions were included. An examination of the responses to these structures may reveal some information on the time course under question.

The Lexical-Functional theory and parsing. In their 1982 paper on syntactic closure phenomena, Ford, Bresnan, and Kaplan outlined a parsing model (described above) which was based on Bresnan's Lexical-Functional Grammar. This section will briefly consider their parsing theory with regard to the claims made for the role of the lexicon during parsing. There will be no direct or implied attempt to evaluate the linguistic claims which underlie this performance theory. Likewise, there will be no evaluation of the claims regarding the relationship of this parsing theory to LFG.

In considering pairs of sentences such as (6) and (7) below, Ford, et al. have claimed that the presence of a single lexical item can alter the preferred syntactic analysis of a sentence.

(6) The tourists objected to the guide that they couldn't hear.

(7) The tourists signaled to the guide that they couldn't hear.

They have stated this claim in terms of a parsing principle, Lexical Preference. Thus they claimed that the parser will resolve an encountered structural ambiguity by selecting the analysis which is "coherent with the strongest lexical form of the predicate" (p. 747). In light of the previous discussion, this principle favors the position that the parser has access to the lexical properties of the verb and their relative strength in the language. Furthermore, it is claimed that the parser uses this information to make decisions regarding the syntactic analysis of a sentence. The parsing system which encompasses this principle (and three others which all serve to determine the parse) is a fully interactive system which has a serial, as well as a parallel processing capacity, and engages in both bottom-up and top-down processing modes. It is a powerful model which lacks the constraints which allow for falsification of the claims. For example, the two primary parsing principles, Lexical Preference and Final Arguments (a late closure principle) each have a default principle which can be deployed and which can account for opposing effects. In addition, with regard to the claim that the parser uses a ranked order of preference to govern its decisions thus implying within language uniformity of these rankings, Ford, et al. acknowledge individual difference but claim that there is sufficient "consistency among people" (p. 747). This seems to be a lot of latitude within a system which has to combat a fair amount of ambiguity within very short time periods. Many of the sentences studied yielded the predicted closure results. However, in presenting structurally ambiguous sentences like "The police told the officer that was interviewing the boy that the woman had left." to subjects who were asked to check their interpretation of the sentences in a response booklet, Ford, et al. failed to obtain the predicted closure preferences. It is of interest to note that for these sentence types the SVO theory predicts the preferred structure.

The important point in considering the Ford, et al. data is the support provided for the postulation that the lexicon exerts some influence during syntactic parsing. In particular, there exists a substantial amount of evidence which suggests that the lexical attributes of verbs have an on-line effect during syntactic parsing. Whether the methodologies used so far to acquire this evidence have been sensitive enough to tap the parsing level alone is an empirical issue. Furthermore, which aspects of the verb are used in syntactic parsing, as well as whether their purported use constitute a falsification of the autonomy hypothesis is also an empirical issue. It is my claim that the SVO model which can account for the aforementioned lexical effects preserves the autonomy position by allowing the parser to read the subcategorization properties of the verb in the same way that it reads tense affixes, etc. The SVO expectancy model is a fully autonomous parsing model. The admission of selectional information at this level of parsing would constitute a different claim, namely, a claim for an interactive parsing mechanism.

Summary: The SVO Expectancy Model in Brief

In this chapter I have considered some of the critical aspects of parsing by examining the evidence and theoretical claims proffered by various researchers over the past 25 years. I would like to propose that the SVO expectancy model described above accounts for a wide range of observations and constitutes an efficient, effective statement of syntactic parsing.

The essential claims of the SVO model can be summarized as follows. Upon receipt of an input, the parser deploys its parsing plan. The plan that the parser initially chooses is roughly equivalent to the phrase structure rule for S. If the sentence contains a marker which contraindicates this assumption (for example, a "wh" word), the parser revises its plan to accommodate the input. Thus the parser stops the parse to read the marker and accesses a second plan which instructs it on how to recover the SVO unit from this alternative form. If there is no sentence initial marker, the parser carries out its original plan by scanning each incoming unit to verify its grammatical role. During this scan the parser may encounter markers which would invoke the revision procedure as stated above.

The question of what constitutes a marker has not been directly addressed in the literature. Conventional markers such as "wh" words, relative pronouns, subordinate conjunctions, etc., comprise one class of markers; inflections, another. Furthermore, it has been suggested in this chapter that some lexical properties, e.g., subcategorization properties of verbs, comprise another class. In addition, as Limber (1976) has suggested, violations of the expected order (e.g., the occurrence of two NPs, etc.) act as markers for the parser. The concept of marker with regard to the claims presented in this model is considerably broad.

The purpose of this thesis was to examine the basic claims of the SVO model. Experiment 1 was designed to test the SVO expectancy hypothesis. The hypothesis predicted that non-SVO structures would increase parsing complexity in proportion to the extent of the SVO violation and the clarity with which the violation is marked. Experiment 2 was designed (a) to test further the SVO expectancy hypothesis, (b) to probe the effectiveness of several conventional markers, and (c) to determine whether lexical or pragmatic information served as markers for the parser. The next chapter details the experimental hypotheses, as well as the experimental designs employed to test the predictions.

Notes for Chapter Two

[1]As previously discussed, there are no data which directly bear on the necessity of positing a second stage which is syntactic, or for that matter, a second stage which is interactive. Of course, proposals such as Ford, et al.'s one-stage syntactic parsing model obviate the issue entirely. I will discuss the issue of the nature of the second stage of syntactic processing in chapter 4. For now, I will assume that the processor is part of cognition rather than perception.

[2]The term marker is used throughout this thesis to refer to the syntactic information used by the parser to perform a structural analysis. The sense of "marker" implied in the SVO Expectancy Theory goes beyond the sense of the term as it is typically used. Within the SVO theory, marker is defined as any syntactic information which guides the parser in adjusting its predictions (original or subsequent). Thus, by hypothesis, this information will account for all of the parser's attachment and closure decision. As suggested in this thesis, future research should be directed to determining how the parser tracks syntactic information during sentence processing. One interesting example of how the parser uses syntactic information is in considering the role of the genitive marker in the underlined segment of the following sentence.

> The author hated <u>his agent</u> but the editor he liked a lot.

The pronoun inflection signals the parser to keep the phrase open by indicating that the pronoun is part of a single NP along with the noun that follows it. This procedure rules out the double NP structure hypothesis. If the pronoun's form does not signal the parser to remain open, it will analyze a pronoun-noun (or a noun-pronoun) sequence as two separate NPs, closing one NP as the next NP arrives. In the sentence above, the double NP structure is itself an ambiguous marker. That is, the parser can predict a conjoined NP, a left dislocation, a relative clause, or an object topicalization structure from this syntactic information. The point is to illustrate the intricacy of the concept of marker and the marking system it entails that is proposed in this thesis.

[3]The SVO Expectancy Model is compatible with the concept of a parser that predicts one structure which may require revision, or one that predicts multiple structures from which one must be selected. In one case the parser may delay predicting the single structure, in the other it may delay its selection of one until the salient syntactic information is received. It is implied throughout this thesis that only one structure is predicted by the parser at a given time. However, the experimental results reported in the next chapter do not bear upon this issue. Thus, the SVO Expectancy Model, as presented here, is neutral with regard to the number of structural predictions the parser makes at choice points. A definitive statement awaits the appropriate experimental tests.

CHAPTER THREE

Methods and Results: Experimental Tests of the SVO Expectancy Model

Experiment 1

The first experiment was designed to test the hypothesis that structures which vary from SVO order increase processing time. It follows from the proposed SVO model that any structure in which the processing of an SVO unit is interrupted will take longer to understand than an uninterrupted SVO sequence. An interruption of the SVO parse will cause the parser to make an on-line revision, i.e., to invoke HOLD and possibly to access a second plan. The model claims that the degree of processing complexity of a given structure is determined by the rapidity and ease with which an acceptable structural assignment, e.g., the SVO assignment, can be made. Thus, parses which require no revisions or require revisions which are easy to effect are the fastest to analyze, i.e., the least complex. Structures which need several revisions, or for which a revision is difficult to effect, require more processing time and are therefore more complex.

As stated above, it is proposed that there are revisions which are easy to effect. Since all revisions are potentially equally complex (as they involve the same set of procedures), it was hypothesized that there are facilitating conditions which reduce the complexity caused by the interruption. The facilitation effect is attributed to the occurrence of an unambiguous marker which directs the revision process. An unambiguous marker, which can be any element clearly signalling an SVO violation, directs the parser to an alternative parsing plan immediately upon its receipt. Two types of markers were indirectly investigated in this study; namely, the relative pronoun in unreduced embedded clause constructions and the inflected verbs of reduced embedded clauses. These were claimed to be equally facilitating.

On the basis of the assumption regarding the facilitating effect of the above markers, it was hypothesized that there exist sentence types which are structurally diverse but are all characterized as easy for the parser to analyze. These sentences can be compared to two other types. There are those which give rise to parsing difficulties and require more time for parsing; and those which cause a misanalysis and require more time for reprocessing. In this study, the first class of sentences (easily parsed) ranged from those in strict SVO order to those with deviations from SVO which were marked in a variety of ways. For example, sentence (8) was considered to be an easily parsed type.

(8) The elderly man carrying the heavy package dropped his house keys.

In this sentence "who was..." is deleted. The inflected ending of the verb of the relative clause signals the parser that it is not the matrix verb. The occurrence of the marker causes the SVO assignment within the matrix clause to halt while the relative clause is parsed. Because of the hypothesized clarity of the marker and thus the ease of the parse, this sentence type was designated a control type. (See Table 1 for examples of each control sentence type.)

The second type of sentences, i.e., those requiring more parsing time, consisted of structures which contained non-SVO clauses, as illustrated by sentence (9).

(9) The author hated his agent but the editor he liked a lot.

In this sentence it is claimed that the SVO assignment is begun but it is halted within the parser when the double noun phrase sequence signals a possible violation. Because two noun phrases are an ambiguous sequence, the double noun phrase sequence was considered an unclear marker. (See note 2, chapter 2 for a discussion of this sentence.) The SVO assignment comes to a halt as the parser waits for the disambiguating information in order to access (if necessary) the appropriate parsing plan. It is claimed that this type of revision is carried out on-line. Sentences in this group were designated as experimental sentence types. (See Materials section below, as well as Table 1 for examples.)

The third sentence type is the perceptual illusion type of sentence which tricks the parser into a misanalysis. The misanalysis causes the sentence to be uninterpretable. Thus, the incorrect analysis is only identified at the interpretation stage where reprocessing using semantic and pragmatic information is attempted.

(10) The manager showed the man that the woman seduced the bill.

In this sentence the occurrence of the ambiguous marker "that" leads the parser to the incorrect structural analysis. It is assumed that since the marker is ambiguous and the parser is faced with a decision, the analysis of choice reflects the parser's preferred solution.[1] After the parse is completed, the SVO package is sent to the processor. The semantic content created by the parser's misanalysis alerts the processor to the problem. In order to determine the sentence meaning, the processor attempts to reprocess the sentence as suggested above. While the locus of the reprocessing/revision effect is predicted to occur at different stages of sentence processing for experimental sentence types two and three, for the purposes of this experiment, these sentence types were not differentiated within the design (described below); both types were designated as experimental types.

A final issue was addressed in Experiment 1. It was proposed earlier that subcategorization information influences the parse, while selection restrictions do not. Experiment 1 partially addressed this issue. In particular, the materials were designed to investigate the effects of selection restrictions on parsing. Sentences such as (11) and (12) were compared in order to determine whether the presence of a violation of the selection restrictions was facilitative during parsing.

(11) The artist believed the canvas was inferior in quality.

(12) The coach believed the quarterback was breaking training every night.

It is important to emphasize that the facilitative effect being addressed is the occurrence of an hypothesized element (a marker) which halts a potentially incorrect SVO parse. The HOLD function presumably allows the parser to read the marker in order to determine whether to access an alternative (to SVO) parsing scheme; or to delay the structural analysis until disambiguating information is received. The interactive view of processing asserts that selectional information provides unambiguous information regarding the sentential analysis. The SVO position stated above does not. Thus, by the SVO hypothesis, selection restriction violations would not block the SVO parse. Only the interpretive component can make use of semantic information to determine sentence meaning.

To summarize, the main hypothesis under consideration was the predicted difference in processing time between the control and experimental sentences. The secondary issue of the effect of various markers with regard to their predicted clarity was evaluated. Finally, the effect of selection restrictions on parsing was also investigated.

Method

Subjects: Thirty-two Queens College undergraduates served as subjects for the first experiment. All subjects were native speakers of English, volunteered to participate, and were paid $2.00.

Materials and design. Fifteen sentence types were tested in Experiment 1. Each of the fifteen types was designated a control or experimental sentence type as described above. That is, a sentence was a control type if it was predicted to be easier to parse (no SVO violation or a clearly marked violation) than the experimental type to which it was compared. Each control type was paired with a structurally related experimental type (or two) in order to make direct comparisons. There were six control types and nine experimental types. Examples of each type are presented in Table 1. (The complete list of materials is presented in Appendix A.) The above types were selected so that the following comparisons could be made:

Control	Experimental
SVO	ObjTop
SVPrep	RevPass IrrevPass
EmClUnRed	EmClUnRedORel
EmClRed	ObjCompSelResVio ObjCompSelResUnVio
EmClRedPass	EmClRedTrunPass
ClSubj	ClObjUnRed ClObjRed

Each sentence type was represented by five versions for a total of 75 sentences. All 75 sentences were 15-18 syllables in length and consisted of two clauses. All contained common lexical items (as judged by native English speakers in a pilot study).

A two-factor design with one within-subjects variable (Sentence Type), and one between-groups variable (Order) was used. Each subject responded to five tokens of each sentence type. One half of the subjects received Order A and the other half received Order B. Order A was derived by random assignment. Order B was the reverse of Order A to control for position effects.

Fifteen questions were devised (one per sentence type). Each question followed the appropriate sentence; however, its occurrence could not be predicted by the subject. The questions were short queries on the information expressed within the sentence (e.g., What did the woman win?). The questions were included to insure that subjects would attempt to understand the sentences.

Procedure. The 75 sentences plus 15 questions were presented to each subject tachistoscopically. The sentences were presented one at a time. The slides were prepared so that a sentence appeared as it would in typewritten text except the lettering was white on a black background. All sentences had initial capital letters and periods at the end. Questions had appropriate final punctuation. No other punctuation was used within the sentence.

Subjects were instructed to read the sentence to themselves and to press a button as soon as they understood the sentence. Each subject sat at a booth. The subject's head was positioned so that he/she could optimally view the slide through a window in the booth. The subject's hand was placed on a rest position of a button console while reading each sentence. As soon as the subject understood the sentence, he/she pressed the button. Slide onset began a timer on the experimenter's side of the booth; the button press stopped the timer. Each reaction time (RT) was recorded before the next slide was presented. The time between each trial was 4.5 seconds. Subjects were instructed to answer the questions verbally. The responses to questions were recorded as correct or incorrect to determine whether the subject had understood the sentence. If a subject failed to respond within any trial, the experimenter waited 10 seconds before terminating the trial. Each subject was instructed in this procedure when he/she entered the lab. The instructions were followed by a practice session. Ten items were used to familiarize subjects with the task. One question was included within the practice set. Subjects were given ample opportunity to ask questions prior to beginning the experimental procedure. After the experiment was over, subjects did a post-task rating of 18 sentences. (The task is described below, and the sentences are presented in Appendix A.) They were asked to check those sentences (a subset of the experimental sentences) which were strange or difficult to understand in any way. If a sentence was checked, the subject was asked to explain why. All subjects were tested individually. The experimental procedure lasted one half hour.

Results and Discussion

The main hypothesis that sentence types can be classified as easy parses or difficult parses was tested in several ways. For each of the reported analyses, missing data were handled in two ways. Data were recorded as missing, i.e., the trial was eliminated, under two conditions: (1) an equipment failure occurred (e.g., the timer did not stop despite the button press); or (2) there was no response by a subject--no button press, no verbal response. These missing trials consituted .5% of the data. During the pilot testing a response pattern termed the "refusal response" emerged. This response which constituted 2.5% of the data for Experiment 1 was said to occur if the subject was unable to respond within the allotted time. A refusal response was defined further as one for which the subject verbally indicated that he or she was having trouble processing the sentence. Because these refusal responses occurred on experimental sentences and not on control types, the pattern was judged to be a reflection of processing problems due to the structural properties of the sentences. Thus, instead of eliminating these trials, the missing scores were replaced with a 10 second score. Ten seconds was the maximum amount of time allotted for a response (based on pilot test data) in order to prevent skewing the data by the inclusion of very long scores when computing the type means. The refusal responses will be discussed below.

First, an analysis of variance was computed using each subject's mean score for each sentence type. The results of the analysis confirmed the predicted effect of sentence type, $F(1,17 = 31.099$, $p < .001$. There was no effect of order; nor was the Order x Type interaction significant.

A second analysis of variance was computed using the individual raw scores. This second analysis was done in order to capture any subtle effects which may have been obscured by collapsing the data in the first ANOVA. The analysis confirmed the effect of sentence type, $F(1,17) = 60.246, p < .01$. Again, the order variable was not significant. It is of interest to note that while the subject variable (as would be predicted) was significant, the Subject x Type interaction was not significant, demonstrating the stability of the effect of type across the subjects.

A series of planned orthogonal comparisons were computed in order to assess the predicted relationship of controls to the relevant experimental types. Of the nine direct comparisons, five showed a significant difference in the predicted direction, while one comparison showed a significant difference in the opposite direction. In addition, three of the comparisons showed no significant differences between the assessed types. These data are presented in Table 2 and will be discussed in various sections below.

The main hypothesis was tested and supported by the results of comparisons 1,2,3,4,5, and 7. (Comparisons 8 and 9 regarding the role of the selection restrictions will be discussed in a subsequent section.) Comparison 1 is the most direct test of the SVO hypothesis. In this comparison, SVO sentence types were responded to faster than were ObjTop sentence types, $F(1,1920) = 35.40$, $p < .01$. Likewise, comparison 5 provides support for the claim that structures containing order violations increase response time. It was shown in comparison 5 that ClObjUnRed sentences were responded to significantly slower than ClSubj sentences, $F(1, 1920) = 33.52$, $p < .01$.

Upon initial consideration the result of comparison 2 was significant in the unpredicted direction. That is, the mean comprehension time for the SVPrep sentence type was significantly longer than the IrrevPass mean. Inspection of the materials revealed that one of the SVPrep sentences (in Appendix A, SVPrep sentence 5) contained a structural ambiguity. This sentence, by hypothesis, would cause the parser to invoke HOLD and revise its structural analysis upon receipt of the verb in the second clause. The mean comprehension time for this sentence was 4.019 seconds. This considerably longer response time actually provides support for the proposed on-line revision. Elimination of this sentence from the analysis yielded a mean comprehension time of 3.336 seconds for the SVPrep type. This adjusted score (presented parenthetically in Table 2) is not different from the Irrev-Pass mean. While this result was not predicted, it does not falsify the SVO hypothesis. It can be interpreted in two ways. The first interpretation is that the parser makes no distinction between the analysis of an SVPrep structure in the active voice and the analysis of one in the passive voice. This suggests that the voice characteristics of the sentence are processed at a higher cognitive level of processing. The second interpretation is that the on-line revision necessitated by the passive construction is made rapidly by the parser since the structure is clearly marked. This view comports with Forster and Olbrei's (1973) findings regarding the active/passive difference. The data in this study are inconclusive with regard to the alternative interpretations.

The results of comparisons 4 and 7 confirm the prediction that structures designated as perceptual illusions, i.e., SVO illusions, are difficult to process. Thus, in comparison 4 the mean response time to EmClRedTrunPass sentence types was significantly slower than the mean response time to the structurally similar, but unambiguously marked, EmClRedPass control, $F(1,1920) = 149.29$, $p < .01$. Similarly, for comparison 7, EmClUnRedORel sentence types produced significantly slower responses than did the EmClUnRed control, $F(1,1920) = 264.54$, $p < .01$. The SVO expectancy model predicts this difference. Specifically, it is claimed that the parser's preference for the SVO analysis in the absence of syntactic contraindicators causes the parser to falsely construct an SVO package. It was further hypothesized that the misanalysis would be perceived by the processor which would then attempt reprocessing. Thus, by hypothesis, these lengthy scores are said to reflect the processor's attempt at reanalysis. The next question to be considered is whether any evidence can be adduced from Experiment 1 to support these claims. A consideration of the error data does provide some initial support.

For the rating task 18 sentences were presented to 31 subjects for judgments. The following sentence types were included: one each of SVO, ObjTop, EmClRed, ObjCompSelResUnVio, ClObjUnRed, ClObjRed; two RevPass; and all (five each) of the EmClRedTrunPass and EmClUnRedORel sentences. The task was developed specifically to probe the two perceptual illusion types, and the other types were included primarily as controls. The percentage of each test type judged to be difficult by the subjects is presented in Table 3. There are several points of interest regarding these data. Of all the types, only the SVO type was never judged as difficult to understand. Furthermore, there is a pronounced difference in the judgments regarding all other types from the judgments of the two perceptual illusions. This difference appears in both the number of difficulty judgments made, 78.7% for EmClRedTrunPass sentences, and 82.6% for EmClUnRedORel; as as well as in the comments made by the subjects regarding the cause of the difficulty.

For the EmClUnRedORel type, 100 of the 128 difficulty judgments were attributed to the semantic bizarreness of the sentences. An additional seven judgments dismissed the sentences as "nonsense". The bizarreness results when the SVO analysis wrongly prevails; as in the underscored portion of "The fortune teller showed the girl that <u>the man kissed the future</u>." Of all of the 128 judgments only six judgments were identified as syntactically based difficulties, and these were general rather than specific syntactic problems. For example, three of the EmClUnRedORel sentences were judged once each as "ungrammatical." Conversely, for the EmClRedTrunPass sentences four of all 122 difficulty judgments were in the semantically bizarre category. Fifty-four were called subject relative sentences, and for the rest of the judgments, they were regarded, notably, as a first clause SVO unit plus a gerund; or a first clause SVO unit plus a coordinate verb; or as being out of order. All subjects regarded these types as unacceptable; some subjects inserted the appropriate markers (given their interpretations), while performing the rating/discussion task. Again, it is of importance to the hypothesis that for all of the specified reanalyses subjects sought to "normalize" the clauses into two SVO contructions. For both the EmClUnRedORel and the EmClRedTrunPass types the SVO illusion often persisted after the correct grammatical analysis was presented and explained. Responses for the other types were varied. There was a small tendency to regard ObjTop and ClObjRed types as out of order (5 of the 18 difficulty judgments over both types--28%); and a general tendency to attribute difficulties with the remaining types to a lack of clarity.

In summary, the problems identified with the two perceptual illusion types appear to be attributable to the persistence of the SVO analysis constructed by the parser despite the processor's attempts at reanalysis. It is of interest to note that a post hoc analysis using a Tukey procedure revealed that these two types were significantly different from all other experimental types ($p < .05$). By hypothesis this difference is said to derive from the locus of the attempted revision, i.e., at the second stage after parsing is completed. I will now turn to the error data to explore this question.

Two types of errors occurred within the course of this experiment, (1) the refusal responses introduced above, and (2) incorrect answers to the 15 questions which followed selected sentences during the experimental task. If the long times associated with the EmClUnRedORel and EmClRedTrunPass sentences are due to attempts at reprocessing, it would be expected that these types would be poorly understood, thus causing subjects to incorrectly answer the probe questions more frequently, and more likely to be consciously unable to understand the sentence. Please recall that the subjects' failure to press the button was recorded as a refusal only if it was accompanied by a verbal statement of processing difficulty. On-line revision, i.e., accessing of an alternative (to SVO) processing scheme, may slow the comprehension process to a greater or lesser degree depending on the clarity of the marker; however, this revision would not be conscious as parsing is an automatic, unconscious procedure.

Table 4 shows the raw scores and the percentages of the refusal responses and the incorrect answers to questions. For the refusal responses, it is interesting to note that for the six control types (a total of 960 responses), only one refusal occurred. For the experimental sentences, each type was rejected by at least one subject one time. The range of refusals for experimental types was 1 - 27 (of a possible 160 for each type). As indicated in Table 4, both perceptual illusion types were refused the greatest number of times (11.9%--EmClRedTrunPass; 16.9%--EmClUnRedORel) thus providing support for the reprocessing failure effect. For the question data, the number of incorrect answers ranged from 1 - 30 (of a possible 32 each). An inspection of the data revealed that for EmClRedTrunPass types 27 of a possible 32 questions were answered incorrectly; for EmClUnRedORel types 30 of the 32 were incorrect. Again, these concur with the expected results if the cause of the difficulty is the misparse, the subsequent need to reprocess, and the failure to reprocess.

The results of the rating task along with the pattern of errors observed indicated that the parser performs an SVO analysis whenever possible (i.e., when it perceives no violations). This parsing preference can cause comprehension problems, as seen in the perceptual illusion data, when the processor needs to derive meaning from the misparsed sentences. For sentences which are clearly marked as non-SVO structures, the parser performs an on-line revision which may slow the comprehension process but does not cause confusion at the level of the processor.

The next question to be addressed, then, is what is a clear marker. By hypothesis, a clear marker is one which provides the parser with unambiguous directions to the alternative (to SVO) analysis. Thus it was expected that the sentences containing clear markers (i.e., control types) would exhibit uniformly faster comprehension times than those which contained ambiguous, obscured, or later occurring markers. A Tukey procedure yielded the finding that the six control types did not significantly differ from each other but differed from the experimental types. There was one exception. Both the IrrevPass and the RevPass yielded faster comprehension times than the other experimental types ($p < .05$), causing them to be grouped with the controls. This finding does not conflict with the marker hypothesis. The hypothesis states that a deviation need only be clearly marked in order for parsing to proceed smoothly despite the necessary revision. (See the discussion of orthogonal comparison 2 above.) One unexpected result, however, is that for cleft object structures and embedded clause structures the reduced version has a slight advantage. (See Table 2 for the comprehension time means for the structures under discussion.) This interesting finding may indicate that the presence of a general, earlier marker (the relative pronoun) which occurs before the more specific marker (i.e., two NPs in the Cleft Object type or the verb inflection in the embedded clause sentences) may cause the revision process to begin earlier in the parse of the unreduced versions. This may cause a longer delay than the single, more specific marker (i.e., two NPs or the verb inflection) of the reduced versions. Given the rapidity of the signal decay and the burden on the parser during conversation, the slight delay due to the redundancy--a general violation heralder plus a specific marker following--no doubt outweighs the problems encountered when a structure is less clearly marked. One further observation regarding the unexpected advantage of the reduced cleft object is worth noting. Namely, the marker used in the unreduced cleft object constructions was "that". It may be that "that" has properties which are so particular or so general as to cause rather than resolve parsing problems. It is of interest with regard to this point that the embedded clause in the EmClUnRedORel was introduced by "that" as well.

The question of markers leads directly to the third area investigated in this experiment, namely, the role of selection restrictions in parsing. A consideration of the results of comparisons 8 and 9 (see Table 2), indicates that selection restrictions are facilitative during sentence comprehension. Particularly, comparison 8 shows that there is no difference between the EmClRed and ObjCompSelResVio types, $F(1,1920) = 1.77$; while comparison 9 indicates that the ObjCompSelResUnVio type differs significantly from these two means, $F(1,1920) = 24.71$, $p < .01$. However, a consideration of the IrrevPass and the RevPass types (see Table 2) revealed that the facilitation effect based on selectional information was not observed. The failure to find evidence for the reversibility effect with the passive types conflicts with the findings regarding the role of selectional information during the parsing of the object complement types. It was assumed that comprehension time was a valid measure of parsing effects in this study. This assumption was based on a two-level model of processing. The first level of processing is the informationally encapsulated parsing stage. All syntactic effects are predicted to occur at this level. The variables of interest in this study were predicted to affect this level of processing. That is, the manipulated variables were syntactic variables. The second level variables such as plausibility, word frequency, etc. were controlled in order to insure that cognitive processing would be equal for all types. (Note that for the perceptual illusion types cognitive processing is increased. The increased processing time is due to predicted syntactic effects.) Thus, by holding cognitive processing constant and manipulating factors at the parsing level, it can be assumed that the observed results are attributable to the predicted differences in parsing. As indicated above, the results of the passive and object complement comparisons are unclear regarding the level at which semantic information is processed. It was concluded that measuring comprehension time is not an appropriate technique for determining the locus of facilitation effects.

Experiment 2

The results of Experiment 1 indicated that sentences can be classified as easy to parse or difficult to parse based on their surface structure properties. In particular, sentences which contained minimal interruptions of the SVO order (e.g., subject relatives) were understood faster than those which violated the SVO order (e.g., object topicalizations). Furthermore, some data indicated that selection restrictions played a role in sentence processing. Reduced complement sentences which contained violations of the selection restrictions for the object noun were understood faster than those which did not contain the violations, and thus appeared to conform to the preferred SVO parse. One possible interpretation of this result is that lexical information is admitted at the syntactic parsing stage and violations of the restrictions are considered by the parser as markers of SVO violations. However, the conflicting result of the passive comparison in which the reversibility effect was not obtained did not rule out the alternative view that parsing operates on syntactic variables only. Experiment 2 was designed to investigate the SVO hypothesis with an on-line measure of processing complexity, and to investigate two of the marking claims which follow from this model. Two syntactic structures were selected for investigation in this study.

The following outline describes and illustrates the two structures and the versions in which they appeared along with the predictions based on the SVO hypothesis. The phoneme monitor task was employed to test the predictions. The location of the monitored phoneme is indicated by the underlining in each sentence. A complete listing of the materials appears in Appendix B.

Set 1--Relative Clause Sentences

The purpose of this material set was to test the claim that violations of SVO (in this case, within a relative clause) inhibit processing. This set was patterned after the materials used by Frauenfelder, Segui, and Mehler (1980) with French-speaking subjects. Their results indicated that for sentences roughly corresponding to the (a) and (c) versions below (the French versions do not entail the change in word order), phoneme monitor times were longer following the embedded object relative clauses (c) than following the subject relatives (a). A within-clause monitor position failed to reveal this difference. Additionally, their data indicated that despite the use of the objective pronoun "que" as a cue to the following word order, the differences between subject and object relatives prevailed. The materials in this present study expanded upon their materials by including object relative sentences with the less specific marker "who" as well as a reduced version of the object relative clause. Thus, in addition to testing the SVO hypothesis on-line, the experiment was designed to examine the effectiveness of various markers for English speakers. The following example illustrates one sentence quadruple used in the relative clause set.

(a) The intern who dated the nurse once
takes out the medical student now.

(b) The intern who the nurse dated once
takes out the medical student now.

(c) The intern whom the nurse dated once
takes out the medical student now.

(d) The intern the nurse dated once
takes out the medical student now.

It was predicted that for version (a), the subject relative, the phoneme monitor latencies would be shorter than for versions (b), (c), and (d), the object relatives, since "who" is an effective marker which indicates an interruption of the SVO parse. It generally has been demonstrated that subject relatives are less complex than object relatives. It is proposed here that the reason lies in the ease in which the embedded clause can be analyzed (an SVO structure), as well as in the unambiguous nature of the marker. It was also predicted that the presence of "whom," which specifies the case of the gap, in version (c) would be a more effective cue to the order violation than "who" in version (b); thus, some reduction of the latencies was predicted for the (c) version of the object relatives. Since "who" in version (b) is at best ambiguous, at worst misleading, it was predicted that the latencies for the (b) version would be no different from the expected long latencies in the reduced relative version (d) due to the increased processing load in both.

Set 2--Reduced Complement Sentences

The purpose of this set was to test whether lexical and pragmatic information serve as markers which direct the parser in constructing its analysis. The following set of sentences illustrates one of the reduced complement quadruples.

(a) The police believed the witness with <u>t</u>otal confidence.

(b) The police believed the witness was <u>t</u>otally incompetent.

(c) The police believed the dog was <u>t</u>otally loyal.

(d) The police believed the insane criminal was <u>t</u>otally secured in the prison cell.

It was predicted that the phoneme monitor times for version (a), the SVO version, would be shorter than the times for versions (b), (c), and (d). This prediction was based on the results of Experiment 1 which indicated that selection restriction violations are facilitative, i.e., cue the parser. Both versions (b) and (d) were expected to produce long latencies, equal in length to each other since the parser in both cases is tricked into the simple SVO assignment and the occurrence of the complement clause verb which precedes the target phoneme is not predicted. In version (b) which corresponds to the ObjCompSelResUnVio structures of Experiment 1, there are no prior cues to the complement clause, as neither the selection restrictions nor the pragmatic constraints are violated. In version (d), the selection restrictions are not violated; however, the pragmatic constraints are. It was hypothesized that the parser does not admit "real world" information; thus, it would fail to utilize pragmatic information as a marker of the subsequent complement clause structure.

While both sets were being investigated with the same experimental procedure, they were analyzed separately. An individual analysis of variance was computed for each sentence set since each structure was included for testing different but related aspects of the SVO hypothesis.

Method

Subjects. Forty Queens College undergraduate and graduate students served as subjects for the second experiment. All subjects were native speakers of English, volunteered to participate, and were paid $2.00 for their participation.

Materials and design. Twenty sentence quadruples (as shown above) were constructed for the relative clause set, and twenty sentence quadruples were constructed for the reduced complement set. Thus, there was a total of 160 experimental sentences. Set 1 contained one unreduced subject relative version, and three object relatives: one marked with "who"; one with "whom"; and one by the double noun configuration (the reduced version). All of the relative clause sentences were reversible so that all contained the same words (other than the marker variation). Thus the word preceding the phoneme to be monitored was identical (always an adverb or an adverbial phrase) for each version in the quadruple. The target phoneme for the experimental sentences in Set 1 was always located in the matrix verb which immediately followed the clause boundary. Set 2, which was designated as the reduced complement set, contained one SVO version, and three reduced object complements. The three complement versions were designed to correspond to the following conditions: (1) selection restrictions and pragmatic constraints were not violated--version (b); (2) selection restrictions were violated--version (c); (3) pragmatic constraints were violated--version (d). Because each of these conditions demanded a particular lexical realization, the versions and thus the critical word could not be identical as in Set 1. However, the words preceding the target phoneme were carefully selected to be as similar as possible. In particular, they were all one syllable words, and each critical word within a quadruple began with the same phoneme. The target phoneme was located in the second lexical item following the object noun phrase. Thus, both sets controlled for the critical word properties that have been shown to affect monitor times by using identical or matched critical words.

Thirty filler sentences were constructed for inclusion in the material sets. These thirty sentences were comprised of varied constructions. Fifteen contained target phonemes which occurred early in the sentence, and 15 did not contain the phoneme specified as the monitor.

As in Experiment 1, a set of questions--a total of ten, five for each set--was devised. Each question followed the appropriate experimental sentence; however, its occurrence could not be predicted. As in Experiment 1, the answers to these short queries were given verbally and were not timed as they were included to insure that subjects would attempt to understand the sentences.

A two-factor design (Order x Sentence Version) was used. The order variable was a between-subjects variable and the sentence version was a repeated measure variable. As stated above although relative and complement sentences were included in the same material sets because their design was the same, they were analyzed separately. All of the experimental sentences were randomly assigned to a master presentation order. From this master, four material sets sere derived such that one version of each experimental sentence apperaed in each set. Thus, each material set contained 40 experimental sentences (20 from each set), 30 filler sentences, and 10 comprehension questions.

Procedure: Using a two-track tape recorder, each material set was recorded by a female native-English speaker using normal sentence intonation. In accordance with standard practice, tones were placed on the inaudible track at the onset of the target phonemes. The tone started a timer which was stopped by the button press of the subject indicating recognition of the target phoneme.

Upon entering the lab, the subject was seated at a booth containing headphones and button console. After the subject was seated, he or she was read a standard set of instructions. The subject was told to listen to each sentence carefully in order to understand its meaning and to locate a sound at the beginning of a word in that sentence. The sound to be identified would be specified before each sentence. If the specified sound appeared in the sentence, the subject was instructed to press the button as soon as he or she heard that sound. If a question regarding the sentence meaning followed the sentence, the subject was instructed to answer the question verbally. The experimenter sat in an adjacent room and recorded all of the reaction times (RTs); and indicated whether answers to the questions were correct.

Incorrect responses were recorded verbatim.

The sentences were presented binaurally. Prior to beginning the experimental set, the subject heard four practice sentences. One question was included in the practice set, as was a sentence which did not contain the specified phoneme. Ample time for questions regarding the procedure was allotted before and after the practice set. Each experimental (and filler) sentence was preceded by a carrier phrase alerting the subject to the onset of the sentence and identifying the sound to be monitored, as in the following example.

> "Ready. Listen for a word that begins with 'duh' as in the word 'deer'. The explorer believed the river might deepen beyond the sandbar."

All 70 sentences were presented in this format. All subjects were tested individually. The experimental procedure lasted one half hour.

Results and Discussion

Set 1. The mean RTs to the target phonemes were computed for each version and are shown in Table 5. An analysis of variance showed that the main effect of version was significant, $F(3,36) = 3.368$, $p < .02$. Inspection of the data revealed that the reduced object relatives showed the effect in the predicted direction. However, the results for the marked object relatives and the subject relatives failed to confirm the SVO hypothesis. The mean RT of 682 msecs. for the subject relatives was slightly slower than the unreduced object relatives mean of 663 msecs. for both markers. The subject relative mean was apparently inflated by the scores of one sentence in Material Set A. When all scores from the anomalous sentence were eliminated, the overall subject relative monitor latency is reduced to 659 msecs., presented parenthetically in Table 5. Thus, there appears to be no difference among all the marked relative clause sentences. This result failed to replicate the Frauenfelder, et al. (1980) finding that the phoneme monitor task is sensitive to this (the subject/object relative) syntactic variable. It may be that the redundancy in the English cue structure causes the listener to anticipate the change in word order through the early appearance of the marker. In addition, the word order in English specifies the nature of the deviation from the SVO while the French object relatives used in the Frauenfelder, et al. study did not. Thus, in English it may be that monitoring after the clause boundary fails to capture the SVO effect.

The hypothesis that "whom" would provide more specific information for the listener, thus allowing the phoneme to be monitored more rapidly was not confirmed. Again, this may be attributable to the failure to place the target phoneme within the clause for the English sentences.

That the reduced object relative showed the predicted effect lends partial support to the SVO hypothesis. As it is a weakly marked deviation from SVO, it would be expected to slow the comprehension process more than the strongly marked versions. It is reasonable to speculate that, as SVO theory asserts, for strongly marked routine reparses the comprehension mechanism recovers rapidly. The loss incurred in making an on-line revision would not necessarily be detectable once the clause was closed. Thus, if the theory is correct, it is not surprising that the after-the-clause boundary position of the target phoneme captured the unmarked violation but not the marked one. Some support for this claim can be found by considering the pattern of errors that emerged to the 10 comprehension questions. I will discuss these findings after presenting the results for the reduced complement set.

Set 2. Mean phoneme monitor times were computed for the complement sentences and are shown in Table 6. An analysis of variance was computed and the results indicated that the monitor times for the tested versions did not differ significantly from each other.

Because the results of the analysis of the relative clause findings cast doubt on the sensitivity of the phoneme monitor task to the on-line revision process, three informal explorations of the data were undertaken. The first exploration involved the examination of the incorrect answers to the comprehension questions, as indicated above. The question explored here was: is there any evidence that violations of SVO order affect the comprehension process despite the failure to find an increase in processing time for the predicted versions as measured by the phoneme monitor task?

The error data are presented in Table 7. While the overall error rate is small (11%), indicating that the sentences were generally understood, there are two patterns of interest to consider. The first is the difference in error rates between the complement and the relative clause structures. The overall error rate for the complement questions was 3%; while the overall error rate for the relatives was 20%. The SVO hypothesis would predict this difference as the SVO analysis of the matrix clause is interrupted by the embedded clause for the relatives. However, while the complement analysis requires the postulation of an additional S node creating a sentence boundary after the first clause has been analyzed, this procedure does not seem as disruptive as the within clause revision that the relatives require.

The second interesting aspect of these error data is the actual versions to which incorrect answers were given. For the complements, version (b) in which the selection restrictions were not violated and version (d) in which the pragmatic constraints were violated were both answered incorrectly three times each--6% incorrect responses. Neither the SVO sentences, version (a) or version (c) in which the selection restrictions were violated were answered incorrectly. For the relatives, each version incurred some incorrect answers.

The questions following the subject relatives received 4 incorrect answers, 8% incorrect responses. For the object relatives, questions following the unreduced versions (b) "who" and (c) "whom" received respectively 18% and 22% incorrect responses. The percentage of incorrect responses increased further in the reduced version (d) to 33%. The differences among the versions of the relative clause sentences were in the direction predicted by the SVO expectancy hypothesis and were significant, $X^2(3,.975) = 9.35$, $p < .025$.

The purpose of the second exploration was to determine whether there was any systematic bias in the experimental sentences of the reduced complement set attributable to the verbs used in this study which could account for the apparently uniform performance across versions. The SVO hypothesis predicted that for version (a) the simple SVO structure, the phoneme monitor latencies would be short when compared with version (b) SelResUnVio structures. This predicted difference was considered to be evidence for the SVO effect. (Versions (c) and (d) were included to test facilitation hypotheses.) Of the 20 experimental sentences, ten exhibited the effect; ten did not. (See Appendix C.) Of the ten which failed to produce the predicted results, four were for-to complements. None of the effect producing verbs could take the for-to complement construction. This division suggested that a bias may exist for a particular verb to enter into a particular structure, thus varying the structural expectancies within the parser (in much the same way as Bresnan, et al. have suggested). A pilot paper-and-pencil test was designed to probe this speculation. Five subjects were read the initial portion of the 20 experimental sentences and were asked to complete these in any way they wanted. (The complete instructions are contained in Appendix C.) Ten of the sentence fragments were read with the object NP present, and ten were read without the object NP. (See Appendix C for the complete list of materials.) The sentences were randomly ordered into the presentation list. Two lists were constructed such that the object NP occurred within different sentence fragments for each of the two conditions. For example, in Condition A subjects heard, "The young musician believed...," and in Condition B those subjects heard, "The young musician believed most composers...."

The results of this test are presented in Table 8. Of interest is the no object presented condition. For sentences which failed to produce the SVO effect in the monitor task, the subjects were as likely to complete the fragment by closing[2] the clause (28%) as they were to complete the fragment with a complement clause (32%). In the same condition, the sentences which had given the SVO effect patterned differently. That is, in the no object condition, subjects preferred the complement construction (46%) to the closed construction (14%). It may be concluded that the non-effect verbs are syntactically ambiguous. Thus, a subject receiving a sentence fragment containing a verb of this type receives no information regarding the subsequent structural properties of the sentence. Likewise, a subject in the phoneme monitor task receiving one of these verbs is unable to predict the subsequent structure and is therefore open to either analysis. There is no revision process in progress when the target phoneme arrives which enables the subject to identify the phoneme quickly. In the object presented condition both verb types were responded to similarly. That is, subjects preferred the closed clause completion to the complement construction.

Thus, it appears from these data that the occurrence of an NP following a complex verb creates a bias for the SVO analysis which is precisely what the SVO hypothesis predicts. However, if the NP does not occur, there is a subset of verbs including those taking for-to complements which do not exhibit this SVO preference. It has been suggested that during the comprehension process these verbs block the SVO analysis, leaving the specification of the incoming structure open until more information is available. This interpretation of the results is fully compatible with Bresnan's linguistic model; and Chodorow's (1978) theory of structural determinacy. These data also provide indirect support for the claim that the subcategorization properties of the verb are taken into account by the parser before the structural analysis is determined.

It was implied in the discussion of Set 1 that the failure to obtain the predicted differences could possibly be attributed to the insensitivity of the phoneme monitor task to some syntactic variables. Thus, a second exploration was undertaken with the materials of Set 2.[3] The purpose of this follow-up study with regard to this thesis was to determine whether a change in methodology would yield the predicted results. If this were the case, the results would provide some support for the claims regarding the inadequacy of the phoneme monitor task for testing syntactic hypotheses. For this purpose, the next word naming task was employed.

Materials. Eighteen sentence triplets were adapted from the materials in Set 2 in the following way. Three of the four conditions were retained for testing--version (d), the pragmatic constraint violation, was dropped as the critical words preceding the target would necessarily have to be too altered to allow for an appropriate comparison to be made among the conditions. In addition, each of the remaining versions was shortened. The target word in this study was changed to the word immediately following the object NP position. For version (a), SVO, the target was an adverb or a preposition; for version (b), SelResUnVio, and version (c), SelResVio, the target word was the verb of the complement clause. (See Appendix C.) The materials were counterbalanced across three sets and presented to 15 subjects, five in each set. An example triplet follows. The target word is indicated in bold type.

(a) The clown knew the strongman **well** from other circus jobs.

(b) The clown knew the strongman **would** frighten the young children.

(c) The clown knew the strong chains **would** frighten the new lion.

Task. The sentences were presented on a CRT in the following way. The word "Ready" appeared, followed by the beginning of the sentence which the subject read silently. When the subject finished reading this portion of the sentence, he or she pressed a bar and the single target word appeared on the screen. The subject read this word aloud. The remainder of the sentence was then displayed for the subject to read silently. Reading time was measured for the target word.

Results. The mean reading time for each version was computed. The SVO version produced a mean reading time of 522 msec.; while the two complement versions produced means of 578 msec. and 582 msec., respectively. These differences are not significant, which is attributable to the small number of subjects tested with this procedure. The pattern suggests that the SVO analysis was the analysis of choice for all three versions. That is, it appears that subjects perform the same analysis for version (a) and for version (b). When the complement verb occurs in version (b), the SVO hypothesis predicts that the parsing operations will halt while the parser accesses the appropriate parsing plan. The observed difference in the two means can thus be attributed to the onset of the revision process which is invoked by the verb of version (b). With regard to the phoneme monitor task, these data suggest that it may be unsuitable to employ the phoneme monitor task to tap these fine differences.

This suggestion is further supported by the data from version (c). The mean reading time for this sentence version indicates that selection restrictions do not block the SVO analysis. This result was predicted by the SVO hypothesis; however, neither the comprehension task used in Experiment 1 nor the phoneme monitor task of Experiment 2 supported the claim that selection restrictions do not operate at the level of parsing. The results of the next word naming task do suggest that selection restrictions operate at a higher level of sentence processing (than at parsing). While these current data are inconclusive, they do provide some evidence for the inadequacy of the phoneme monitor task with regard to testing parsing variables. This issue will be discussed in the next chapter.

In summary, the results of Experiment 2 fail to provide direct support for the SVO hypothesis. However, the results of several exploratory procedures including an error analysis, a sentence completion task, and a next word naming task are consistent with the claims of the SVO hypothesis. In addition, the findings suggest, in contrast to the Frauenfelder, et al. (1980) conclusion, that the phoneme monitor task is not a sufficiently sensitive procedure to use in syntactic parsing studies.

Notes for Chapter Three

[1]It is of interest to note that the matrix verbs used for this sentence type (i.e., showed, told, promised) are subcategorized for two NPs. Thus, the appearance of the marker "that" confirms one possible prediction made by the parser, namely, to expect two NPs. In this sentence type the marker "that" incorrectly indicates that the second NP contains an $\bar{S}$. Thus the frequently reported object complement "garden path" effect for these embedded object relatives is, by hypothesis, due to the subcategorization properties of the matrix verb, the specific marker used (i.e., "that" instead of "who"), and the incorrect prediction and subsequent verification of the SVO analysis of the second clause (i.e., attaching the actual object of the matrix clause incorrectly within the embedded clause). Experiment 1 was designed to investigate the SVO expectancy aspect only. However, it is true that the SVO analysis is only applicable if the subcategorization information is used by the parser, and, in fact, overrides the assignment of the direct object role to the first NP and the relative clause analysis of the second clause. I take this fact as evidence for the view that the markers are as integral a part of parsing as the initial (SVO) and subsequent (revised) structural expectancies. The parser's use of subcategorization information as a marker to predict or revise the parsing plan is evidence for the breadth of the marking concept.

[2]Of importance is the fact that while subjects closed the clause, they frequently did not close the sentence. Thus Closed vs. Complement is not a simple notion of more or less complexity. It is only an indication of the occurrence/non-occurrence of a clause boundary. In fact, Closed represents subjects' choosing simple, main-main, main-subordinate, and main-relative structures.

[3]This research was conducted by Lise Jensen at The Graduate School and University Center of the City University of New York under the supervision of Dean H. S. Cairns of Queens College of the City University of New York. Dean Cairns has generously made these results available to me for use in this discussion.

CHAPTER FOUR

Toward A Theory of Parsing: Evidence for the SVO Effect

This thesis was conceived of as a preliminary investigation of the SVO parsing model. While the experiments described in the previous chapter have yielded both expected and unexpected results, on the whole the data are consistent with the model. The unexpected results point to necessary refinements of the originally proposed model. However, the refinements serve to strengthen rather than weaken the proposed characterization of the model. The purpose of this chapter is threefold. First, I will discuss the experimental results as they pertain to the following questions: (a) Is there evidence enough to support the SVO effect as predicted, and (b) does the experimental evidence suggest that violations of selection restrictions are read as markers by the parser? Secondly, I will briefly comment on the use of the phoneme monitor task in parsing studies. Third, and in conclusion, I will present the refined SVO parsing theory. I will suggest that because it is such a highly constrained parsing theory that future research be directed toward substantiating its claims.

The SVO Effect

The first question posed was whether an SVO effect could be documented during sentence processing. The following results have provided support for the existence of this effect. In Experiment 1, control sentence types which were SVO or clearly marked deviations from SVO were understood faster than the non-SVO or less clearly marked counterparts. Thus, a variety of structures unified only by their conformance to the definition of easily parsed structures provided by the SVO model were observed as exhibiting the predicted uniformity.

It is important to emphasize that the claim is that the parser has an SVO expectation (for English) as a point of departure at the onset of the parse. The theory predicts that the revision process itself does not necessarily entail processing difficulty. The revision process is defined here as a two-step process. When the parser encounters a marker, as a first step it invokes HOLD. HOLD suspends the ongoing parsing activity while the parser reads the marker. The second step is the parser's accessing of an alternative parsing scheme. The new parsing scheme will then govern the parser's subsequent expectancies, at least over the segment of information governed by the marker. The clarity of the marker will partially determine sentence complexity since it is assumed that an ambiguous marker can lead to false starts. The number of interruptions the parser encounters will also determine sentential complexity. (Consider, within this framework, the well-documented problems the parser has with double-center-embedded sentences.) The parser is always seeking the elements of the SVO package it is obligated to formulate. The markers serve as signposts which guide the parser to the appropriate elements, or, alternatively, provide the appropriate interpretation for the elements under analysis. The HOLD function is crucial, in this view of revision as an on-line process, otherwise, reparsing would necessarily become a routine operation. It seems more efficient to stop the parse and revise the parsing plan immediately than to redo it at a later time. Chodorow's (1979) data provided evidence for a decision lag during syntactic processing. I take this to be evidence for HOLD, as the theory suggests that the ongoing parse is suspended until (as soon as) the parser determines the course of action. The longer the parser is in the HOLD mode, the more difficult the parse. The more ambiguous the marker, the longer the parser is in HOLD. Thus, that the sentences of Experiment 1 can be classified, as predicted, on the basis of the markers supports the existence of the SVO effect.

The SVO model predicts that the SVO analysis will be carried out whenever the syntactic properties of a sentence are consistent with the expected structure (i.e., no marked violations). The two perceptual illusion sentences show a strong SVO effect. Both the sentence comprehension task data as well as the judgment task data yielded this result. That is, the mean comprehension times of the perceptual illusion sentence types were significantly longer, subjects more frequently refused to respond to these types, and subjects more frequently responded incorrectly to questions following these types on the comprehension task. The judgment task revealed that subjects were frequently unable to perceive the correct sentence structure (non-SVO) despite the explanation proferred by the experimenter. Subjects, instead, persisted in their original (SVO) analysis, and opted to label the sentences as unacceptable. The EmClUnRedORel were most frequently labelled as semantically unacceptable, while the reduced truncated passives were more often labelled as syntactically unacceptable. The unacceptability is a result of the misapplied SVO analysis.

The acceptability ranking based on the results of the judgment task provides support for the SVO claims. (See Table 3.) The SVO sentence was never judged as unacceptable. All other structures were regarded as unacceptable by at least two subjects. The order from fewest to most judgments of unacceptability was RevPass, ClObjUnRed, EmClRed, ObjComp-SelResUnVio, ObjTop, ClObjRed, EmClRedTrunPass, EmClUnRedORel.

As only 3% of the subjects judged the reversible passive to be unacceptable, it is apparently not regarded as difficult to process. The passive structure is clearly and redundantly marked syntactically. Thus, while the passive structure was not originally predicted to be an easy parse type, this result (also see the mean comprehension score in Table 2) is in accordance with the workings of the SVO model. The passive result suggests more strongly than originally proposed that the marking system and the on-line revision function of the parser are of equal importance during parsing to the SVO expectation.

Is this desirable? Why not propose that the parser stores a variety of expected structures that are deployed in accordance with the data. The reason is basically that a model which has a single initial expectancy, a few instructions to read, and only a minimal amount of revising that it can do, is a strong, parsimonious, falsifiable model. A parser accorded too much power (too many "expectations" at sentence onset) could churn out alternative analyses without limit. Given these possibilities, the imposition of non-syntactic constraints on the parser can seem appealing. However, if the claim is the autonomous claim that the first stage of syntactic processing is only syntactic in nature, then the constraints should be syntactically based as well. The highly constrained parsing model described above preserves the autonomy claim by proposing an initial syntactic parsing routine which can be altered by the occurrence of syntactic markers. Based on the information provided by the marker, the parser can revise its initial routine by selecting a secondary syntactic parsing routine. Thus, as stated above, the passive construction does not routinely pose a parsing problem unless the syntactic markers are somehow obscured. Returning to the passive data in Experiment 1, when the mean comprehension times (see Table 2) for all of the tested passive constructions are compared, the following pattern is found. From fastest to slowest comprehension time, they order IrrevPass, RevPass, EmClRedPass, EmClRedTrunPass. Given the strength of the marker hypothesis, this is, in general, the predicted order.

Returning to the order of the acceptability judgments, those structures in which SVO deviations were clearly marked by pronouns or verb forms were judged to be equally acceptable. That is, only 10%, 13%, and 16% of types ClObjUnRed, EmClRed, and ObjCompSelResUnVio respectively were judged to be problematic in processing. The percentages jump to 26% and 32% respectively for ObjTop and ClObjRed structures. The double NP marker which serves as the violation indicator for these forms was hypothesized to be less effective. These data provide support for the predicted marker effectiveness.

Finally, the perceptual illusions were judged to be the least acceptable of the tested structures. Again, their unacceptability arises only if the SVO parse is incorrectly applied. That the parser makes mistakes which are SVO mistakes is taken as evidence in support of the SVO model as described. First of all, a parser with limitations as severe as those imposed in the SVO model is bound to err. The parser need not perform perfectly. If it were to do so, the parser would need to receive, each time, clearly specified input, which it doesn't; or it would need unlimited time for performing a structural analysis which it doesn't have. Secondly, there is no other plausible reason for the parser to err in favor of an SVO analysis unless the parser favors that analysis to begin with. If an SVO bias doesn't exist, why not guess any of the possible structures, thereby producing a less consistent response pattern across subjects? Why not simply break down before applying the SVO analysis? However, the parser does neither. The evidence yielded from the perceptual illusion types is very stable, and it points to an SVO bias within the parser.

The second experiment failed to produce a direct confirmation of the SVO effect, however, there is some indication that a methodological problem exists. As indicated above, the phoneme monitor task will be discussed in a subsequent section. Regarding the second experiment, there is evidence for the SVO effect provided by the results of the formal and informal post hoc investigations. In addition, an analysis of the incorrect responses to questions in the phoneme monitor task yielded an interesting and supportive pattern.

Beginning with the error analysis, it was shown that the answers to questions following relatives were wrong more frequently than to queries of the complements. It was suggested earlier that, given the SVO parsing principle, it is more complex to interrupt the SVO analysis (as in the relatives)--invoking HOLD, accessing a second plan, returning to the matrix clause--than it is to add an S node (as in the complements). Thus, assuming that errors reflect sentential complexity, it is taken as evidence for the SVO effect that more errors are associated with the relatives which, by the SVO hypothesis, are more complex.

Within the relative set, the error pattern supports the predicted relationships among the types. That is, to begin with, subject relatives are easier to parse than object relatives. Subject relatives yielded fewer errors than any of the object relative types. The "who" and "whom" marked objects produced aproximately a 20% error rate each; while the reduced object relative produced a 33% error rate. This pattern is consistent with the predictions of the SVO hypothesis; namely (a) the marking and order advantage for the subject relative structure; (b) the deterioration in performance as the order advantage is lost for the marked object relatives; and (c) the poorest performance for the weakly marked, inverted order in the reduced object relative.

In summary, the pattern of the errors is in accord with the degree of complexity predicted for each sentence type by the SVO parsing theory. The theory predicts the lack of complexity for the SVO type only. (Note that the ObjCompSel-ResVio type exhibits an advantage in the error analysis.

The level at which the advantage is proposed to occur will be discussed below.) Of the non-SVO types, it was proposed that the object complements would be the least complex, followed by marked subject relatives. Object relatives were predicted to be more complex, with the reduced, or weakly marked, version being the most complex.

The sentence completion task also yielded supportive results for the SVO effect. Namely, in the object NP presented condition, the subjects tended to treat the presented fragment as a completed SVO unit, thereby closing the presented clause. In contrast, when the object NP was not presented, the completion response appeared to be governed by the properties of the matrix verb. The contrast between the two conditions provides evidence for the SVO effect. That is, as has been claimed, if an SVO analysis is not contraindicated, the parser will analyze a structure as such. The occurrence of the Subject-Verb-Object sequence in the object presented condition appears to override the bias of the matrix verb. In the no object condition, however, the argument structure of the verb influenced the way the subjects completed the fragments. If the parser had no preference for the SVO analysis, there would be no reason for the difference in response patterns between the two conditions. That is, the verbs should be uniformly influential if the parsing mechanism is based primarily on a lexical preference model as Ford, et al. (1982) have suggested.

The final piece of evidence for the SVO effect is derived from the next word naming study (Cairns, Jensen, and Jablon, 1984) conducted with the materials adapted from the second experiment. Of particular interest is the difference between the SVO and the ObjCompSelResUnVio mean reading scores. While the 56 msec. difference between the means was not significant, given the small sample size, it is safe to say that this difference does indicate a trend in the predicted direction. Referring to the sentence completion task results, this difference would not be expected if lexical preference was operating as the primary parsing principle. That is, the results of the sentence completion task indicated that a subset of the matrix verbs demonstrated a preference for the complement reading. We should predict, then, that this subset would counteract the preference of the remaining verbs and wipe out the SVO effect in the next word naming task. Instead, subjects exhibited an expectation for the SVO structure for the ObjCompSelResUnVio sentences as indicated by the delayed response to the target word--the complement clause verb. If the matrix verb was exerting influence, we would expect the clause to be open at the target word (HOLD having been invoked earlier) and the appearance of a marker expected. Rather, it appears as if the complement verb is unexpected and the revision process is begun at the receipt of that verb.

Taken in total, the evidence from Experiment 1 and

Experiment 2 point to a consistent SVO effect. This consistency is taken as solid support for the SVO parsing theory. It should be noted that despite the failure of the data to confirm the predictions of the SVO parsing theory in the second experiment, there is no strong falsification to be found in these data. The utter uniformity of the phoneme monitor times for the complement set suggests a methodological problem more than a theoretical problem. Since the data from Experiment 1 as well as the data from each probe of Experiment 2 proved to be consistent with the proposed theory, I am concluding that there is sufficient evidence to support the existence of an SVO structural preference at the level of the parser.

Selection Restrictions

The results of the comprehension time study can be most facilely interpreted as supporting the hypothesis that selection restrictions are read by the parser. This implies that semantic information can facilitate (at the least) the parse. While the results of this study regarding the use of selectional information is at best inconclusive, I would like to suggest an alternative analysis, along with some data supportive of this analysis.

My claim is that the comprehension times yielded in Experiment 1 for the ObjCompSelResVio and ObjCompSelResUnVio contrast, and the IrrevPass and the RevPass contrast result from facilitation by the semantic information at the level of the processor. There are two studies which bear on this hypothesis. They do so by supporting the claim that the parser is not sensitive to the selection restriction violations. Rather, the parser projects the same syntactic analysis for the same syntactic forms despite the semantic oddity that arises when one member of the pair contains the selection restriction violation. Both of the studies to be discussed employed on-line measures in contrast to the post-sentential measures used in Experiment 1.

Cowart and Cairns (1984) initially employed the next word naming task to investigate the "Pronoun Bias Effect." They found that an early occurring pronoun (they) exerted a bias on the interpretation of an ambiguous phrase (e.g., visiting uncles). The effect is such that a singular verb (is) presented visually following an auditorily presented sentence fragment which ended in the ambiguous phrase yielded a slower reaction time than the plural verb (are). In a second investigation of the effect which is of primary interest for this discussion, Cowart and Cairns asked whether other syntactic as well as non-syntactic properties of the sentence altered the Pronoun Bias Effect. They presented subjects with sentence pairs. For one member of each pair the biased plural reading resulted in an anomalous sentence. Of particular interest is the contrast between the selectional anomalies and the structural anomalies. For the selectional anomalies, the co-reference assignment is not blocked; for the structural anomalies, the co-reference assignment is blocked. The conclusion to be drawn is that there exists a level of structural analysis at which the selection restrictions are not influential. By hypothesis, this level is the parsing level. By virtue of the Cowart and Cairns data, it appears as if selectional information is not admitted by the parser.

The Cairns, Jensen, and Jablon (1984) study reported in chapter 3 resulted in a related finding. For their sentence triplets SVO, ObjCompSelResUnVio and ObjCompSelResVio, both the SelResUnVio and the SelResVio yielded longer reading times, 578 msec. and 582 msec. respectively, as compared to the SVO mean reading time of 522 msec. Again of particular interest is the failure of the selectional information to block the incorrect (SVO) structural analysis. The complement verb for both SelResUnVio and SelResVio structures apparently serves as the first SVO-deviation marker for the parser which then engages the revision procedure. If the selection restrictions were admitted at the level of the parser, the SelResVio mean would be predicted to approximate the SVO times. This should result from the earlier onset of the revision procedure as the parser encountered the selection restriction violation.

These two findings are contradictory to the result of Experiment 1, the comprehension time study. Here the results indicated that the SelResVio type was understood as fast as the EmClRed control to which it was compared. Furthermore, the SelResUnVio sentences took significantly longer to understand than the SelResVio and the control. Given the above findings regarding the level at which selection restrictions appear to intervene, the results of the first experiment can be interpreted as follows. The SelResVio advantage in the sentence comprehension task is proposed to derive from facilitation effects in the second stage processor, which, by hypothesis, has access to semantic and pragmatic information. This processor uses all available information in order to determine the full sentence meaning, and to integrate this meaning with previously acquired information. Thus the selection restriction violation which showed a clear advantage in the post-sentential measure used in Experiment 1 but failed to block incorrect preliminary structural analyses as measured by the next word naming task, is hypothesized to facilitate processing at the second stage. Specification of the nature of this effect is beyond the scope of this paper; however, future research should continue to investigate this issue. A clear understanding of how information is used in syntactic processing will bear directly on whether we accept the autonomous or modular view of processing; or move toward a more interactive view. The rapidity with which second stage processing occurs can easily obscure the true workings of the parser. The challenge at this time lies equally in selecting sensitive on-line measures as it does in interpreting their results.

The Phoneme Monitor Effect

The results of Experiment 2 failed to confirm the hypotheses under investigation. However, the flat configuration of the means led to the speculation that the phoneme monitor task was the source of the failure. Specifically, it was suggested that the phoneme monitor task is not an appropriate measure to employ to tap parsing effects. Frauenfelder, et al. (1980) tested this hypothesis, and on the basis of their data concluded that the phoneme monitor task was sensitive to syntactic variables. Frauenfelder, et al. used two target positions. Only one yielded results. They concluded that by placing the target phoneme in the clause boundary position, syntactic variables could be tapped. The results of Experiment 2 for the relative sentence set failed to replicate their findings. However, as indicated above, the error data and the post hoc probes of the sentences did yield the predicted results. This discrepancy in conjunction with the flat configuration of the monitor latencies cast doubt on the validity of the measure.

One obvious problem in employing the phoneme monitor task in parsing studies is the selection of the site for the target phoneme. The monitor task is sensitive to competing processing operations. Therefore, the location of the target should be at the point in the sentence at which the effect of the structural complexity occurs. For lexical items, with which the monitor task has been used successfully, the location is straightforward. That is, the predicted complexity would be within the lexical item itself; therefore, the target word would necessarily immediately follow the item. For syntactic effects the site of the predicted complexity may not necessarily be at a specific location. That is, a complex structure may slow the entire comprehension process so that the sentence comprehension process is affected overall. Furthermore, even if an effect could be theoretically isolated to a particular point in the sentence, it is difficult to predict the point at which the complexity could be measured. For example, when the parser encounters a double NP marker, does the activation of the HOLD function increase processing complexity at the second NP? Or does the increase occur at the verb of the embedded clause where the revision is being cued, or immediately following the verb as per the lexical effect? Or, as Frauenfelder, et al., have suggested following the clause boundary to capture, perhaps, a cumulative effect of the preceding operations? Syntax describes relations among the elements of a sentence. Is it, therefore, reasonable to expect that all syntactic effects can be reliably isolated in a way that the phoneme monitor task could measure?

A case in point is the Hakes/Chodorow studies described in chapter 2. Hakes (1971, 1972, 1973) failed to tap the verb complexity effect with the phoneme monitor task, but consistently observed increased sentential complexity using post-sentential measures on the same materials. Chodorow's (1979) results indicated that the complex verb itself caused a recall decrement not exhibited by words in the surrounding positions. In addition, like Hakes, Chodorow found that after the occurrence of a complex verb sentence processing is affected in a general way. This is exactly the pattern observed in Experiment 2 in this paper. For the complement set, the next word naming task revealed a performance decrement at the site of the complement verb. The phoneme monitor task failed to detect that decrement following the verb. Furthermore, the error pattern for the relative and complements showed an overall performance decrement in the predicted direction. Thus, at least for the variables tested in this present study, the phoneme monitor task was apparently a poor choice of measure. The Hakes/Chodorow results indicate that the inadequacy of the phoneme monitor task might be more pervasive than Frauenfelder, et al. have suggested.

There is an aspect of the materials used in Set 1 of Experiment 2 which may account for the differences in these data from the results obtained by Frauenfelder, et al. Namely, the occurrence of an adverb or an adverbial phrase between the relative clause verb and the matrix clause verb may have shifted the clause boundary in this study. For example, in "The intern who the nurse dated once takes out the medical student now," depending on the preferred attachment of the adverb, the clause boundary may have occurred earlier with respect to the matrix verb than in sentences in which the Verb-Verb sequence occurs. Frazier and Fodor (1978) proposed the Local Attachment principle to account for adverbial attachment preferences which violate Kimball's (1973) Right Association parsing principle. The sentences used in this study do not seem to violate either Right Association or Local Attachment (which is not directional). Thus the occurrence of the matrix verb, despite the absence of the double verb marker (Limber, 1976), should have signalled the clause boundary. However, despite the preferred readings of these sentences, the occurrence of an adverb may have invoked HOLD. The parser may have predicted early closure and may have delayed attaching the adverb until more information was received. If this was the case, it is unclear what the effect at the matrix verb (the monitor site in this study) should have been. Thus, the results obtained in this study possibly could be attributed to a materials effect rather than a task effect. Again, the readings of the sentences used in this study do not provide direct support for a materials effect. It is true that the sentences of Set 1 in Experiment 2 did differ from Frauenfelder, et al.'s sentences such that there was an intervening word or phrase prior to the clause boundary. This observation of the possible effect of the adverb underscores the need in studies of parsing for continuous measures which monitor throughout the sentence (e.g., the eye-movement task employed by Rayner, et al., 1983; or the continuous syntactic decision task, M.S. Chodorow, personal communication, March 18, 1986), rather than discrete measures which may fall short of capturing the effects.

The SVO Expectancy Model

The SVO Expectancy Model is a two-stage model. Like other two-stage models it is divided by function into a first-stage parser and a second stage processor. The parser operates automatically and unconsciously using a small set of parsing principles to accomplish its task, which is to provide the structural analysis of the input as quickly as possible. To accomplish its task the parser reads portions of the input which it then packages and sends to the second stage processor. The processor is concerned with determining the meaning of the sentence and integrating this meaning with previously stored information. Unlike the parser, the processor has access to a variety of information including semantic and real world knowledge. It utilizes all available information in order to determine an enriched sentence meaning. The parser, on the other hand, has access to a rather limited input which enables it to make rapid decisions without working through irrelevant information. The limited input can work against the parser. If the syntactic information is ambiguous, the parsing procedures will be delayed.

If the ambiguity cannot be resolved by the syntactic input, the parser will perform the analysis based on assumptions that may be incorrect. Incorrect parses are resolved at the level of the processor. This system prevents the parser from hopelessly bogging down in a series of reparsing attempts. The parser, however, is equipped to revise its parsing plan by accessing an alternative plan, thus shifting its expectancies (its structural predictions); by adding nodes; by suspending analyses to parse intervening material; or by suspending its analyses to wait for disambiguating information. These revisions take place on-line. Once an analysis is determined and sent to the processor, the parser automatically moves on to the next segment.

Given this framework, the question of how the parser accomplishes its task needs to be addressed. The principal problem is the specification of the parsing routines and the way in which the parser employs these routines. It is being claimed that the parser's primary goal is to determine the SVO unit of each input string. The parser operates on the assumption that every sentence is in this order unless otherwise marked.

Thus, at the onset of a sentence the parser activates the SVO plan into which it will slot the appropriate lexical items. It will search the input for markers of deviations from this format. If no markers appear, the SVO form is verified and sent to the processor to await subsequent input or to be integrated with previously analyzed segments. If a marker does appear, the parser will halt the SVO parse, read the information contained in the marker, and proceed with the appropriate parse.

The appearance of any potential marker will cause an increase in processing time as the parser determines the appropriate course of action. The extent of the delay in parsing will be determined by the strength of the marker, and thus, the ease with which the parser can revise the original SVO plan. The revision plans are analogous to cross reference cards which inform the parser of the location of the SVO elements within alternative structures. The parser's actions upon receipt of a marker depend on the nature of the SVO deviation encountered. For example, the receipt of a passive marker requires the relabelling (in some way) of previously parsed material. An embedded clause marker, however, instructs the parser with regard to an interruption of the current parse, and with regard to the structural properties (perhaps) of the intervening material. The output of the parser is always an SVO package--annotated if necessary.

The SVO model is a combination of top-down and bottom-up parsing. This allows for the most efficient use of both knowledge of the language and of the actual input. That is, the parser expects a particular form and regards the input as conforming to the expected pattern (top-down) unless the input contains a contraindicator. Thus the parser needs only to read for potential markers (bottom-up parsing). Once the marker has been encountered, it may alter the expectancy and the parser returns to the top-down mode with the new expectancy or resuming the old.

The parsing principles are the expected forms that the parser can access. As stated above, these principles derive from one's knowledge of the language. Thus the parser is that part of the comprehension mechanism where the grammar is "realized." While the parser's first choice of a parsing routine is the SVO structure, the alternative forms are not ranked or ordered in any way. They are instead cataloged by their identifying syntactic elements. Thus the identifying elements become a critical component in parsing theory. This is so, not because the identifying elements serve as cues to the deep structure, but because they steer the parser along the appropriate course. Parsing, in this view, is a dynamic operation. The parser starts with an expectancy, verifying its expectation with the input properties. It shifts to being data driven when the expectancies are violated. It alters its expectancies and resumes its verification process. These shifts and changes are the constants of parsing.

In the SVO model, segmentation is not an end. It is a by-product of a completed SVO package. There is no boundary search, no limited viewing window. There is only the goal of creating SVO packages to send to the processor. Each SVO package entails a boundary; thus it appears as if the parser is seeking that segment.

Finally, that the parser has access to only syntactic information simplifies the parser's task. Interactive theories are built on the premise that shortcircuiting the grammar by utilizing semantic and real world knowledge facilitates the comprehension process. However, it would seem that a parser which had so many avenues to explore could easily and frequently break down under the burden of choice. The limited input allows the parser to quickly determine the structural analysis. If the information is insufficient, the parser imposes the most likely structure, given the syntactic properties of the input. The processor has access to semantic and pragmatic information which it can utilize in resolving problems which the parser could not, or for interpreting a misparsed string. However, by providing a structural analysis as a point of departure for the processor, the parser has reduced the processing load and narrowed the choices that the processor need consider. A system which is as potentially openended as human language can work only if the mechanism is narrowly defined at critical stages. Too much flexibility within the system would probably result in less flexibility in what could be said, hence, in what could be understood. The richness of language is testimony to the fact that the mechanism which supports it is narrowly defined and not very flexible.

CHAPTER FIVE

Summary and Conclusions

It was concluded that there is sufficient evidence to support the SVO Expectancy Model of processing. At the outset of this work, it was claimed that this model encompasses exactly those parameters which have been proposed as the key elements in various syntactic processing models. For example, the SVO parsing principle accounts for the closure phenomena that the lexical preference model of Ford, et al. (1982) accounts for. In addition, the SVO principle predicts those instances where Ford, et al. fail to get the predicted preference.

The SVO model is in full accord with Milsark's (1983) proposed S boundary principle. For similar reasons to those presented by Milsark, the SVO theory accounts for the effects reported in the clause boundary literature. As has been noted, the difference in the two accounts of the clause boundary effect is that the SVO parser does not actively seek a clausal (or sentential) segment; rather, the isolation of the segment is a by-product of the SVO package.

Superstrategy (Fodor, 1979) and subsequent parsing principles proposed to account for the processing of filler-gap dependencies are subsumed in the SVO principle. That is, a parser seeking to complete an SVO assignment for a structure containing gaps and fillers will need to resolve these relationships. The SVO model suggests thta the parser reads a plan which essentially points to the location of the gap. Because the parser is claimed to be the interface between linguistic knowledge and linguistic use, it also (as Super-strategy does) has access to the language constraints.

The SVO model has a clear advantage over the Sausage Machine (Frazier and Fodor, 1978). The Sausage Machine's packaging preferences are explained in terms of a numerical limit. However, language processing does not seem bound by the seven item limit of the narrow viewing window. The SVO model has syntactic limitations which constrain its parsing capacities. As noted earlier, this comports with a modular view of processing. Furthermore, it is less arbitrary than the seleciton of a number of items which may or may not comport with the syntactic structure under analysis.

The point here is as follows. Many models have been proposed over the years to account for syntactic processing. Some aspects of these models have represented keen insight into the workings of a processing mechanism. As with all theories, some aspects have been somewhat ad hoc (and therefore less satisfying) in attempts to explain the apparent contradictions inherent in language within the confines of a given theory. The SVO model is the logical next step in parsing theory. That is, rather than dismissing previous principles of parsing, the SVO parsing theory is built upon the theoretical claims which run through all of the recent important processing theories with regard to the parsing routines (or strategies).

The strength of the model is its strong claims and its highly constrained functioning. The claims can be easily falsified. However, based on the experiences in this study, finding measures which only tap the level of parsing is one of the major challenges psycholinguists face. Semantic effects creep in rapidly. The routine, automatic and unconscious nature of the parser makes it difficult to tap. There is a long way to go before the SVO parsing theory becomes a satisfactory and a well-understood explanation of the role of syntax in comprehension. This paper represented an initial step in that inquiry. Future research must be addressed to a better understanding of the nature and the role of the marking system and the on-line revision process as these two elements are the substance of the SVO parsing theory.

TABLE 1

SENTENCE TYPES USED IN EXPERIMENT 1

Controls

Type	Example	Label in Text
Subject-Verb-Object	The captain greeted the passengers while the crew prepared the cabins.	SVO
Subject-Verb-Prepositional Phrase	The family ate dinner while the dog waited patiently in the yard.	SVPrep
Embedded Clause-Unreduced	The ballplayer who quit the team became a famous film star.	EmClUnRed
Embedded Clause-Reduced	The woman buying the sneakers won the marathon in record time.	EmClRed
Embedded Clause-Reduced Passive	The old house restored by the Girl Scouts became a tourist attraction.	EmClRedPass
Cleft Subject	It was the beautiful actress who married the old director.	ClSubj

Experimentals

Perceptual Illusions

Type	Example	Label in Text
Embedded Clause-Unreduced Object Relative	The fortune teller showed the girl that the man kissed the future.	EmClUnRedORel
Embedded Clause-Reduced Truncated Passive	The exhausted shopper pushed through the crowded subway car collapsed.	EmClRedTrunPass

(table continues)

Type	Example	Label in Text
	Non-SVO Order	
Object Topicalization	The people mistrusted the lawyer but the judge everyone respected.	ObjTop
Reversible Passive	The expressway was crowded because a truck was hit by a bus.	RevPass
Irreversible Passive	The yard looked better after the grass was cut by the gardener.	IrrevPass
Cleft Object-Unreduced	It is his big house in the country that the rich young man likes best.	ClObjUnRed
Cleft Object-Reduced	It was the sculptor the art dealer met at the gallery.	ClObjRed
	Selection Restrictions	
Object Complement-Reduced: Selection Restrictions Violated	The carpenter knew the wood was hard oak from Massachusetts.	ObjCompSelResVio
Object Complement-Reduced Selection Restrictions Not Violated	The new recruits believed the old sergeant was dangerously insane.	ObjCompSelResUnVio

TABLE 2

MEAN COMPREHENSION TIMES (IN SECONDS) FOR

CONTROL AND COMPARED EXPERIMENTAL TYPES

Comparison No.	Control Type	Experimental Type	Result
1	SVO 3.282	ObjTop 3.948	$p < .01$
2	SVPrep 3.617 (3.336)	IrrevPass 3.272	$p < .01$
3	---	Rev Pass 3.479	NS
4	EmClRedPass 3.552	EmClRedTrunPass 4.919	$p < .01$
5	ClSubj 3.179	ClObjUnRed 3.827	$p < .01$
6	---	ClObjRed 3.458	NS
7	EmClUnRed 3.323	EmClUnRedORel 5.143	$p < .01$
8	EmClRed 3.168	ObjCompSelResVio 3.019	NS
9	---	ObjCompSelResUnVio 3.575	$p < .01$

Note: For Comparisons 3, 6 and 9 in which a control type was compared with a second experimental type, the control mean was actually the weighted sum of the means of the previous comparison.

TABLE 3

RAW SCORES AND PERCENTAGES OF SENTENCES JUDGED
AS DIFFICULT TO UNDERSTAND IN THE
POST-EXPERIMENT JUDGMENT TASK

Sentence Type	Raw Score	Percentage
SVO	0/31	0.0
RevPass	2/62	3.2
ClObjUnRed	3/31	10.0
EmClRed	4/31	12.9
ObjCompSelResUnVio	5/31	16.1
ObjTop	8/31	25.8
ClObjRed	10/31	32.3
EmClRedTrunPass	122/155	78.7
EmClUnRedORel	128/155	82.6

TABLE 4

RAW SCORES AND PERCENTAGES OF REFUSALS TO RESPOND AND INCORRECT ANSWERS TO QUESTIONS

	Refusals[a]		Incorrect Answers[b]	
Sentence Type	Raw Score	Percentage	Raw Score	Percentage
SVO	0	0.0	1	3.1
ObjTop	4	2.5	8	25.0
SVPrep	0	0.0	1	3.1
IrrevPass	2	1.3	2	6.3
RevPass	1	.6	6	18.0
EmClRedPass	1	.6	7	21.9
EmClRedTrunPass	19	11.9	27	84.4
ClSubj	0	0.0	1	3.1
ClObjUnRed	2	1.3	2	6.3
ClObjRed	2	1.3	1	3.1
EmClUnRed	0	0.0	8	25.0
EmClUnRedORel	27	16.9	30	93.8
EmClRed	0	0.0	0	0.0
ObjCompSelResVio	0	0.0	5	15.6
ObjCompSelResUnVio	1	.6	4	12.5

[a]N = 160 for each type
[b]N = 32 for each type

TABLE 5

MEAN REACTION TIMES (IN SECONDS) TO TARGET PHONEMES FOR RELATIVE CLAUSE SENTENCES

Subject Relatives	Object Relatives		
Who	Who	Whom	Reduced
.682 (.659)	.663	.663	.725

TABLE 6

MEAN REACTION TIMES (IN SECONDS) TO TARGET PHONEMES

FOR COMPLEMENT SENTENCES

SVO	Selection Restrictions: Not Violated	Selection Restrictions: Violated	Pragmatic Constraints: Violated
.634	.636	.646	.642

TABLE 7

SENTENCE COMPREHENSION QUESTIONS:

ERROR DATA

Complements

	Version (a) SVO	Version (b) SelResUnVio	Version (c) SelResVio	Version (d) PragConsVio
Total Questions Asked	50	50	50	50
Total Responses	49	49	48	50
Incorrect Responses	0	3	0	3
% Incorrect	0%	6%	0%	6%

Relatives

	Version (a) Subject	Version (b) Object-Who	Version (c) Object-Whom	Version (d) Reduced
Total Questions Asked	50	50	50	50
Total Responses	49	49	49	48
Incorrect Responses	4	9	11	16
% Incorrect	8%	18%	22%	33%

Note: For each version there were five questions asked of 10 subjects totalling 50 questions asked. The total responses were the total number of questions asked minus the number of "no response" within each version.

TABLE 8

PERCENTAGES FOR COMPLETION RESPONSES IN THE POST-EXPERIMENT SENTENCE FRAGMENT TASK

	Complement		Closed	
	Object Presented	No Object Presented	Object Presented	No Object Presented
Effect Verbs	8	46	32	14
Non-Effect Verbs	4	32	36	28

APPENDIX A

Experiment 1

Comprehension Task Sentences

The materials presented here are organized by type. They are presented with the control type preceding the experimental type (or types) to which it was compared.

SVO

1. The children ate their snack when the music teacher left the room.
2. The children played tag outside while their parents ate a late dinner.
3. The captain greeted the passengers while the crew prepared the cabins.
4. Mother cooked a special dinner when Dad got his promotion.
5. The landlord raised the rent when the new tenant signed the three-year lease.

ObjTop

1. I held separate interviews but some of the couples I saw together.
2. The ham sandwiches were left over but the bagels the children ate first.
3. The fresh broccoli was overcooked but the string beans everyone praised.
4. The people mistrusted the lawyer but the judge everyone respected.
5. The author hated his agent but the editor he liked a lot.

SVPrep

1. The committee hired a great band so that the seniors would come to the prom.

2. The teacher cancelled the class so that the students could go to the rally.

3. The family ate dinner while the dog waited patiently in the yard.

4. The men rode their bikes last week because the transit workers were on strike.

5. Our boy scout troop goes camping each year after school closes for the summer.

RevPass

1. The audience was angry when the guest star was insulted by the host.

2. No one was there when the policeman was killed by the criminal.

3. The baseball fans went wild when the Red Sox were beaten by the Yankees.

4. The expressway was crowded because a truck was hit by a bus.

5. The press agent was pleased when the actor was kissed by the model.

IrrevPass

1. The yard looked better after the grass was cut by the gardener.

2. The commuters were upset when the fare was increased by the mayor.

3. Every race ends when the finish line is crossed by the last runner.

4. The students cheered when the midterm was postponed by the professor.

5. The lawyer felt proud after the verdict was delivered by the jury.

EmClUnRed

1. The ballplayer who quit the team became a famous film star.

2. The dancer who broke her right leg took a two-month leave of absence.

3. The young woman who owned the book store was dating my brother.

4. The butcher who cheated his customers closed up his shop Saturday.

5. The governor who raised the sales tax lost the election this year.

EmClUnRedORel

1. The fortune teller showed the girl that the man kissed the future.

2. The boss told the secretary that no one befriended the reason.

3. Mother promised the child that the babysitter would watch ice cream.

4. The informer told the policeman that the drug dealer shot the plan.

5. The manager showed the man that the woman seduced the bill.

EmClRed

1. The elderly man carrying the heavy package dropped his house keys.

2. The professor teaching the home economics course gives high grades.

3. The people selling this house will sell their furniture with it.

4. The woman buying the sneakers won the marathon in record time.

5. The boy riding the old bicycle delivers our Sunday newspaper.

ObjCompSelResVio

1. The artist believed the canvas was inferior in quality.
2. The carpenter knew the wood was hard oak from Massachusetts.
3. The editor promised the new novel would be a best seller.
4. The class felt the final examination was totally unfair.
5. The farmer felt the bad weather would destroy the summer crops.

ObjCompSelResUnVio

1. The youngsters understood the complicated game had many rules.
2. The excited policeman reported the robbery was taking place now.
3. The new recruits believed the old sergeant was dangerously insane.
4. The coach believed the quarterback was breaking training every night.
5. Everyone in the class knew the popular girl would win the election.

EmClRedPass

1. The test car driven by the safety experts passed inspection.
2. The student distracted by the music put his law books away.
3. The old house restored by the girl scouts became a tourist attraction.
4. The new restaurant praised by the reviewer was crowded every night.
5. The young intern berated by the resident left the hospital early.

EmClRedTrunPass

1. The college student failed throughout the first semester quit school.

2. The sickly young art student walked home every night bought a car.

3. The frightened old woman jumped on the crowded subway train screamed.

4. The leading lady's understudy watched from the wings was outstanding.

5. The exhausted shopper pushed through the crowded subway car collapsed.

ClSubj

1. It was the old tailor who altered the costumes for this play.

2. It is the French chef who makes the president's favorite soup.

3. It is the new teacher who is driving our school bus this term.

4. It was the beautiful actress who married the old director.

5. It was the guard who found the tourist's wallet in the museum.

ClObjUnRed

1. It is the fine old wine that the gracious host serves at his parties.

2. It is his big house in the country that the rich young man likes best.

3. It is the New York City Marathon that most runners enter.

4. It is our school's budget that the central school board discusses frequently.

5. It is the dangerous lion that the zookeeper watches closely.

ClObjRed

1. It was the old tennis player the young pro beat in the match.
2. It was the younger librarian my mother knew very well.
3. It was the greedy publisher the editor hated all these years.
4. It was the best-selling author the reporter interviewed.
5. It was the sculptor the art dealer met at the gallery.

Post-Experiment Judgment Task Sentences

The materials are presented here in the order in which they were presented to the subjects.

1. The press agent was pleased when the actor was kissed by the model.
2. The manager showed the man that the woman seduced the bill.
3. The children played tag outside while their parents ate a late dinner.
4. The college student failed throughout the first semester quit school.
5. The informer told the policeman that the drug dealer shot the plan.
6. The sickly young art student walked home every night bought a car.
7. It was the sculptor the art dealer met at the gallery.
8. The author hated his agent but the editor he liked a lot.
9. Mother promised the child that the babysitter would watch ice cream.
10. The leading lady's understudy watched from the wings was outstanding.
11. The audience was angry when the guest star was insulted by the host.

12. The boss told the secretary that no one befriended the reason.

13. The excited policeman reported the robbery was taking place now.

14. The frightened old woman jumped on the crowded subway train screamed.

15. It is his big house in the country that the rich young man likes best.

16. The fortune teller showed the girl that the man kissed the future.

17. The woman buying the sneakers won the marathon in record time.

18. The exhausted shopper pushed through the crowded subway car collapsed.

APPENDIX B

Experiment 2

Phoneme Monitor Task Sentences

The experimental sentences are presented in quadruples to show the contrasts. The monitored phoneme is underlined in each sentence. The fillers are presented following the experimental sentences. The material sets presented to the subjects contained one version of each sentence for each set. The fillers were identical for all four material sets.

Set 1--Relative Clause Sentences

1. a. The professor who knew the comedian well gave a lecture on humor.

   b. The professor who the comedian knew well gave a lecture on humor.

   c. The professor whom the comedian knew well gave a lecture on humor.

   d. The professor the comedian knew well gave a lecture on humor.

2. a. The policeman who shot the crook fearlessly got hurt badly.

   b. The policeman who the crook shot fearlessly got hurt badly.

   c. The policeman whom the crook shot fearlessly got hurt badly.

   d. The policeman the crook shot fearlessly got hurt badly.

3. a. The accountant who hired the chef this summer kept late hours.

   b. The accountant who the chef hired this summer kept late hours.

c. The accountant whom the chef hired this summer kept late hours.

d. The accountant the chef hired this summer kept late hours.

4. a. The agent who drove the actor to the theatre daily signed the contract.

b. The agent who the actor drove to the theatre daily signed the contract.

c. The agent whom the actor drove to the theatre daily signed the contract.

d. The agent the actor drove to the theatre daily signed the contract.

5. a. The intern who dated the nurse once takes out the medical student now.

b. The intern who the nurse dated once takes out the medical student now.

c. The intern whom the nurse dated once takes out the medical student now.

d. The intern the nurse dated once takes out the medical student now.

6. a. The governor who hated the mayor vehemently told the press his feelings.

b. The governor who the mayor hated vehemently told the press his feelings.

c. The governor whom the mayor hated vehemently told the press his feelings.

d. The governor the mayor hated vehemently told the press his feelings.

7. a. The teacher who phoned all the parents at home kept records of every discussion.

b. The teacher who all the parents phoned at home kept records of every discussion.

c. The teacher whom all the parents phoned at home kept records of every discussion.

d. The teacher all the parents phoned at home kept records of every discussion.

8. a. The drummer who applauded the singer wildly proposed after the concert.

   b. The drummer who the singer applauded wildly proposed after the concert.

   c. The drummer whom the singer applauded wildly proposed after the concert.

   d. The drummer the singer applauded wildly proposed after the concert.

9. a. The freshman who liked the senior a lot bought candy for him on Valentine's Day.

   b. The freshman who the senior liked a lot bought candy for him on Valentine's Day.

   c. The freshman whom the senior liked a lot bought candy for him on Valentine's Day.

   d. The freshman the senior liked a lot bought candy for him on Valentine's Day.

10. a. The director who admired the actress tremendously chose her for the leading role.

   b. The director who the actress admired tremendously chose her for the leading role.

   c. The director whom the actress admired tremendously chose her for the leading role.

   d. The director the actress admired tremendously chose her for the leading role.

11. a. The pilot who had respected the co-pilot for many years charged him with negligence at the hearing yesterday.

   b. The pilot who the co-pilot had respected for many years charged him with negligence at the hearing yesterday.

   c. The pilot whom the co-pilot had respected for many years charged him with negligence at the hearing yesterday.

   d. The pilot the co-pilot had respected for many years charged him with negligence at the hearing yesterday.

12. a. The manager who had trusted the saleswoman completely fired her unexpectedly this morning.

    b. The manager who the saleswoman had trusted completely fired her unexpectedly this morning.

    c. The manager whom the saleswoman had trusted completely fired her unexpectedly this morning.

    d. The manager the saleswoman had trusted completely fired her unexpectedly this morning.

13. a. The old woman who regarded the neighbors affectionately died suddenly on Sunday night.

    b. The old woman who the neighbors regarded affectionately died suddenly on Sunday night.

    c. The old woman whom the neighbors regarded affectionately died suddenly on Sunday night.

    d. The old woman the neighbors regarded affectionately died suddenly on Sunday night.

14. a. The writer who phoned the editor daily completed the manuscript on time.

    b. The writer who the editor phoned daily completed the manuscript on time.

    c. The writer whom the editor phoned daily completed the manuscript on time.

    d. The writer the editor phoned daily completed the manuscript on time.

15. a. The architect who consulted the engineer on the project declared bankruptcy today.

    b. The architect who the engineer consulted on the project declared bankruptcy today.

    c. The architect whom the engineer consulted on the project declared bankruptcy today.

    d. The architect the engineer consulted on the project declared bankruptcy today.

16. a. The model who met the film producer in London got star-billing in his new movie.

    b. The model who the film producer met in London got star-billing in his new movie.

c. The model whom the film producer met in London got star billing in his new movie.

d. The model the film producer met in London got star-billing in his new movie.

17. a. The electrician who recommended the carpenter to me did all of the work at the White House.

b. The electrician who the carpenter recommended to me did all of the work at the White House.

c. The electrician whom the carpenter recommended to me did all of the work at the White House.

d. The electrician the carpenter recommended to me did all of the work at the White House.

18. a. The stockbroker who advised the banker wisely lost his entire fortune yesterday.

b. The stockbroker who the banker advised wisely lost his entire fortune yesterday.

c. The stockbroker whom the banker advised wisely lost his entire fortune yesterday.

d. The stockbroker the banker advised wisely lost his entire fortune yesterday.

19. a. The child who loved the puppy a lot developed an allergy to animal hairs.

b. The child who the puppy loved a lot developed an allergy to animal hairs.

c. The child whom the puppy loved a lot developed an allergy to animal hairs.

d. The child the puppy loved a lot developed an allergy to animal hairs.

20. a. The woman who dates my brother in the country sold many of her paintings at the art show in the Village.

b. The woman who my brother dates in the country sold many of her paintings at the art show in the Village.

c. The woman whom my brother dates in the country sold many of her paintings at the art show in the Village.

d. The woman my brother dates in the country sold many of her paintings at the art show in the Village.

Set 2--Reduced Complement Sentences

1. a. The clown knew the strongman well from other circus jobs.

   b. The clown knew the strongman would frighten the children.

   c. The clown knew the strong chains would frighten the lion.

   d. The clown knew the stranger would frighten the superstitious juggler.

2. a. The young musician believed most composers and painters' tales of suffering.

   b. The young musician believed most composers piece together old unpublished melodies.

   c. The young musician believed most composed pieces put together some of the best elements of musical history.

   d. The young musician believed Mozart performed together with Beethoven.

3. a. The writer demanded the new edition by Collier's Publishing House.

   b. The writer demanded the new edition be completed immediately.

   c. The writer demanded the new editor be completely in charge.

   d. The writer demanded Nero's edict be copied into modern English immediately.

4. a. Jane hoped for the best answer to the situation by morning.

   b. Jane hoped for the best answer to resolve the situation by morning.

   c. Jane hoped for the best man to resolve the situation by morning.

   d. Jane hoped for the beast to resolve the situation by turning into a prince.

5. a. The police believed the witness with total confidence.

   b. The police believed the witness was totally incompetent.

   c. The police believed the dog was totally loyal.

   d. The police believed the insane criminal was totally secured in the prison cell.

6. a. The lawyer knows the reporter's secret source of the classified information.

   b. The lawyer knows the reporter's secret source had the classified information.

   c. The lawyer knows the reporter's notebook held the classified information.

   d. The lawyer knows the dead reporter had the classified information.

7. a. The explorer believed the guide most during the journey beyond the river banks.

   b. The explorer believed the guide might desert him beyond the river banks.

   c. The explorer believed the river might deepen beyond the sand bar.

   d. The explorer believed the gods might damage his gear if he went beyond the river banks.

8. a. The hotel manager feared the celebrity and his wild animals too much.

   b. The hotel manager feared the celebrity would arrive too late for the ceremony.

   c. The hotel manager feared the celebration would annoy too many guests.

   d. The hotel manager feared the sensitive woman would annoy too many guests.

9. a. Mary and Joe found a lot of money down by the old mill.

   b. Mary and Joe found a lot of money doesn't buy much these days.

c. Mary and Joe found a long marriage doesn't bind a couple in a loving relationships.

d. Mary and Joe found a luminous mirage dulls both the visual and auditory senses for at least one hour.

10. a. The secretary understood the handwritten manuscript with no problem at all.

b. The secretary understood the handwritten manuscript was no problem at all to read.

c. The secretary understood the wide margins were no problem at all to set up.

d. The secretary understood the hieroglyphics were no problem at all to copy.

11. a. The student requested the final grade before May 31st.

b. The student requested the final grade be mailed to the admissions committee.

c. The student requested the first grade boys march in the graduation procession.

d. The student requested the failing grade be mailed to the appeals committee.

12. a. The young child learned the ancient poem by heart.

b. The young child learned the ancient poem brought hope to the survivors.

c. The young child learned the Argentine poet brought help to the victims.

d. The young child learned Aristotle's Poetics began the history of analyzing drama.

13. a. The waiter suggested the cold soup as a better appetizer.

b. The waiter suggested the cold soup was a better appetizer.

c. The waiter suggested the cold day was best forgotten with a good cocktail.

d. The waiter suggested the curdled sauce would be replaced immediately.

14. a. I resented his whining tone during the meeting.

    b. I resented his whining tone dominating the meeting.

    c. I resented his winter vacation delaying the meeting.

    d. I resented his wonderful speech defending the mayor.

15. a. The witness had reported the final events clearly to the police.

    b. The witness had reported the final events were clear to him.

    c. The witness had reported the final evening was clear although it had rained the rest of the week.

    d. The witness had reported the future events were clearly determined by the past.

16. a. The old man wished for the long gone days of carnival shows.

    b. The old man wished for the long gone days to come back.

    c. The old man wished for the young guest's date to come soon.

    d. The old man wished for long gowns and dresses to come back in style.

17. a. The senator ordered the present by mail.

    b. The senator ordered the present be mailed early.

    c. The senator ordered the purpose be made clear.

    d. The senator ordered the president be met early.

18. a. Bill imagined the entire episode without any real difficulty.

    b. Bill imagined the entire episode was actually reasonable.

    c. Bill imagined the empty apartment was actually rented.

    d. Bill imagined the energy crisis was actually receding.

19. a. I expect the worst with holiday traffic.

    b. I expect the worst will happen.

    c. I expect the week will have an end.

    d. I expect the werewolf will have a part in myths and legends of all countries.

20. a. Our doctor suggests a good rest to his patients once a year.

    b. Our doctor suggets a good rest helps patients recover from major illnesses.

    c. Our doctor suggests gargoyles once had power to cure disease.

    d. Our doctor suggests a gangrene limb heals partially if treated early.

Fillers--Early Monitor

1. Whenever Mary goes to the country she packs a picnic lunch for the ride.
2. Our return flight was delayed because the heavy rains had flooded the airport.
3. The truck driver stopped for coffee at the same diner every morning.
4. Our high school band received an invitation to play in the Thanksgiving Day Parade.
5. After he painted his bedroom, John decided to do the rest of the house as well.
6. Joan's roommates arranged a surprise party to celebrate her 21st birthday.
7. During the power failure Susan was trapped on the elevator by herself.
8. The students complained because the library would not be open on Saturdays this semester.
9. Before the children went to the park, they saw a short film on safety.
10. The neighbors collected money and clothes to help the young couple after the fire.

11. Although Debbie was on vacation, she phoned her office every morning.

12. The boys gathered enough wood to make the fire for the barbeque.

13. If we leave the house before six every morning, we can beat the traffic.

14. Since the team lost every game last season, they are more determined than ever this year.

15. Alice planned to have a big wedding at her uncle's country estate.

Fillers--No Monitor

1. Because the doctor is frequently late, his receptionist has to deal with angry patients quite often.

2. Since many museums are closed on Mondays, the department stores are crowded with tourists.

3. Although the critics disliked the play, the audiences loved it.

4. Because of the unhealthy air quality in the city during the summer, many residents go to the country on the weekends.

5. Our puppy is a picky eater at mealtime, but he'll eat anything he finds on the street.

6. Everyone felt sad when the famous actress died.

7. The new baby brought much joy to the entire family.

8. After she finished her evening exercises, Jean went out for pizza and a beer.

9. Tim is usually late for his first class because he has a difficult time finding a parking space near campus.

10. Whenever Bob is depressed, he stops off at Dunkin Donuts for a treat.

11. The quiet librarian shocked the townspeople when she ran off with the high school principal.

12. The express line in the supermarket is the longest and the slowest one.

13. Although his friends tried to stop him, Gary entered the motorcycle race last Saturday.

14. Because the owner constantly ridiculed the players, they had no team spirit.

15. The rainy weather spoiled our plans for a festive picnic on the lake.

APPENDIX C

Experiment 2: Follow-Up Procedures

Sentence Fragment Completion Task

Instructions for Sentence Completion Task

I am going to read the instructions to you. Please feel free to stop me at any time to ask any questions that you may have.

I am going to read some sentence fragments to you in the following way. First, I will read the sentence fragment number, then the sentence fragment. Pleae number each fragment on your paper. If you wish, you may also write down the sentence fragments that I will read. Let me know if you want to write, so that I can read slowly. After I read the sentence fragment, I'd like you to complete the sentence any way you want. Some sentence fragments will will contain more information than others. It doesn't matter with regard to your task. You may add as much or as little information as you like to each fragment that you hear. It is extremely important that you respond as naturally or spontaneously as possible. There are no other constraints. Let's consider some examples.

Fragment 1: The girl saw ....

This could be completed any number of ways including

... the boy.

... the boy who she loved.

... that the boy loved her.

... through his story.

... well.

Fragment 2: The girl the tree ....

This could be completed in the following ways.

... shaded relaxed.

... and the book were all special to him.

Do you have any questions? Let's begin.

Sentence Fragments

The sentence fragments are presented in the order in which the subjects heard them. Condition A differed from Condition B with regard to which of the fragments appeared with the object NP. The object NP used in this procedure was the same NP used in the (a) and (b) versions of the experimental sentences in Set 2.

Condition A. The verbs which produced the SVO effect in the phoneme monitor task are underlined.

1. The young musician believed ....
2. The police believed the witness ....
3. Jane hoped for the best answer ....
4. The old man wished for the long gone days ....
5. The clown knew ....
6. I expect ....
7. The hotel manager feared the celebrity ....
8. The witness had reported ....
9. The explorer believed the guide ....

10. The waiter <u>suggested</u> ....

11. The student requested ....

12. The writer demanded the new edition ....

13. The senator ordered the present ....

14. The young child <u>learned</u> ....

15. The secretary understood the handwritten manuscript ....

16. The lawyer <u>knows</u> the reporter's secret source ....

17. I <u>resented</u> ....

18. Our doctor suggests ....

19. Mary and Joe found a lot of money ....

20. Bill <u>imagined</u> the entire episode ....

<u>Condition B</u>

1. The young musician <u>believed</u> most composers ....

2. The police <u>believed</u> ....

3. Jane hoped for ....

4. The old man wished ....

5. The clown <u>knew</u> the strongman ....

6. I expect the worst ....

7. The hotel manager <u>feared</u> ....

8. The witness had reported the final events ....

9. The explorer <u>believed</u> ....

10. The waiter <u>suggested</u> the cold soup ....

11. The student requested the final grade ....

12. The writer demanded ....

13. The senator ordered ....

14. The young child <u>learned</u> the ancient poem ....

15. The secretary understood ....

16. The lawyer <u>knows</u> ....

17. I <u>resented</u> his whining tone ....

18. Our doctor suggests a good rest ....

19. Mary and Joe found ....

20. Bill <u>imagined</u> ....

<u>Next Word Naming Task</u>

The following sentences presented in the comparison triplets were adapted from the Set 2 experimental sentences. The target word is underlined.

1. a. The clown knew the strongman <u>well</u> from other circus jobs.

   b. The clown knew the strongman <u>would</u> frighten the young children.

   c. The clown knew the strong chains <u>would</u> frighten the new lion.

2. a. The young musician believed the composer <u>with</u> perfect confidence.

   b. The young musician believed the composer <u>was</u> present at the concert.

   c. The young musician believed the composition <u>was</u> played at the concert.

3. a. The writer demanded the new edition <u>by</u> Collier's Publishing House.

   b. The writer demanded the new edition <u>be</u> completed immediately.

   c. The writer demanded the new editor <u>be</u> completely in charge.

4. a. Jane hoped for the best answer to <u>the</u> situation by morning.

   b. Jane hoped for the best answer to <u>be</u> chosen by the judges.

c. Jane hoped for the best man to be elected President.

5. a. The police believed the witness with total confidence.

   b. The police believed the witness was quite incompetent.

   c. The police believed the dog was totally loyal.

6. a. The explorer believed the guide most during the last part of the journey.

   b. The explorer believed the guide might desert him beyond the river banks.

   c. The explorer believed the river might deepen further beyond the sand bar.

7. a. The hotel manager feared the celebrity with the doubtful reputation.

   b. The hotel manager feared the celebrity would arrive too late for the ceremony.

   c. The hotel manager feared the celebration would annoy two of the other guests.

8. a. Mary and Joe found a lot of money down by the bank of the river.

   b. Mary and Joe found a lot of money doesn't buy much these days.

   c. Mary and Joe found a long marriage doesn't bind you in a loving relationship.

9. a. The secretary understood the handwritten manuscript with no problems at all.

   b. The secretary understood the handwritten manuscript was no problem at all to read.

   c. The secretary understood the wide margin was no problem at all to set up.

10. a. The student requested the final grade by May 1st.

   b. The student requested the final grade be mailed to the admissions committee.

   c. The students requested the new teacher be instructed to meet punctually.

11. a. The young child learned the ancient poem <u>by</u> heart without any problem.

    b. The young child learned the ancient poem <u>had</u> brought hope to the survivors.

    c. The young child learned the Argentine poet <u>had</u> brought help to all the victims.

12. a. The waiter suggested the cold soup <u>as</u> an appetizer instead of fruit.

    b. The waiter suggested the cold soup <u>was</u> a better appetizer than fruit.

    c. The waiter suggested the cold day <u>was</u> best forgotten with a good cocktail.

13. a. I resented his whining tone <u>during</u> the whole meeting.

    b. I resented his whining tone <u>didn't</u> cease throughout our conversation.

    c. I resented his winter vacation <u>didn't</u> allow us to complete the project.

14. a. The witness reported the final events <u>with</u> the omission of a crucial detail.

    b. The witnes reported the final events <u>were</u> still quite clear in his memory.

    c. The witness reported the final evening <u>was</u> clear although it had rained most of the week.

15. a. The senator ordered the present <u>by</u> express mail.

    b. The senator ordered the present <u>be</u> mailed early.

    c. The senator ordered the purpose <u>be</u> made clear.

16. a. Bill imagined the entire episode <u>with</u> no real difficulty.

    b. Bill imagined the entire episode <u>was</u> fairly reasonable.

    c. Bill imagined the apartment <u>was</u> actually rented.

17. a. I expect the worst <u>with</u> holiday traffic.

    b. I expect the worst <u>will</u> happen.

    c. I expect the week <u>will</u> also have an end.

18. a. Our doctor suggests a good rest <u>to</u> all his patients once a year.

    b. Our doctor suggests a good rest <u>can</u> help patients recover their health.

    c. Our doctor suggests a good nurse <u>can</u> help patients regain their will to live.

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