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LATENCY FOR MEANING RECOGNITION AND PICTURE VERIFICATION
OF SYNTACTIC AND LEXICAL AMBIGUITY

by

Richard C. Ney

A Dissertation Submitted to the Faculty of the Graduate School
of Loyola University of Chicago in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

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PREFACE

The history of psycholinguistics, as with most sciences, has been marked by false starts, dead ends, and seemingly fruitless avenues of research. Over a period of time, several theories of language processing and language learning have been offered only to be discarded in the light of discrepant data and unexplained linguistic phenomena. However, it is neither the intention nor within the scope of the present paper to discuss all of the historical foundations for the present state of psycholinguistic research. The historical background for language studies is discussed only as it relates to the development of a transformational model of generative grammar.

Prior to any consideration of language as the object of scientific research, the format of the present paper must be delineated. Firstly, a short history of scientific language study will be presented. Secondly, linguistics will be treated in terms of the development of a transformational model of generative grammar according to Chomsky's standard theory. Thirdly, the basic distinctions between linguistic competence and performance will be delineated, and the concepts of deep and surface structure defined.

LIFE

The author, Richard C. Ney, is the son of Charles J. Ney and Ann (Frauenhoffer) Ney. He was born April 30, 1948, in Chicago, Illinois.

His elementary education was obtained in the parochial schools of Chicago, Illinois, and secondary education at Saint Patrick High School, Chicago, Illinois, where he was graduated in 1966.

In September, 1966, he entered Loyola University of Chicago, and in June, 1970, received the degree of Bachelor of Science with a major in psychology. The author was graduated in June, 1970, with honors.

In September, 1970, he was granted an assistantship in psychology at Loyola University of Chicago. In June, 1973, he was awarded the Master of Arts in psychology.

While at Loyola University of Chicago, the author presented several papers at the Midwestern Psychological Association meetings and at several meetings of the American Psychological Association. Among the author's publications is the following: Associative Symmetry and the B-Ar Paradigm - A Stage Analysis, Psychonomic Bulletin, 1974.

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TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	ii
PREFACE	iii
LIFE	iv
LIST OF TABLES	vii
LIST OF ILLUSTRATIONS	viii
CONTENTS OF APPENDICES	ix
 Chapter	
I. INTRODUCTION	1
History and Development	1
Constructs	5
Competence and Performance	5
Deep and Surface Structure	8
II. LINGUISTIC PROCESSING OF AMBIGUOUS SENTENCES	11
Ambiguous Sentences: A Definition	11
Review of Research	13
Experimental Rationale and Definition	13
Perception Time	15
Ambiguous Sentences: Bias	17
Linguistic Processing Hypothesis	19
Summary	23
Cue Versus Non-Cue	25
III. METHOD	29
Subjects	29
Materials	29
Apparatus	30
Procedure	31
IV. RESULTS	33
Meaning Judgment	35
Picture Verification	41

TABLE OF CONTENTS

(contd.)

	Page
Omission Errors	47
Summary	50
V. DISCUSSION	53
Types of Ambiguity: Meaning Judgment	54
Types of Ambiguity: Picture Verification	58
Cue Conditions: Omission Errors	61
Meaning Versus Meaningfulness	63
The Effect of Instruction	65
Linguistic Processing: Present Models	67
Linguistic Processing: A Proposed Model	68
Cue Versus Non-Cue	75
Conclusion	76
SUMMARY	78
REFERENCES	81
APPENDIX A	86
APPENDIX B	88
APPENDIX C	90

LIST OF TABLES

Table	Page
1. Mean Latencies (in Seconds) for Perception Time to Process the Sentence Types in the Sentence Meaning Judgment Task	34
2. Three-Way Analysis of Variance for a One Within Factor, Two Between Factor Repeated Measures Design. Within Factor = Sentence Type, Between Factors = Cue and Gender	36
3. Mean Latencies (in Seconds) for the Sentence Type X Cue Interaction--Meaning Judgment	37
4. Planned Orthogonal Comparisons for Effect of Sentence Type in the Analysis of Variance for Sentence Meaning Judgment Latency	40
5. Least Significant Difference Comparisons for Pairs of Sentence Types--Sentence Meaning Judgment Latency	42
6. Three-Way Analysis of Variance for a One Within Factor, Two Between Factor Repeated Measures Design. Within Factor = Sentence Type, Between Factors = Cue and Gender	44
7. Planned Orthogonal Comparisons for Effect of Sentence Type in the Analysis of Variance for Picture Verification Task	45
8. Two-Way Analysis of Variance for Omission Errors	49

LIST OF ILLUSTRATIONS

Figure	Page
1. Latency in Seconds to Perform Meaning Judgment Tasks on Sentences Containing Different Types of Ambiguity--Cue X Sentence Type Interaction	38
2. Latency in Seconds to Perform Meaning Judgment Tasks on Sentences Containing Different Types of Ambiguity	56
3. Latency in Seconds to Perform Picture Verification Tasks on Sentences Containing Different Types of Ambiguity	59
4. From MacKay (1966). Completion Times for Sentences at Various Levels of Ambiguity	60

CONTENTS OF APPENDICES

	Page
APPENDIX A Tree Diagram of an Underlying Syntactic Ambiguous Sentence	86
APPENDIX B Stimulus Sentences Used in the Experimental Tasks	88
APPENDIX C Stimulus Pictures Used in Experimental Tasks	90

CHAPTER I

INTRODUCTION

Throughout its long history, linguistics has been claimed as the stepchild of many disciplines: philosophy, rhetoric, philology, history, and only very recently psychology. As far back as the ancient Greeks, questions were raised concerning the relationship between an object and its verbal description. The study of language continued to be of interest because of its apparent specifically human characteristic, and as such was approached from a variety of directions. Depending on the assumptions made about the nature of language, various schools of linguistic research developed. From the standpoint of philosophy, language was treated as an introspective phenomenon whose essential nature was only discoverable from the self-reports of the individual. As such, language study was constrained by the parameters of memory limitations, forgetting, and stimulus-cue generalization. In short, an understanding of language was only as accurate as the person reporting the data.

History and Development

The scientific approach to language was first developed by Bloomfield and the structuralist schools of linguistics. The fundamental distinction in theory between form and meaning, or structure and content, originally formulated by De Saussure, was accepted by the structuralists. Language was then to be investigated

as a formal structure separable from meaning or content. This theoretical clarification served to separate the study of language from the less-objective approaches of philosophy.

The principal aim of the structuralist school was to develop a methodology for the discovery of the basic units of language, which method was called constituent analysis. These units were to be considered in their objective structural form without consideration of the cognitive or mental contents underlying them. The basic language components were specified as minimal sound units, termed phonemes, and minimal syntactic units, termed morphemes. By describing the units of language structure and the syntactic combination of these units, the linguist was able to derive the grammar of the language under investigation.

By definition, then, the structural or taxonomic linguist dealt with the formal structure of language. The linguist analyzed objective language utterances and attempted to identify and classify the structures and rules of combination and ordering.

Late in the 1950's another discipline was emerging which combined linguistics and psychology called psycholinguistics--the study of the language-user (cf. Osgood & Sebeok, 1965). As Hormann (1970) stated, the object of this psycholinguistics was not to describe language as a formal structure but to describe the process of language use. Psycholinguistics, then, viewed psychology as a natural and necessary partner to linguistics.

About this same time the linguist Noam Chomsky presented a

different approach to linguistic analysis called Transformational Generative Grammar. This approach accepted the basic form-content distinction from the structuralist school. But Chomsky (1957) began a revolution in language study by formulating the goal of linguistics as description and explanation of the linguistic intuitions of a native speaker-hearer. He hypothesized a deductive model of grammar for an idealized speaker-hearer, from a totally homogeneous language community, who knew and used perfectly the rules of grammar.

Chomsky attempted, then, not only to describe the particular linguistic data, but also to explain the descriptions in terms of a universal grammar. In 1965, he formally presented the Standard Theory of transformational generative grammar. This model proposed to provide a structural description for all, and only all possible sentences grammatically acceptable to a native speaker-hearer of English. In 1972, Chomsky developed the Extended Standard Theory of transformational grammar which incorporated some of the subtle semantic data which could not be handled by the original theory.

This new direction in linguistic investigation was soon influential in the psychological research on language. Miller first brought Chomsky to the attention of the psychological community. He presented the results of the first experimental studies of sentences based on a transformational model of syntactic structure. The results were consistent with two of Chomsky's theoretical axioms. The first was that the sentence was not merely a combination of words and associations, but rather that "the structure of the sentence contrib-

utes as much to its interpretation as its elements. Therefore, the understanding of the sentence could not be expected as a by-product of the study of the word" (Gough, 1971, p. 255). Prior work by psychologists (cf. Gough & Jenkins, 1963) had dealt almost exclusively with the word, its related properties of meaning associations, and its role in memory and perception. The second was Chomsky's demonstration that sentence comprehension and production was a species of rule-governed behavior (Greene, p. 11, p. 19).

As described by Gough (1971) transformational grammar ascribed to every sentence a number of properties: degree of grammaticality, surface and deep structure, and transformational complexity. These properties were hypothesized to be not only linguistic constructs, but in some sense, psychological realities. A succession of psychological studies examined the effects of these properties. Early research had shown that grammatical sequences of words are both perceived more easily and also memorized more readily than a randomly ordered sequence of words (Miller, Heise, & Lichten, 1951; Miller & Selfridge, 1956). Later, degrees of grammatical well-formedness were shown to be related to the ease with which sentences could be repeated (Epstein, 1961), memorized (Marks & Miller, 1964) or paraphrased (Downey & Hakes, 1968). Clifton and Odom (1966) found that perceived similarity between sentences was related to the differences in transformational complexity between the sentences.

The above research delineated the importance of syntactic structure and Chomsky has been further responsible for much of the

current interest in language comprehension, long-term storage of sentences, depth of comprehension, and retrieval of stored linguistic inferences.

Constructs

Competence and performance. A key concept in the theory of Chomsky was that of the distinction between competence and performance. Basically competence refers to what a native speaker-hearer knows of his language, and performance to how he uses it. While the concept of performance is fairly straightforward, that of competence is not. Lenneberg (1967) suggested that part of the difficulty lay in the misuse of the word "grammar." Grammar has alternatively referred to an abstract linguistic model of grammatical rules and to an internalized set of these rules and their actual use in sentence comprehension and production.

The abstract model of grammar was a linguistic grammar which generated structural descriptions for all and only all the sentences of a language. This model proposed to describe and explain an idealized speaker-hearer's competence or knowledge of grammar. The idealized speaker-hearer was hypothesized to possess perfect intuition about the grammaticality of sentences in the language. Chomsky himself best summarized the nature of this type of competence model. "A generative grammar as it stands is no more a model of the speaker than it is a model of the hearer. Rather...it can be regarded only as a characterization of the intrinsic tacit knowledge or competence that underlies actual performance" (1965, p. 140).

The linguistic data for this model were the possible, grammatically well-formed sentences of an idealized speaker-hearer. These sentences were described in terms of the linguistic constructs: generative syntactic phrase-structure and transformational rules, and interpretive semantic and phonological rules. This model of grammatical competence projected no claim about the actual use of the rules of grammar by the native speaker-hearer, nor were its data the sentences of language as actually produced by a particular speaker.

The second concept of grammatical competence, internalized rules, and their actual use, described something more than the abstract knowledge of grammar of an idealized speaker-hearer. Somehow, an actual native speaker-hearer had mastered and organized a grammar in a manner similar to the idealized competence model. In this second sense, grammar competence became a performance variable in actual language use.

Part of the problem in understanding the competence model has been in failing to distinguish the two understandings of grammatical competence. Chomsky has on many occasions disclaimed the notion that the competence model in any way described the actual process of sentence production or comprehension. Yet he seems also to have on occasion implicitly argued for the internalized competence model in actual comprehension and production of sentences (Chomsky, 1965, p. 8; 1972a, p. 116).

Fodor and Garrett (1966) attempted to clarify the situation by formally specifying the two ways in which competence may be understood.

The first understanding was that of competence as a formalization of a speaker-hearer's grammatical information. In this sense competence is not to be confused with behavior, where behavior is the corpus of actual linguistic experience indicative of the speaker-hearer's grammatical knowledge.

The second type of competence referred to the speaker-hearer's linguistic capacity which interacts with other mechanisms in the production of verbalizations. This competence includes knowledge of the language, and the psychological processes which interact with this knowledge. This second type of competence was termed internalized competence and although rejected by Fodor and Garrett, it represented the closest link to a possible performance model of grammar.

In addition to changing the relationship between the understanding of competence and performance, the notion of internalized competence necessarily changed the data base for its grammatical model. Because the production component had become such a large part of the model, the idealized speaker-hearer was no longer an adequate source for the linguistic rules. The rules had to be derived on the basis of the actual linguistic productions of the native speaker.

Performance, then, became an important component of the inferred internalized grammar of the actual speaker-hearer. A definition of actual performance, however, has been difficult to specify because it involves so many different processes in the actual native speaker-hearer. This includes all those cognitive processes underlying the production and comprehension of sentences, such as perception, storage,

and retrieval.

Lenneberg (1967) defined performance in terms of the extra-linguistic beliefs of the speaker-hearer and the cognitive principles mentioned above. Performance was presented as a perceptual model and Lenneberg challenged psychologists to define the parameter of this model.

Fodor and Garrett (1966) took a different tack in the discussion of linguistic performance. Performance was conceived as the behavioral manifestation of the speaker-hearer's knowledge of his grammar. In this context, the nature of the linguistic knowledge is inferred and formalized from observable behavior and is seen as entirely separate from the model of abstract competence.

Understood in this way, the psychological relationship between competence and performance was amenable to experimental study.

Deep and surface structure. Equally as fundamental to an understanding of the transformational generative grammar model was the distinction between deep and surface structure. The surface structure of a sentence was defined as the final perceptual form of the sentence. This level contained the final sequence and arrangement of words, generated by syntactic rules, and interpreted by the semantic and phonological rules of the grammar.

The deep structure of the sentence was defined as the abstract syntactic structure which specified the underlying syntactic structures and their relationships necessary for an interpretation of the sentence. Deep structure categories and relations determined the final organizations

and sequencing of linguistic elements in the final surface structure.

Chomsky (1972) used the following example to illustrate this surface--deep structure distinction: "Invisible God created the visible world." The sentence level which is composed of the sound signal corresponds to the surface level. However, underlying the form of this sentence three propositions are hypothesized: that God is invisible, that he created the world, and that the world is visible. The three propositions interrelate to form the deep structure.

A further example of this distinction is the following: The process which Tom, who you know, described failed. This is the final surface structure. According to Chomsky's theoretical model, a basic structure was hypothesized as underlying the surface structure; i.e., The process failed. However, embedded within the surface sentence were two other hypothesized sentences: Tom described the process, and You know Tom. These hypothesized underlying sentences were then mapped into the surface structure through such transformational operations as addition, deletion, and substitution.

The distinction between the deep and surface structure of sentences, and the competence and performance of speaker-hearers are of theoretical interest if one is to establish cognitive universals of linguistic analysis. The psycholinguist asks the question: What does the native speaker-hearer know about his language? He wants to establish as a psychological reality the basic cognitive principles underlying knowledge of a grammar. If the concepts of deep and

surface structure are viable principles of cognition, then the individual knows more about his language than is evident from the perceptual sentence output. The deep and surface structure distinction should reveal empirical differences in sentence processing.

CHAPTER II

LINGUISTIC PROCESSING OF AMBIGUOUS SENTENCES

Ambiguous Sentences: A Definition

The ambiguous sentence has been hypothesized as one grammatical structure which could be useful in empirically demonstrating the psychological validity of deep and surface structure and perhaps clarifying the competence-performance distinction. Ambiguity may be defined as a set of stimulus patterns, in this case the sentence constituents, which admits of two or more interpretations.

Ambiguity may arise from the deep or surface structure of a sentence in more than one way. Ambiguity in the surface structure is resolved by any simple rearrangement of the constituents. Resolution of the ambiguity does not involve complex analysis of the underlying syntactic or semantic relations. An example of ambiguity in the surface structure is the following: The three masted British ships were sailing south. Segmentation of the sentence before the word three suggests that an unspecified number of British ships with three masts sailed south. Segmenting the sentence after the word three suggests that three British ships with an unspecified number of masts sailed south. The two interpretations underlying the ambiguous sentence were derived from the same surface structure constituents. Although the ambiguity is found in the surface structure, it is the underlying syntactic relationship of the adjective three to the noun

phrase constituent of the sentence that determines the position of the segmentation.

The resolution of deep structure ambiguity involves more than simply rearranging the surface structure components. An example of deep structure ambiguity is the following: The shooting of the hunters was terrible. A simple rearrangement or segmentation of the surface structure cannot resolve the ambiguity. What is implied in this sentence is a more complex relationship of the gerund shooting to the prepositional phrase of the hunters. Either the hunters are the object of the shooting (the hunters were the ones who were shot) or the hunters themselves did the shooting. Because the implied relation between the gerund and prepositional phrase is one of actor or acted upon, this type of ambiguity is termed deep structure syntactic ambiguity. Appendix A contains the tree diagrams illustrating the underlying syntactic relations.

Another type of ambiguity may be termed lexical ambiguity. This type of ambiguity focuses on the semantic referent of a surface structure constituent. In the following sentence: The soldier filled the tank. the ambiguity lies in the lexical referent of the word tank. Again, a segmentation of the surface structure constituents does not resolve the ambiguity in the sentence, nor does a specification of the syntactic relations. Only when the lexical referent of the noun phrase is determined can the possible interpretations of the sentence be resolved. In the above sentence, the word tank can refer to a receptacle for liquids, or it can refer to a portable military

weapons system.

In summary, there are two types of ambiguity, syntactic and lexical. Syntactic ambiguity may arise in the surface structure or in the underlying deep structure. Lexical ambiguity arises in the specification of the referent of a word or constituent in the sentence.

Review of Research

In recent years, much psycholinguistic research has been directed toward the psychological processes involved in the understanding of ambiguous sentences. The research will be reviewed as follows: 1) reasons for studying ambiguous sentences; 2) a discussion of the empirical definitions of ambiguity; 3) the use of perception time as a methodology for studying ambiguity; 4) bias as a factor in ambiguity resolution; 5) the postulating of a linguistic processing hypothesis; 6) the importance of prior experimental cueing for the comprehension of ambiguity; and 7) a summary.

Experimental rationale and definition. Empirical study of ambiguous sentence processing is of interest for two reasons. Firstly, Cairns (1973) stated that many, if not all, fully processed unambiguous sentences are ambiguous prior to their conclusion, and if the psycholinguistic processes associated with the ambiguous sentences can be discovered, then inference into the day-to-day comprehension of non-ambiguous linguistic input can be made. Secondly, the study of ambiguous sentence processing may provide insights into the psychological aspects of the deep and surface dichotomy, and perhaps reveal something

of abstract sentence processing hypothesized for all language performance.

In general, however, psycholinguistic research has failed to specify how a native speaker-hearer interprets and understands the possible interpretations associated with the ambiguous sentence. Gleason (1965) stated that previous research failed to specify an adequate operational definition of ambiguity and as a result the interpretation of some of the experimental results has been tenuous. In rectifying this problem, MacKay and Bever (1967) empirically defined sentence ambiguity as any stimulus pattern which is capable of two and only two distinct interpretations. Ambiguous sentences can have more than two meanings, but limiting the sentences to only two interpretations has the effect of permitting the E to make more accurate inferences about the cognitive comprehension process. If only two meanings are possible, direct comparisons can be made between the experimental sentences.

MacKay and Bever (1967) empirically defined one type of ambiguity as syntactic ambiguity in the surface structure of the sentence. This level was represented by the various ways in which the same sentence could be segmented to yield more than one meaning. An example of such sentence ambiguity is the following: The three masted British ships were sailing south. (as discussed on page 11).

A second type of ambiguity was related to the underlying, or syntactic deep structure of the sentence. The underlying syntactic relation between constituents was the locus of the ambiguity. An

example is the sentence: The shooting of the hunters was terrible.
(as described on page 12 and schematically diagramed in Appendix A.)

A third type of ambiguity was empirically defined as semantic or lexical ambiguity. As stated on page 12 this type of ambiguity involves ambiguity in the lexical referent of a word or words in the sentence. An example of this type of ambiguity is the following:
The soldier filled the tank.

MacKay and Bever (1967) also described a more complex type of ambiguity. These sentences involve a combination of both surface syntactic structure and semantic referent ambiguity. An example of a sentence which is ambiguous in both lexical referent and syntactic surface structure is the following: He unclogged the pipe in the bathroom. Ambiguity arises from uncertainty about the meaning of the word pipe, and the surface structure segmentation of the constituents. Should the major break come after unclogged or pipe? What type of pipe is being referred to in the above sentence? Also, was the pipe taken to the bathroom and cleaned or was the pipe already a part of the bathroom and cleaned?

Perception time. Among the various methods used to measure linguistic processing of ambiguous sentences, perception time (PT) has been most frequently and successfully utilized. Perception time was defined as the latency between the presentation of the ambiguous sentence and the S's resolution of the ambiguity. MacKay (1966) used a sentence completion task with perception time as a means of measuring ambiguity comprehension. In the completion task, the Ss were given

ambiguous sentence fragments and required to complete them. The time to complete each fragment was defined as the perception time. MacKay found increasing processing time in the following order: unambiguous sentences, lexical ambiguity, surface structure ambiguity, and finally underlying syntactic ambiguity.

Using a different type of task, MacKay and Bever (1967) found perception time to be a function of the type of ambiguity. In this study Ss were asked to search for the second meaning of the ambiguous sentence. Perception time for lexical ambiguity was shorter than for the sentences involving surface structure ambiguity. The longest perception times were found in the sentences which involved syntactic deep structure ambiguity.

Mistler-Lachman (1972), however, found a different relationship between the perception times for the various types of ambiguity. Her study employed three types of ambiguity and five types of response tasks. The five tasks were: 1) comprehension for meaningfulness without context; 2) comprehension for meaningfulness with context; 3) comprehension for context integration; 4) comprehension for production without context; and 5) comprehension for production with context. The first task required the S to judge whether a target sentence was meaningful or not without the presentation of context. The second task required the S to make the same meaningfulness judgment with the addition of context preceding the target sentence. The third task required the S to judge whether the target sentence followed from the context given. The fourth and fifth tasks required the S to make

up a sentence which would follow the target sentence. Ss were told that their sentence should follow reasonably from the target sentence. In the fourth task the production was made without preceding context, and in the fifth task preceding context was provided. The Ss were told that they need not necessarily use the context in the production of their sentence.

For the purpose of the present study, the meaningfulness task without context is most relevant. Meaningfulness judgment was defined as the judgment of whether a sentence was meaningful or nonsense. In this task, the latency was measured from the time the sentence was visually presented to the time when the S had completed a judgment. Mistler-Lachman (1972) found no significant differences in the latencies meaningfulness judgments for the different categories of ambiguity.

Ambiguous sentences: Bias. As a variable of study, biased meanings of ambiguous sentences have been hypothesized to affect perception time. In general, meaning bias is defined as the S's preference for one meaning over another in an ambiguous sentence. The higher the preference for one meaning, the greater the likelihood that this meaning will be perceived first or solely in the resolution of the ambiguity. Although the above definition is generally applicable, Es have defined bias according to the demands of the experiment.

Defining bias as the percent of Ss in a pre-study who reported seeing one of the meanings first, MacKay and Bever (1967) found that longer PTs were obtained when the first interpretation seen by the S

was the less biased meaning. This relationship was especially noted in underlying syntactic structure ambiguity. PT was also greater for lexical and surface ambiguities, when one of the meanings of the sentence was more probable. The longer PT was found, however, regardless of whether the more or less probable meaning was seen first.

Mehler and Carey (1968) used subject expectation as a definition of bias. Ss were given 11 specially prepared pictures followed by 11 sentences presented through earphones. The S was to mechanically indicate by flipping a switch whether each sentence was true or false with respect to the picture. The sentences were either a predicate nominative construction or a transitive verb construction. For one-half of the Ss 10 of the sentences were a predicate nominative construction, e.g., They are performing monkeys., followed by a sentence containing a transitive verb, e.g., They are bombarding cities. The other half of the Ss received 10 transitive verb constructions followed by a predicate nominative. The results showed that processing latencies for true sentences containing an unexpected surface structure were longer than for sentences with an expected structure.

Carey, Mehler, and Bever (1970) used the same definition of expectation as above with a picture verification task. Ss were auditorily preset to expect a sentence with either a predicate nominative or transitive verb construction followed by an ambiguous sentence of the type: They are lecturing doctors. Pictures which made one of the meanings of the sentences true or false, followed the sentences. The results showed that Ss who heard the ambiguous materials

as consistent with the preset structure had latencies equal to those of non-ambiguous sentences. Ss who heard the ambiguous sentence as being inconsistent with the preset structure showed longer latencies than Ss who had been set for the reading they heard.

Cairns (1973) pre-experimentally defined bias as the proportion of a sample of Ss who perceived a particular meaning of a sentence. A sentence may have an 80% bias if 80% of the Ss perceived one meaning of an ambiguous sentence. Sixteen lexically ambiguous sentences were presented with a second sentence which served to disambiguate the first. The results showed that highly biased ambiguous sentences associated with unexpected sentences had longer latencies than unambiguous sentences paired with unexpected sentences. Pairs containing highly biased ambiguous sentences paired with expected sentences resulted in the same latencies as for unambiguous sentences paired with expected sentences.

In summary, from the above studies perception time seems a reliable response variable to measure the complexity of linguistic processing. Perception time has been used to study the effect of ambiguity and bias on processing. On the assumption that perception time reflects a portion of cognitive functioning, valid hypotheses were derived concerning ambiguous sentence comprehension.

Linguistic processing hypothesis. Foss, Bever, and Silver (1968) postulated three distinct comprehension processes employed by the S when confronted with ambiguous sentence interpretation. Model I hypothesized that the native speaker-hearer analyzes all possible

interpretations of the ambiguous sentence and then chooses from among these interpretations the one most appropriate. Model II hypothesized that sentence interpretation is withheld until further information or context is provided allowing a single interpretation. Model III held that Ss tend to assign one meaning to a sentence until further information allows a different interpretation. Using a picture verification task the results of the study showed that verification time was not significantly different for ambiguous or non-ambiguous sentences. Verification time was defined as time taken by the S to state whether or not a picture supported an interpretation of an ambiguous sentence. These results suggested that Ss first assigned one meaning to a sentence thus supporting Model III.

The "one-meaning hypothesis" implies that only one meaning of an ambiguous sentence is comprehended (cf. Carey, Mehler, & Bever, 1970). Studies manipulating bias have presented some support for a single meaning hypothesis. MacKay and Bever (1967) found longer PTs when the first interpretation seen by the S was the less probable. If two interpretations had been processed and simultaneously available, no effect would have been noted for bias. The fact that a less probable meaning increases latency suggests that both interpretations were not immediately available. Using S expectation as a type of bias, Mehler and Carey (1968) further demonstrated that processing latencies for true sentences containing an unexpected surface structure were longer than for true sentences with an expected structure. A two meaning hypothesis was inconsistent with these data.

Cairns (1971) however, questioned the generality of the one-meaning hypothesis. She tested both lexically and syntactically ambiguous sentences, each highly biased toward one meaning. Cairns (1971, 1973) had pre-experimentally defined sentence bias as the percentage of Ss who perceived a particular meaning of a sentence. Ss were presented with pairs of sentences (1971). The first was lexically or syntactically ambiguous and the second was not. The S was to judge whether the second sentence was compatible with the ambiguous sentence meanings by pushing a yes or no button.

To explain the process Cairns (1971) hypothesized the operation of a Language Comprehension Device (LCD) which is a type of cognitive organization capable of comprehending all and only all of the sentences produced by the language grammar. If the LCD were operative for all levels of ambiguity then an increasing latency should reflect the reprocessing technique necessary in the compatibility judgment if the S comprehended both meanings of the ambiguous sentence. The results of the compatibility judgment showed an increased latency time only for the lexically ambiguous sentences, but not for the syntactically ambiguous sentences. Consequently, the LCD was hypothesized to be capable of simultaneously computing and analyzing two interpretations for the biased syntactically ambiguous sentences. However, the two meanings of the lexically ambiguous sentences were hypothesized to be analyzed immediately upon receipt by the LCD in succession rather than in a parallel manner.

To further investigate this latter hypothesis Cairns (1973)

presented the Ss with 16 lexically ambiguous sentences and a second sentence which served to disambiguate the first. One-half of the ambiguous sentences were highly biased and the other half were relatively unbiased. Four types of sentence pairs were constructed:

- a) a pair in which S1 was ambiguous and S2 disambiguated the first according to the expected (more probable) meaning of the ambiguity;
- b) one in which the ambiguous S1 was disambiguated by S2 according to its unexpected (less probable) meaning; c) a control pair in which S1 was minimally altered to express unambiguously the more probable meaning and conjoined to the expected S2; and d) a control pair in which S1 was minimally altered to express unambiguously the less probable meaning and conjoined with the unexpected second sentence (p. 338).

As in the earlier study, each S was to decide whether the two sentences of the pair went together by pushing a yes or no button. The results of the 1973 study showed that highly biased ambiguous sentences associated with unexpected sentences had longer latencies than unambiguous sentences paired with unexpected sentences. A similar effect was not found for the unbiased sentences. Pairs containing highly biased ambiguous sentences paired with expected sentences revealed the same latencies as for similar unambiguous sentences.

Cairns then hypothesized two processing stages intervening between the end of the second sentence and the button pushing of the judgment task. The first stage was hypothesized to be a matching stage during which the S compared the two sentences by some sort of

matching strategy. During the second stage or report stage the S used the information from the first stage and made a compatibility judgment concerning the two sentences. A third stage or reprocessing stage was hypothesized to occur when the matching operation not only yielded a mismatch but also a misperception of the ambiguity in the first sentence. This stage, which was hypothesized to occur between the matching and report stage, involved a computation of a second, compatible meaning.

Summary. Previous studies have attempted to specify the processes underlying sentence comprehension. Various experimental designs have been proposed as ways of determining the relative influence of deep and surface structure. Two of the more important methods in the study of sentence processing have been the use of perception and verification latencies with ambiguous sentences.

MacKay (1966) found increasing perception time with increasing complexity of ambiguity. Foss (1970b) used a phoneme-monitor task to investigate the effect of ambiguity on sentence comprehension. He found that reaction time was slower following the ambiguous material.

Other studies (cf. Cairns, 1971, 1973; Carey, Mehler, & Bever, 1970; Foss, Bever, & Silver, 1970) have found that bias and S expectancy result in longer processing latencies. Mistler-Lachman (1972) found that with certain tasks, underlying structural ambiguity has shown the longest latencies when compared with other types of ambiguity.

The relationship between latency and levels of ambiguity has

served to verify empirically a psycholinguistic model of deep and surface structure processing. It has also led to the development of several models of linguistic processing and different cognitive structuring (e.g., Language Comprehension Device) which specifically dealt with the language function.

However, several important considerations have not been fully accounted for by previous studies. Firstly, Mistler-Lachman stated that previous studies failed to control for levels of comprehension. In the meaningfulness judgment the S was told to imagine a situation in which the presented sentence might mean something. The meaningfulness judgment alone was found to be inadequate for the study of deep level comprehension of ambiguous sentences since the Ss were not required to process the meaning of the entire sentence.

What, then, might be a task which not only requires the S to judge the meaningfulness of the sentence, but also actively to interpret the meaning of the sentence? A procedure which would force the S actively to search for a meaning or meanings of a sentence could eliminate the shallowness of comprehension noted by Mistler-Lachman (1972). The shallowness was said to result from the failure to fully comprehend the meaning of the sentence.

Secondly, previous research has not specified sublevels of semantic ambiguity. Specifically, those studies which have tested for the processing of lexical ambiguity have not distinguished between simple and complex lexical ambiguity. In MacKay and Bever (1967) simple lexical ambiguity was defined as the specification of the

referent to only one word of the sentence. Complex lexical ambiguity was defined as ambiguity involving a phrase or constituent of a sentence whose resolution determines the meaning of the entire sentence. For example, the sentence: On top of everything there was a tarpaulin. involves ambiguity in the sentence constituent, on top of everything. Only by specifying the complex relationship of this phrase to the entire sentence can the ambiguity be resolved. Due to the difference in the underlying complexity of the semantic ambiguity, differences in processing or recognition time would be expected for each type of sentence. MacKay and Bever (1967) have viewed lexical ambiguity as a unitary phenomenon. The question remains whether processing time would vary if the distinction were made between simple and complex lexical ambiguity.

Cue versus non-cue. The issue of S cueing in the processing of ambiguous sentences has been almost a non-issue up to the present time. No E has specifically tested the effect of cue versus non-cue on ambiguous sentence processing.

The one-meaning interpretation hypothesis was clearly predicted on the Ss' lack of awareness of the ambiguity in the experimental sentences. This hypothesis would not be applicable to those experiments in which the Ss expected ambiguous test sentences. The assignment of one meaning to a sentence would be probable only if the S were not actively searching for ambiguity.

Despite the apparent need for a separation of the cue versus non-cue condition of experimental ambiguity, studies have failed to

take into account Ss' expectations of ambiguity in the experimental materials. It is important, then, to separate the findings of Cairns (1971, 1973) and Mistler-Lachman (1972) who did not cue the Ss into expecting ambiguous sentences and those studies which specifically informed the Ss they were to be presented with ambiguous sentence materials (Carey, Mehler, & Bever, 1970; MacKay & Bever, 1967). In the former instance the E presumably investigated ambiguous sentence processing under the more natural conditions of non-cue or non-expectation of finding sentence ambiguity. The latter studies examined ambiguous sentence processing under more artificial conditions in which the Ss were told that they would be presented with sentences which could have more than one meaning.

Different latencies would be predicted because of the differences in the Ss' expectations. Such latency variations were obtained (cf. Mistler-Lachman, 1972) but were not related to the effect of instructing S prior to the experimental task. The Ss' expectations of ambiguity or non-ambiguity appears to be a pertinent variable if a viable perception model of sentence processing is to be developed.

The purpose of the present study was then to: 1) clarify the interrelationship or interaction between types of ambiguity and time to process under cue and non-cue conditions; 2) verify the differences in perceptual processing time between simple and complex lexical ambiguity; and 3) analyze omission errors committed by the S when he failed to resolve the ambiguity.

The following hypotheses were then offered:

1. For both the meaning judgment task and the picture verification task, increased PT latencies will be a function of increased complexity of ambiguity.

- a) Ambiguous sentences will require longer time to process than non-ambiguous sentences.
- b) Underlying syntactic structure ambiguity will require longer time to process than surface syntactic structure ambiguity.
- c) Sentences with complex lexical ambiguity will require longer time to process than sentences with simple lexical ambiguity.

2. Ss not cued to the presence of ambiguity in the sentences prior to the picture verification task will commit more omission errors.

3. Ss in the cue condition will show significantly longer process latencies in both tasks than those in the non-cue condition.

Two tasks were proposed to test these hypotheses: 1) a meaning judgment; and 2) a picture verification task. It was proposed that a picture verification task would reveal resolution of either one or both of the meanings of the sentence.

Five sentence types were tested: unambiguous, syntactic surface structure ambiguous sentences, underlying syntactic structure ambiguous sentences, simple lexically ambiguous sentences, and complex lexically ambiguous sentences. Surface ambiguous sentences were defined as sentences whose meaning is resolved by the rearrangement of the surface structure components. Deep structure, or underlying, ambiguous sentences were defined as sentences whose meaning is resolved

by the different interpretation of linguistic strings hypothesized to underlie the surface structure. Simple lexical ambiguity was defined as the specification of the referent to only one word of the sentence. Complex lexical ambiguity was defined as ambiguity involving a phrase or constituent of more than one word, whose resolution determines the meaning of the entire sentence.

Finally, the omission errors were recorded in order to reveal whether there was a predominance of single meaning perception in a non-cue condition, or a complete resolution of the sentence meanings. The ineffectiveness of the meaningfulness task in the Mistler-Lachman (1972) study might have been a function of the level of S awareness of ambiguity and not the task as such. The present study differed from Mistler-Lachman (1972) in: 1) cueing half of the Ss to the ambiguity; and 2) giving the Ss a task (meaning judgment) which would induce full comprehension of the sentence meaning.

CHAPTER III

METHOD

Subjects

A total of 60 Ss participated in the experiment, some in partial fulfillment of a course requirement, and some as volunteers from undergraduate classes at Loyola University of Chicago. An equal number of males and females were evenly divided into two conditions of cue and non-cue. The primary restrictions on the Ss were that they be native speakers of English and at least second generation Americans.

Materials

The 50 sentences used were taken from the Mistler-Lachman (1972) dissertation. Appendix B contains the experimental sentences. The categories for the sources of ambiguity were taken from the same source with the exception of the lexically ambiguous sentences. Mistler-Lachman presented the lexically ambiguous sentences under one category. Simple lexical sentences were defined as those sentences in which the referent of a single word was in question. Complex lexical ambiguity was defined as those sentences in which the referent of a word determined whether the meaning of a whole phrase or the meaning of a whole sentence was ambiguous. Measurements of temporal latency were taken to 1/100th of a second. The sentences were counter-balanced for length and embedding. Percentage of bias was randomly

distributed throughout all sentence categories.

Five types of sentences were presented: non-ambiguous, surface structure ambiguous, simple lexical ambiguous, complex lexical ambiguous, and syntactically ambiguous. Of the 50 sentences presented, 10 sentences, or two from each category, were used for practice sentences and were not included in the final statistical analysis. Following the presentation of the first 10 sentences, 40 sentences were presented, randomly arranged according to non-ambiguous, ambiguous, and types of ambiguity.

Four pictures followed each sentence. The pictures were cartoon caricatures which depicted the single or double meaning of the test sentences (correct) and two or three foils related to the theme of the test sentence (incorrect). The pictures were judged previous to the actual experiment for quality and consistency by three Ss. Appendix C contains a sample of the pictures used in the experiment. The Ss were told the meaning(s) of the test sentences and asked to choose the pictures which visually represented the meaning(s) of the sentence. No errors of mismatching for any type of sentence and picture were found among the three Ss.

Apparatus

The apparatus for the study included a Kodak carousel projector, a BRS/LVE print-out counter and a BRS/LVE pulse generator which measured the temporal latencies in 1/100th of a second. A hand-operated button changed the slides and also served as a mechanical means for indicating meaning judgment and termination of the picture

judgment. A small rear-projection screen was used which was divided into four quadrants A, B, C, and D. The target sentences were presented in the center of the screen and the four pictures for the picture verification tasks were presented simultaneously, one each in each of the four quadrants. The position of the correct pictures was counterbalanced for each of the four areas of the screen.

Procedure

The Ss were taken individually to an experimental booth and seated in front of a small projection screen. Each was asked to read along as the E read the following instruction:

Cue Condition

A series of sentences will be projected onto the screen in front of you. You will be asked to look at each sentence and to press the button in front of you when you have determined the meaning of the sentence. Now some of the sentences you see can have more than one meaning. For example, the sentence: The boy stood near the deck., can mean the boy stood near the deck of a ship or near a deck of cards. Make sure you see all the possible meanings of the sentence before you press the button. Following the judgment of the sentence meaning, a series of four pictures will be projected on the screen in front of you. You are to look at the pictures and choose those which visually show the meaning of the previously presented sentence. You are to indicate your choice by calling out the letter of the quadrant containing the picture or pictures you have chosen. When you have made your final choice press the button again and another sentence will appear. You will then follow the same procedure. You will continue this procedure for a total of 50 sentences. Are there any questions?

Non-cue Condition

The instructions were the same as those given in the cue condition with the exception that no mention was made of sentence ambiguity. Instead, an example of a non-ambiguous sentence was used when the S was instructed to determine the meaning of the sentence.

The non-cue condition instructions were the following:

A series of sentences will be projected onto the screen in front of you. You will be asked to look at each sentence and to press the button in front of you when you have determined the meaning of the sentence. You might see a sentence like the following: They are removing the boxes. This sentence might mean that a group of people were removing assorted boxes from a room for example. Make sure you see all the possible meanings of the sentence before you press the button. Following the judgment of the sentence meaning, a series of four pictures will be projected on the screen in front of you. You are to look at the pictures and choose those which visually show the meaning of the previously presented sentence. You are to indicate your choice by calling out the letter of the quadrant containing the picture or pictures you have chosen. When you have made your final choice press the button again and another sentence will appear. You will then follow the same procedure. You will continue this procedure for a total of 50 sentences. Are there any questions?

Following the instructions, the first sentence was projected on the screen. Coincidental with the projection, the timer was automatically activated. The timer gave a cumulative recording of the latencies each time the S pressed the button indicating he had determined the meaning of the sentence or had terminated the picture search.

CHAPTER IV

RESULTS

Three types of data analyses were carried out: two three-way analyses of variance on the meaning judgment and picture verification latencies, and a two-way analysis of variance for omission errors. The analysis of variance for the latencies was a one within subject factor and a two between subject factor design for repeated measures. The within subject factor was sentence type and the between factors were gender and cue condition. The analysis for the meaning judgment was computed on eight sentences within each type. Sentences within type was considered a fixed factor. The analysis for the picture verification condition was computed on the pictures for eight sentences within five types. The mean perceptual latencies, in seconds, were taken for all sentence types across all conditions, and used as the input for the analyses.

The mean perceptual processing latencies for the two tasks appear in Table 1. The latencies for the meaning judgment revealed longest PTs for surface and underlying syntactic ambiguous sentences, and shortest PTs for the two lexically ambiguous sentences with the unambiguous sentences showing shorter PTs than syntactic and longer than lexical ambiguity. The latencies for the picture verification condition revealed longer PT for all types of ambiguous sentences when compared with the unambiguous sentences.

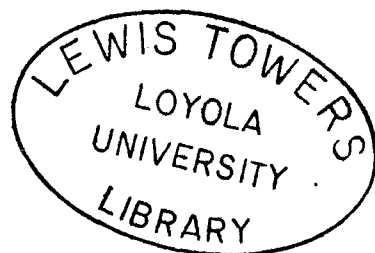


Table 1

Mean Latencies (in Seconds) for Perception Time to Process the
Sentence Types in the Sentence Meaning Judgment Task

Type	Unambiguous	Surface	Under- lying	Simple Lexical	Complex Lexical
	5.61	5.92	5.92	5.25	5.23

Mean Latencies (in Seconds) for Perception Time to Process the
Sentence Types in the Picture Verification Task

Type	Unambiguous	Surface	Under- lying	Simple Lexical	Complex Lexical
	9.86	11.25	12.00	10.52	11.19

Meaning Judgment

Results of the meaning judgment appear in Table 2. Two effects were significant: that for between sentence types, grouped ambiguous and unambiguous, $F(4, 224) = 9.97$, $p < .001$, and that for sentences within type, $F(35, 1960) = 10.04$, $p < .001$. The latter effect indicated an unequal degree of difficulty among the sentences within type, probably due to different degrees of bias randomly distributed among the sentences.

Neither cueing nor gender were significant effects. Cueing did not significantly increase perception time latencies for ambiguous sentences. The Cue x Type interaction was almost significant at the .05 level. The mean perceptual latencies of this interaction are summarized in Table 3.

The cue condition resulted in longer, although nonsignificant latencies for all sentence types when compared with the non-cue condition. In the cue condition, unambiguous, surface and underlying syntax sentence types showed almost identical PTs. The simple and complex lexical sentences had shorter perceptual latencies than any of the other three types. The non-cue condition resulted in longer latencies for the surface and underlying syntax sentences versus the unambiguous sentences. The unambiguous, simple lexical and complex lexical latencies were almost identical. The results of the Cue x Type interaction are graphically summarized in Figure 1.

Two further analyses of the data were computed. A series of planned orthogonal comparisons were formulated for the significant

Table 2

Three-Way Analysis of Variance for a One Within Factor, Two Between
Factor Repeated Measures Design. Within Factor = Sentence
Type, Between Factors = Cue and Gender

Source	Error	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Mean	P (CG)	74981.38	1	74981.38	906.96	
C*	P (CG)	214.98	1	214.98	2.60	N.S.
G*	P (CG)	226.84	1	226.84	2.74	N.S.
T*	PT (CG)	221.49	4	55.37	9.97	< .001
S (T) *	PS (CGT)	1592.13	35	45.49	10.04	< .001
CG	(PCG)	60.77	1	60.77	0.74	N.S.
CT	PT (CG)	52.46	4	13.12	2.36	< .10
GT	PT (CG)	6.76	4	1.69	0.30	N.S.
P (CG) *		4629.68	56	82.67		
CS (T)	PS (CGT)	178.57	35	5.10	1.13	N.S.
GS (T)	PS (CGT)	147.55	35	4.22	0.93	N.S.
CGT	PT (CG)	18.02	4	4.50	0.81	N.S.
PT (CG)		1244.00	224	5.55		
CGS (T)	PS (CGT)	152.34	35	4.35	0.96	N.S.
PS (CGT)		8878.94	1960	4.53		

*C = cue and non-cue, G = gender (male and female), T = sentence type,
S = sentence, P = people or subjects

Table 3

Mean Latencies (in Seconds) for the Sentence Type X Cue

Interaction--Meaning Judgment

Type	Unambiguous	Surface	Under- lying	Simple Lexical	Complex Lexical
Cue	6.18	6.14	6.21	5.37	5.54
Non-cue	5.06	5.70	5.63	5.14	4.93

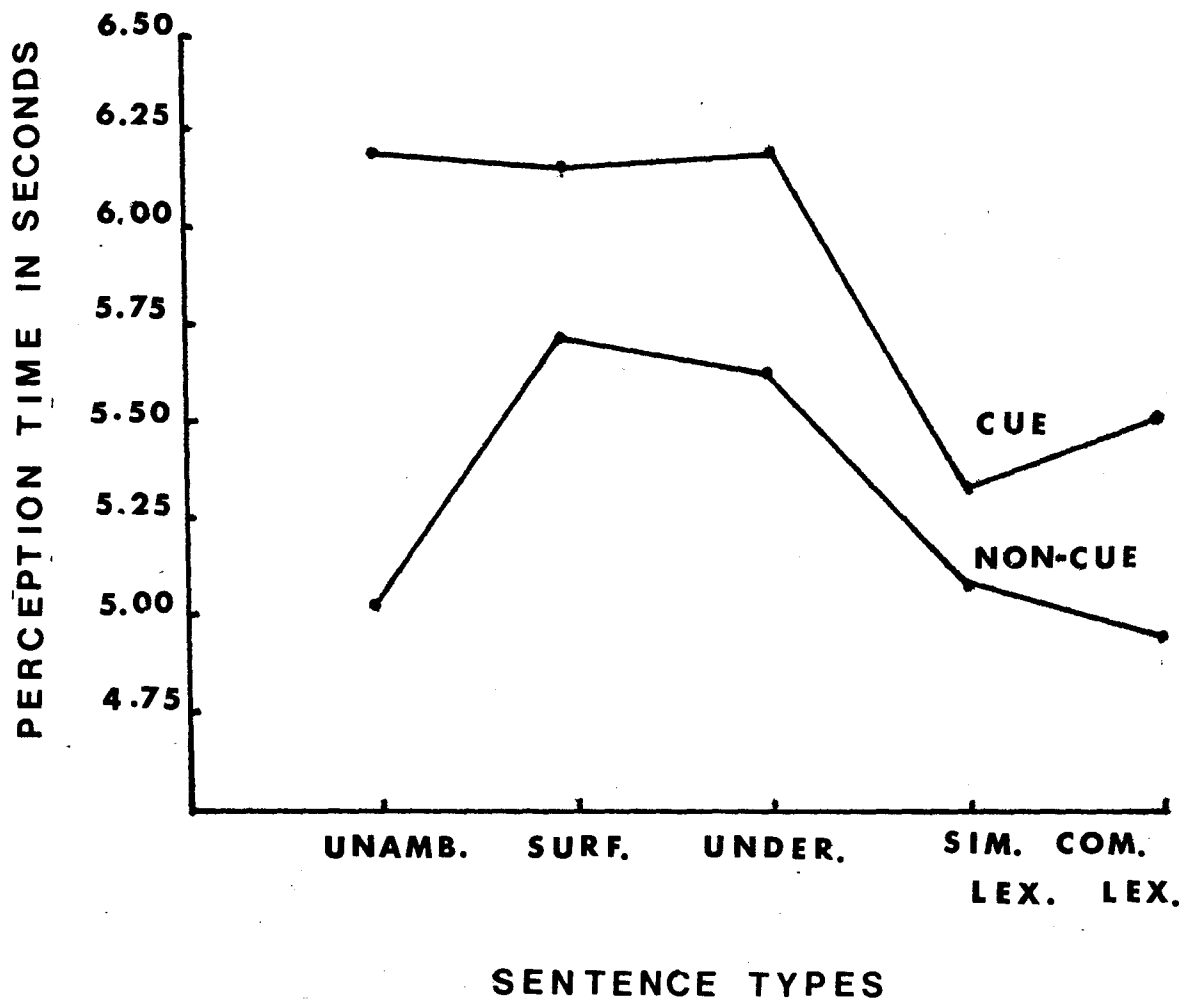


Figure 1. Latency in seconds to perform meaning judgment tasks on sentences containing different types of ambiguity--cue x sentence type interaction.

effect of sentence types. These analyses were needed to measure the locus of significant differences between the ambiguous and unambiguous sentences. A least significant difference comparison was also computed for each ambiguous sentence type versus the unambiguous sentence type. Results of the orthogonal comparisons are summarized in Table 4. Two comparisons were non-significant and three were significant. The PT for ambiguous sentences combined did not differ significantly from the PT for the non-ambiguous category, as noted in line a of Table 4. And, a non-significant difference was also found between the simple and complex lexically ambiguous sentences as in line d of Table 4.

Three significant effects were found in the comparisons summarized in Table 4. The perceptual time latency for the surface syntactic ambiguity differed significantly from the combined latencies for the underlying syntactic and lexical ambiguity, as noted in line b. Additionally, line c of Table 4 reveals that the PT latency for the underlying syntactic category was significantly longer than the combined latencies for both lexically ambiguous sentence types. The most important finding is summarized in line e of Table 4. The combined perceptual processing times for the surface and underlying syntactically ambiguous sentences were significantly different from the combined processing times of the simple and complex lexically ambiguous sentences. An examination of Table 1 reveals that the syntactically-based sentences had longer latencies than the lexically-based sentences.

Table 4

Planned Orthogonal Comparisons for Effect of Sentence Type
in the Analysis of Variance for Sentence
Meaning Judgment Latency

Sentence Type	Unambiguous	Surface	Underlying	Simple	Complex
a.	+4	-1	-1	-1	-1
b.		+3	-1	-1	-1
c.			+2	-1	-1
d.				+1	-1
e.	0	+1	+1	-1	-1

a.	$\underline{t} = .28$	$\underline{p} = \text{N.S.}$
b.	$\underline{t} = 3.63$	$\underline{p} < .01$
c.	$\underline{t} = 5.16$	$\underline{p} < .01$
d.	$\underline{t} = .14$	$\underline{p} = \text{N.S.}$
e.	$\underline{t} = 6.31$	$\underline{p} < .01$

As noted in Table 2 a significant effect was found for sentence type. The orthogonal comparison in line e of Table 4 also revealed a significant difference between the surface and underlying syntactic versus simple and complex lexical types. A least significant difference comparison was computed to determine a difference between each ambiguous type and the unambiguous sentence category. The results are summarized in Table 5. The data revealed that the ambiguous sentence perceptual processing latencies were significantly different from the latencies for the non-ambiguous sentences. The mean latencies summarized in Table 2 combined with the results in Table 5 revealed that the surface and underlying syntactic sentences each took significantly longer to process than the non-ambiguous sentences. The lexically ambiguous sentences each took significantly less time to process than the non-ambiguous sentences.

In summary, for the meaning judgment task the following order of increasing PT latency was found: 1) lexically ambiguous sentences, with no difference between simple and complex; 2) non-ambiguous sentences; and, 3) syntactically ambiguous sentences, with no difference between surface and underlying complexity. No significant effects appeared for sex differences or cued and non-cued condition.

Picture Verification

Two analyses were computed for the data in the picture verification condition. The data were the times to perceptually

Table 5

Least Significant Difference Comparisons for Pairs of
Sentence Types--Sentence Meaning Judgment Latency

Types

Unambiguous vs. Surface	$\underline{t} = 2.00$	$\underline{p} < .05$
Unambiguous vs. Syntactic	$\underline{t} = 2.01$	$\underline{p} < .05$
Unambiguous vs. Simple Lexical	$\underline{t} = 2.38$	$\underline{p} < .02$
Unambiguous vs. Complex Lexical	$\underline{t} = 2.52$	$\underline{p} < .02$

process the pictures or sketches following each sentence. These data were measured in seconds. The two analyses were: 1) an analysis of variance for the perceptual processing latencies, and 2) a series of planned orthogonal comparisons.

The results of the analysis of variance are summarized in Table 6. A comparison of the results between Table 2 and Table 6 revealed complete consistency between the analyses of variance for the two experimental tasks. In both analyses, that for the meaning judgment condition (Table 2), and that for the picture verification task (Table 6) the same effects were significant. The first effect was for sentence type, the second for within sentences of the same type. In the picture verification task for sentence type, $F(4, 224) = 8.2$, $p < .001$. For sketches within type, $F(35, 1960) = 6.84$, $p < .001$. Although the sentences and sketches were not identical materials they were analogously related. Both sentences and sketches showed variability in level of difficulty within each type of sentence category related to different bias percentages. This confirmed a similar finding in the meaning judgment condition. No significant effects were found for either cue, gender, or the Cue x Type interaction.

Given the significant effect of sentence type, a series of planned orthogonal comparisons were computed for the ambiguous and non-ambiguous sentences. The data are summarized in Table 7. Of the five comparisons, three were significant and two were non-significant. These results were not identical with the orthogonal

Table 6

Three-Way Analysis of Variance for a One Within Factor, Two Between
Factor Repeated Measures Design. Within Factor = Sentence
Type, Between Factors = Cue and Gender.

Source	Error	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Mean	P (CG)	288490.40	1	288490.40	565.00	
C*	P (CG)	346.26	1	346.26	0.68	N.S.
G*	P (CG)	113.71	1	113.71	0.22	N.S.
T*	PT (CG)	1256.17	4	314.04	8.12	< .001
S (T) *	PS (CGT)	5333.42	35	152.38	6.84	< .001
CG	P (CG)	432.19	1	432.19	0.85	N.S.
CT	PT (CG)	152.44	4	38.11	0.98	N.S.
GT	PT (CG)	116.23	4	29.06	0.75	N.S.
P (CG) *		28593.73	56	510.60		
CS (T)	PS (CGT)	641.17	35	18.32	0.82	N.S.
GS (T)	PS (CGT)	920.40	35	26.30	1.18	N.S.
CGT	PT (CG)	299.85	4	74.96	1.94	N.S.
PT (CG)		8665.23	224	38.68		
CGS (T)	PS (CGT)	841.29	35	24.04	1.08	N.S.
PS (CGT)		43672.68	1960	22.28		

*C = cue and non-cue, G = gender (male and female), T = sentence type,
S = sentence, P = people or subjects

Table 7

Planned Orthogonal Comparisons for Effect of Sentence Type
in the Analysis of Variance for Picture Verification Task

Sentence Type	Unambiguous	Surface	Underlying	Simple	Complex
a.	+4	-1	-1	-1	-1
b.		+3	-1	-1	-1
c.			+2	-1	-1
d.				+1	-1
e.	0	+1	+1	-1	-1

-
- a. $\underline{t} = 4.35$ $\underline{p} < .01$
 b. $\underline{t} = .05$ $\underline{p} = \text{N.S.}$
 c. $\underline{t} = 3.28$ $\underline{p} < .01$
 d. $\underline{t} = 1.19$ $\underline{p} = \text{N.S.}$
 e. $\underline{t} = 2.70$ $\underline{p} < .01$

comparisons for the meaning judgment. This indicated that although both analyses of variance showed the same variables to differ significantly, the source of the significance was different for the two tasks.

Consistent with Table 4 are the results summarized in lines c, d, and e of Table 7. The latency for the underlying sentences versus the combined latencies of the lexically ambiguous sentences were significant. These data are analyzed in line c of Table 7. An examination of the means in Table 1 for the picture verification task revealed a longer latency for the underlying syntactic ambiguity than either of the latencies for the lexically ambiguous sentences. The second consistent result is summarized in line d of Table 7. The latencies between simple and complex lexically ambiguous sentences were not significantly different. The third consistent result is summarized in line e of Table 7. A significant difference was found between the syntactically-based sentences and the lexically-based sentences. Combining the information in Table 1 with the result in line e, Table 7, the syntactically-based sentences had longer perceptual processing latencies than the lexical-type of ambiguity.

Inconsistent with the results in Table 4 are the data in lines a and b of Table 7. In line a, the combined latencies for the ambiguous sentences were significantly different from the unambiguous sentences. The results from the verification task as well as the meaning judgment task, summarized in Table 1, showed that the mean latencies for the ambiguous sentences in the verification task were

longer than the mean latency for the unambiguous sentences. The longer latencies for the ambiguous sentences than for the unambiguous sentences in the picture verification task were partially due to the demands of the task. The ambiguous sentences required the S to choose two pictures and the unambiguous sentences only one picture. Logically, more time is required to choose two pictures than one.

The second inconsistent result is summarized in line b, Table 7. The surface syntactic latencies did not differ significantly from the combined latencies of the other unambiguous types. The inconsistent result was due to the relative increase in the mean latencies for lexically ambiguous sentences in the picture verification task.

Omission Errors

In the picture verification condition, it had been hypothesized that the non-cue condition would produce more omission errors than the cue condition. This hypothesis was based on the assumption that prior awareness of ambiguity was necessary for complete resolution of an ambiguous sentence. Without this awareness, a failure to choose or "find" the second picture was expected. The analysis of omission errors was necessary, then, as a measure of the prevalence of single meaning perception, especially in the non-cue condition.

A specific type of omission was chosen to analyze response characteristics in the cue versus non-cue condition. Omission errors were defined as the failure to select one appropriate picture in conjunction with a single correct choice. An example is the

following: The crowd gathered to see the star. This sentence is ambiguous on the simple lexical level. An omission error was committed when one correct picture was chosen, e.g., a picture of a crowd viewing a celestial body, but the second correct picture was not chosen, e.g., a picture of a crowd gathering to see a movie star. This type of error represented the instance where the S perceived a single meaning of the sentence and failed to resolve the ambiguity.

The results of the analysis of variance on errors are summarized in Table 8. The main effects were cue versus non-cue and male versus female. Gender was studied to determine if the non-difference between male and female in process times for meaning judgment and picture verification tasks also held for omission errors. For cue, $F(1, 56) = 8.90$, $p < .005$, and for gender, $F(1, 56) = .59$, $p = NS$. The Cue x Gender interaction was non-significant, $F(1, 56) = .11$, $p = NS$. The mean number of omission errors for the cue condition was 10.10 and 16.03 for the non-cue condition. This finding in conjunction with the analysis of variance for omission errors showed significantly more errors in the non-cue condition than in the cue condition.

In order to eliminate the possibility that the Ss in the non-cue condition were unaware of the necessity of choosing two pictures if two correct pictures were present, all Ss were questioned following the final sentence presentation. All of the Ss reported that they had understood the instructions to choose two pictures if two

Table 8

Two-Way Analysis of Variance for Omission Errors. Omission Errors for Analysis were Defined as a Single Omission Error in Conjunction With One Correct Response

Source	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>	<u>p</u>
Total	3891.73	59			
Cue	528.06	1	528.06	8.90	< .005
Gender	35.26	1	35.26	.59	N.S.
Cue X Gender	6.68	1	6.68	.11	N.S.
Error	3321.73	56	59.32		

meanings were present.

Random samplings of approximately 15 Ss in the non-cue condition gave some clue as to the comprehension process following the picture verification stage. The Ss in the non-cue condition fell into two distinct categories. Approximately 8 Ss reported actively failing to choose the second meaning of some sentences explaining that the second "less-biased" meaning was rejected as being improbable. This response pattern prevailed despite an understanding by the Ss of the necessity of choosing two pictures if they recognized two meanings. A second category of Ss reported a failure to recognize the second meaning in most of the experimental sentences despite the fact that 80% of the sentences were ambiguous. These Ss lent tentative support to the one-meaning hypothesis (cf. Foss, Bever, & Silver, 1968; Carey, Mehler, & Bever, 1970) discussed above, which contended that one meaning of an ambiguous sentence is immediately perceived without interference from the other meaning.

Summary

In summary, the following hypotheses were offered with the corresponding results:

- 1) For both the meaning judgment task and the picture verification task, increased latencies of recognition were hypothesized to be a function of increased complexity of ambiguity. This hypothesis was partially confirmed. Longest latencies occurred in the processing of underlying syntactic ambiguity in both tasks. However, in the meaning judgment task the shorter latencies in both lexical categories

were not predicted.

- 1a) Ambiguous sentences will require longer time to process than non-ambiguous sentences. This hypothesis was partially confirmed in the meaning judgment task and completely confirmed in the picture verification task. In the meaning judgment task only the syntactically-based ambiguous sentences showed longer latencies than the unambiguous sentences. The lexically based sentences showed significantly shorter latencies than the unambiguous sentence types.
- 1b) Underlying syntactic structure ambiguity will require longer time to process than surface syntactic ambiguity. Although the picture verification task showed latencies in the hypothesized direction, neither task showed a significant difference between the underlying and surface syntactic ambiguity in time to process.
- 1c) Sentences with complex lexical ambiguity will require longer time to process than sentences with simple lexical ambiguity. This hypothesis was not confirmed in either of the experimental tasks although the picture verification task showed latencies in the hypothesized direction.

2) The SS not-cued to the presence of ambiguity in the sentences prior to the experimental task will commit more omission errors. Statistical confirmation was found for this hypothesis. More errors were found in the non-cue than cue condition.

- 3) The SS in the cue condition will show significantly longer

processing latencies in both tasks than those in the non-cue condition. No significant differences were found in the latencies for the cue and non-cue conditions, although the latencies were in the direction hypothesized.

CHAPTER V

DISCUSSION

The discussion of the data is divided into three general considerations: 1) a comparison of the present results with the results of prior studies; 2) an explanation of the present results; and, 3) an interpretation of these results. The first two considerations are discussed in terms of the meaning judgment task, the picture verification task, cue condition latencies, omission errors, meaning versus meaningfulness, and linguistic processing models. An interpretation of the data is discussed in terms of a compromise model.

A brief review of the types of ambiguity and experimental tasks precedes the discussion. The sentence materials were of five types: unambiguous, surface structure syntactic ambiguous, deep structure syntactic ambiguous, simple and complex lexical ambiguous sentences. Surface ambiguous sentences were defined as sentences whose meaning is resolved by the rearrangement of the surface structure components or by a second constituent analysis of the surface structure of the sentence. Deep structure ambiguous sentences were defined as sentences whose meaning is resolved by an understanding of possible strings which are hypothesized to underlie the surface structure. Simple lexical ambiguity was defined as the specification of the referent to only one word of the sentence.

Complex lexical ambiguity was defined as ambiguity involving a phrase or constituent of a sentence whose resolution determines the meaning of the entire sentence.

The Ss in this experiment read the sentences and performed the following tasks: 1) in a meaning judgment the Ss pressed a button when they understood the meaning of the sentence; 2) in a picture verification task the Ss chose the picture or pictures which gave a visual explanation of the previously shown sentence. The Ss, one-half of whom were male and one-half of whom were female, performed these tasks under two conditions: 1) half were alerted to possible ambiguity in the task (cue condition); and 2) the other half were not (non-cue condition). The major variables of the study, then, were types of ambiguity, cueing, and gender.

Types of Ambiguity: Meaning Judgment

In the meaning judgment task the unambiguous sentence latencies were significantly different from the latencies for the ambiguous sentences. Both the surface syntactic and underlying syntactic sentences required significantly longer processing times than the unambiguous types, but underlying syntactic ambiguity demanded no longer time to process than that for surface structure. Both lexically ambiguous categories showed shorter latencies than the unambiguous sentences, but again showed no latency difference between lexical types.

The above results were derived from the combined latencies of the cue and non-cue conditions. As previously noted, in the Cue x

Type interaction, the syntactically-based ambiguous sentences had longer latencies than the unambiguous sentences only in the non-cue condition. The simple lexical and complex lexical latencies were shorter than the unambiguous sentence latencies only in the cue condition. In both instruction conditions, however, the syntactically-based ambiguous sentences showed longer times to process than the lexically-based ambiguous sentences.

Figure 2 represents the effect of type of ambiguity on processing time. Contrary to MacKay (1966) not all of the ambiguous sentences resulted in longer latencies as a function of level of complexity. The lexically ambiguous sentences not only did not yield longer latencies when compared with the unambiguous category, but rather showed significantly shorter perception times than the unambiguous sentences.

Mistler-Lachman (1972) found that a meaningfulness judgment without context produced no significant differences in perceptual latencies between unambiguous and ambiguous sentences. When context was provided for the meaningfulness judgment, surface syntactic ambiguity required a significantly longer time than the unambiguous, syntactic underlying, or lexical types. No significant differences were found in the latencies between the latter three categories. Mistler-Lachman's results, however, did not reflect the full comprehension of the sentence meaning. The failure to comprehend the sentence could have resulted in a failure to resolve the ambiguity. Using a different task these results were not confirmed in the present

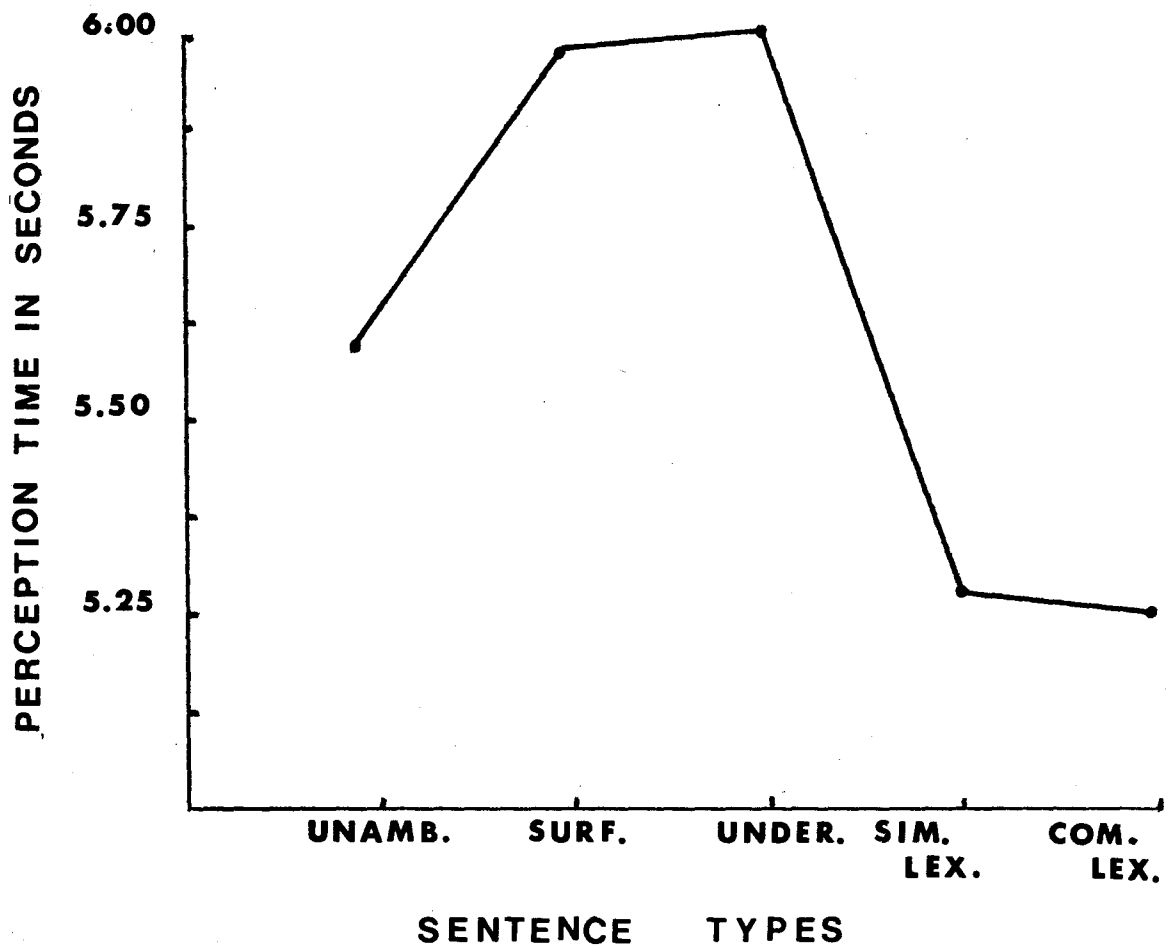


Figure 2. Latency in seconds to perform meaning judgment tasks on sentences containing different types of ambiguity.

study. In a meaning judgment, without context, the present study showed a significant difference between the ambiguous and unambiguous sentences. As noted above, the surface structure did require longer processing time in relation to the single-meaning sentences, but underlying syntactic sentences also required longer latencies than lexical or unambiguous sentences. Therefore, in using a meaningfulness judgment Mistler-Lachman was not testing the effect of ambiguity on sentence processing. Her task allowed the S to make a judgment without completely processing the sentence.

Foss (1971), using a phoneme-monitoring task, also found no differences between lexical and deep syntactic ambiguity. The longer latencies for surface syntactic and deep structure ambiguity versus simple and complex lexical ambiguity in the present study were contrary to Foss' results.

The present study confirmed in part the results of MacKay and Bever (1967). They found that perception time for lexical ambiguity was shorter than that for surface structure ambiguity, but their longest latencies were obtained for the underlying syntactic ambiguity. Although, in the present study, deep structure syntactic ambiguity required the longest time to process of all the sentence types no significant differences were found between this type and the surface syntactic structure ambiguity. Lexical ambiguity showed the shortest latencies among ambiguous sentences in the MacKay and Bever (1967) study. These latencies, however, were not significantly shorter than those for unambiguous sentences as found in the present study.

The following results need to be explained: 1) the shorter perception time in the lexically ambiguous categories than in the unambiguous sentences. No previous studies reported this finding. 2) The identical latencies for the underlying and surface ambiguity. In previous studies the relative perception time for surface structure has fluctuated depending on the task. 3) The identical latencies for the simple and complex lexical categories. No previous studies have made this distinction.

Types of Ambiguity: Picture Verification

The picture verification task revealed data similar in some respects to the meaning judgment task but with specific differences requiring a more comprehensive explanation. Figure 3 shows the effect of ambiguity on picture verification times. The present data argued against Mistler-Lachman's (1972) criticisms of MacKay's (1966) data. MacKay found the following order of processing times: unambiguous, lexical, syntactic surface, and underlying syntactic. The present study provided tentative support for MacKay's data as presented in Figure 4. Discounting the complex lexical category which was not used in MacKay's study, the curve for the present study was similar in configuration to the MacKay (1966) study. In the present study, significant differences were not found between all ambiguity categories.

Mistler-Lachman (1972) questioned MacKay's results primarily on the basis of methodology. She criticized the imprecision of stop-watches to measure latency. The completion times in the MacKay

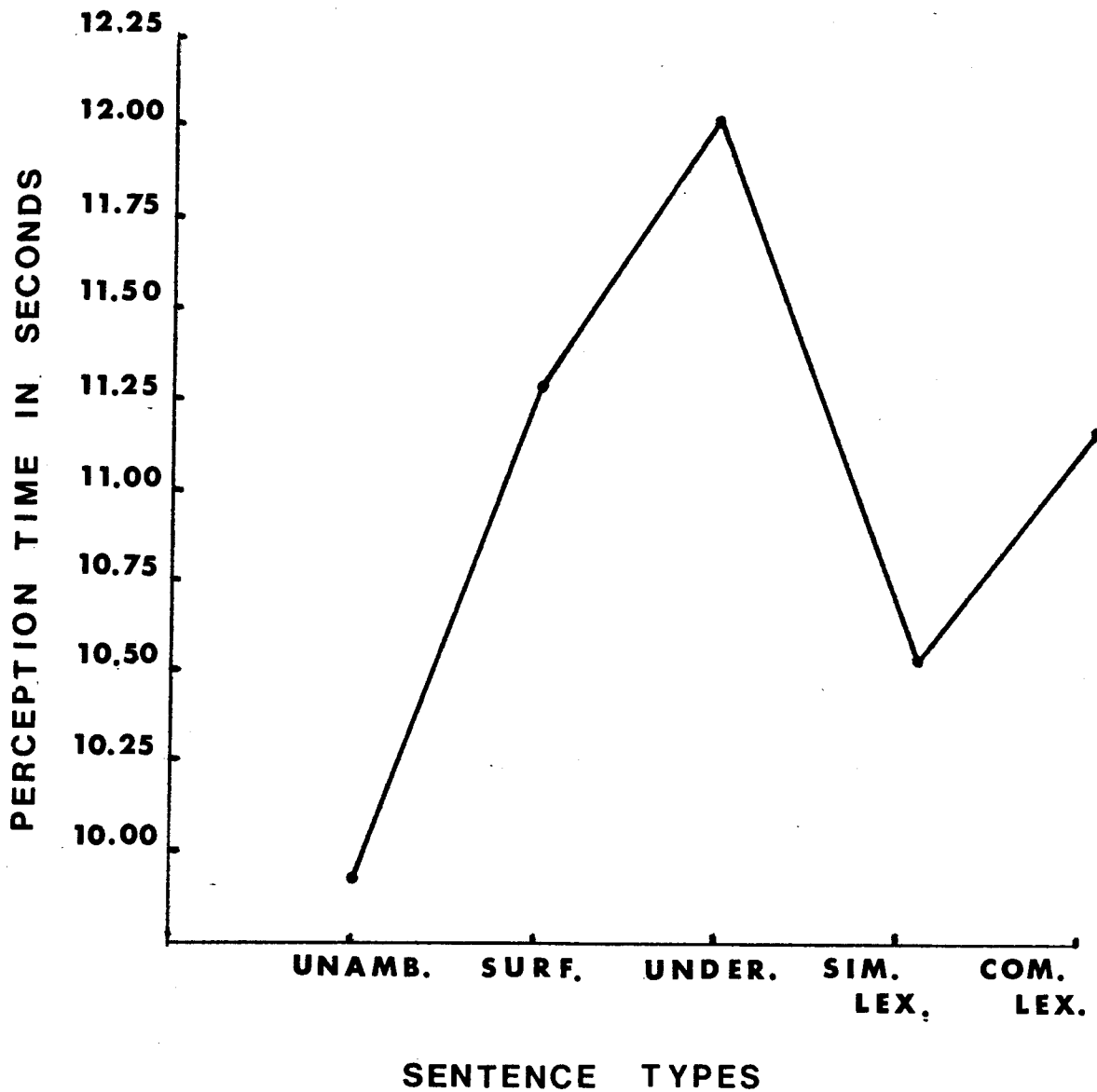


Figure 3. Latency in seconds to perform picture verification tasks on sentences containing different types of ambiguity.

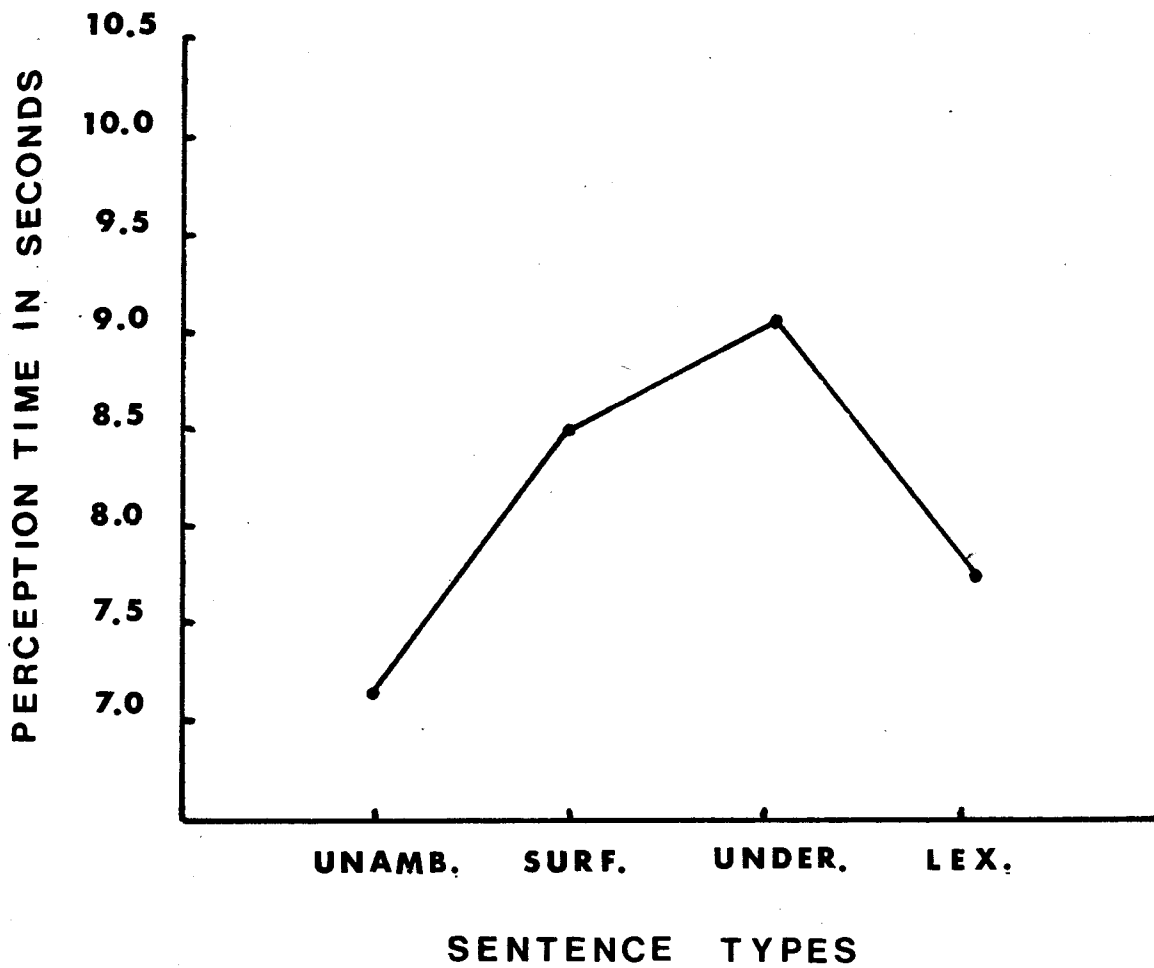


Figure 4. From MacKay (1966). Completion times for sentences at various levels of ambiguity.

study included the reaction time of the E in starting and stopping the watch, the time to flip over an index card, the time to read the fragment silently, the time to think of a completion, the time to read the fragment aloud, and the time to speak the completion aloud.

Although possibly valid for MacKay's methodology, Mistler-Lachman's criticisms of the MacKay study do not apply to the methodology of the present study. The present study used a picture verification task in place of the production without context of MacKay (1966) and Mistler-Lachman (1972). The picture verification task was under the complete control of the S who pressed a button when he made his final choice. The task then measured time to recall the sentence, time to scan the pictures, time to verbalize the picture choices, and time to press the button. The reaction time measurement was entirely automatic thus eliminating a major portion of the Mistler-Lachman criticism. Given the precision of the present methodology, MacKay's findings of differential processing times relative to levels of ambiguity seem more valid than Mistler-Lachman's findings of no difference.

Cue Conditions: Omission Errors

A discussion of the data from the omission errors must necessarily consider the non-significant difference found between latencies in the cue and non-cue conditions. Contrary to the hypothesis, the cue condition did not reveal longer latencies than the non-cue condition. The longer latencies were hypothesized as

a result of an active search process for ambiguity.

Of interest to the present study was the effect of prior cueing on the response patterning during the picture verification task. It was specifically hypothesized that Ss in the non-cue condition would have a tendency to produce single responses on the picture verification task. This hypothesis was based on the presumption that Ss in the non-cue condition would fail to resolve the ambiguity more often than Ss who had been cued to the presence of ambiguity.

The present study found no significant differences in overall processing times between cue and non-cue conditions but, a significant difference was found between the two cue conditions in number of omission errors and a nearly significant Cue x Type interaction. As previously stated, omission errors were defined as the failure of a S to resolve one meaning of the ambiguous sentences although the alternate meaning was correctly verified. The non-cue condition had more single omission errors than the cue condition. The greater number of omission errors indicated either a lack of comprehension of the alternate sentence meaning or, though the alternate meaning was perceived, the corresponding picture was not indicated in the response.

Previous studies have given only partial explanations for a small portion of the reported experimental results. An adequate model of linguistic processing must explain the differential perceptual processing time for different ambiguity types in the

meaning judgment condition, the different PTs in the picture verification task, and the difference in omission errors in the cued and non-cued conditions. The first stage in the development of such a model is the specification of the difference between the present meaning judgment task and the meaningfulness task of Mistler-Lachman (1972).

Meaning Versus Meaningfulness

Given the present findings of some differences in the latencies for the experimental sentences, a comparison must be made between the meaningfulness task of Mistler-Lachman (1972) and the meaning judgment task in the present study. As previously mentioned, the meaningfulness judgment, especially without any context for the sentences, yielded no difference in the perceptual latencies. The lack of any difference between the processing times for ambiguous and non-ambiguous sentences was attributed to the lack of comprehension when judging whether a sentence was meaningful or not. Mistler-Lachman reported that some Ss did not even finish reading the sentence before making the judgment. Evidently, the Ss were tapping their knowledge of sentence structure and semantics (Katz & Fodor, 1963). Mistler-Lachman (1972) stated that the Ss were not looking for sentence meanings as much as searching for semantic anomalies or selectional constraints as a basis for a meaningful or non-meaningful response. These semantic anomalies usually involved violations of subcategorization rules which according to Chomsky (1965) and Katz and Fodor (1963) are essentially syntactic violations.

The present data did not agree with the findings of Mistler-Lachman's meaningfulness judgment task. From the present results, it was clear that ambiguity affected processing time.

The present experiment, then, attempted to test the adequacy of the Mistler-Lachman explanation of the data by using a meaning judgment task which differed from the meaningfulness judgment in one respect. Instead of the S simply judging whether a sentence was meaningful or not, it was hypothesized that the S must comprehend the sentence in actively searching for its meaning. This task should have required the S to finish reading the entire sentence before making any judgment about the meaning of the sentence. Given this task the S would search the entire syntactic structure, both surface and underlying, as well as the meaning for lexical items, for clues to the meaning of the sentence.

The present data supported an hypothesized difference between a meaningfulness and meaning judgment. If "levels" of comprehension is a valid way to explain linguistic processing (cf. Mistler-Lachman, 1974), the meaning judgment required a "deeper" comprehension of the linguistic strings.

In the meaning judgment, two fundamental distinctions were made between the ambiguous sentences: those with ambiguity on a syntactic level and those with ambiguity on a semantic level. A significant finding was that lexical ambiguity required a shorter time to process than non-ambiguity.

Lexically, or semantically, based ambiguity was recognized

rapidly (5.25 sec. for simple and 5.23 for complex). This search may be analogous to the primitive or immediate comprehension which includes the invoking of the semantic memory system (Mistler-Lachman, 1972). This primitive comprehension includes initial word decoding, parsing, and the invoking of semantic memory.

An hypothesized reason for the short latencies was that the Ss were not parsing the entire sentence but simply cueing in on the single ambiguous word or the ambiguous constituent of the sentence. This cueing would not necessarily require the S to resolve the ambiguity but simply to find a single meaning of the word or constituent.

A more complex effect was noted in the meaning judgment task when both surface structure and deep structure ambiguity showed significantly longer latencies than the unambiguous sentences, though, no significant differences were noted between the two types of syntactic ambiguity. The longer latencies indicated that these two ambiguous categories demanded some extra processing time in the linguistic decoding.

If the meaning judgment were shallow as in the levels of "meaningfulness" then no differences in processing times for the syntactic ambiguous categories would be expected.

The Effect of Instruction

Prior to a discussion of linguistic processing models, consideration must be given to the Cue x Type interaction in the meaning judgment task. Although no significant effect was found

for cue in the above task, a nearly significant effect was found for cue x type. The data in the Cue x Type interaction might explain the following: 1) the shorter latencies for the lexically ambiguous versus unambiguous sentences, and 2) longer latencies for the syntactic ambiguous sentences.

When compared to the unambiguous sentences, shorter latencies for the lexically-based sentences were found only in the cue condition. In the non-cue condition nearly equal latencies were obtained for unambiguous, simple lexical and complex lexically ambiguous sentences. An examination of the instructions for the cue and non-cue condition showed that for the cue condition an example of a lexically ambiguous sentence was given to the subject. No other type of sentence was given to the subject. The lexically ambiguous example might have "pre-set" the subject to look for this particular type of ambiguity, and to "cue-in" on the locus of ambiguity. A similar effect of shorter latencies for the lexically ambiguous sentences was not found in the non-cue condition. Once pre-set for the lexically ambiguous sentences, the subject may have found the presence of syntactic ambiguity and non-ambiguous sentences confusing resulting in longer processing times for these latter types of sentences.

The non-cue condition showed almost identical latencies for non-ambiguous, simple, and complex lexically ambiguous sentences. The subjects in this condition were given an example of a non-ambiguous sentence in the instructions. Without a pre-set for lexical ambiguity as in the cue condition, the subject could not as easily

cue-in on the locus of ambiguity. Instructional bias seems to account for the shorter latencies in the cue condition for lexical versus unambiguous sentences, and bias may represent the best explanation for the lexical latency data. The subjects in the non-cue condition did not have the advantage of cueing and their data is consistent with other researchers who have found no effect due to lexical ambiguity (e.g., Mistler-Lachman, 1972). The longer latencies in the syntactically-based ambiguous sentences, however, cannot be explained solely on the basis of the instructional set.

Although the above explanation of the lexical data pertains to a portion of the data, it cannot explain the longer latencies in the syntactically-based ambiguous sentences versus the unambiguous sentences. An examination of present linguistic processing models might yield an appropriate model for the present data.

Linguistic Processing: Present Models

Three general models of ambiguous sentence processing have been proposed from past research. A brief review of these models may be helpful in understanding that model to be proposed based on task demands.

Carey, Mehler, and Bever (1970) discussed an exhaustive computation hypothesis. According to this model all of the possible meanings of an ambiguous sentence are encoded and processed and finally a choice is made between the meanings. It was hypothesized that the differences in ambiguous sentence processing latencies reflected the extra time to process two meanings and to choose the

appropriate meaning.

A second model was also proposed (Foss, Bever, & Silver, 1968) which has been called the unitary perception model. This model stated that a single meaning of an ambiguous sentence is computed with no interference from the other possible meanings. The second meaning is only computed when contextual information disconfirms the increased latencies present.

A third model, an oblivion hypothesis, was hypothesized by MacKay (1966) in which no meaning is assigned to ambiguous sentences until there is enough information from context or other sources to choose among the possible meanings.

A fourth model was suggested by Olson and MacKay (1974) which was appropriately labeled an interaction model. This model emphasized the role of perceptual suppression in the processing of ambiguous sentences; especially the lexically ambiguous ones. It was hypothesized that "the ambiguous lexical input simultaneously activates two conflicting sets of semantic features which correspond to the two meanings of the ambiguity" (Olson & MacKay, 1974, p. 468). These two meanings were said to interact with mutual inhibition at a subthreshold level. The perception of the one meaning necessarily required the suppression of the other meaning. This model was said to account for the usual non-perception of ambiguity in everyday speech.

Linguistic Processing: A Proposed Model

The above-presented models of comprehension have given explanations of linguistic processing which could apply to the present

data. Clearly, process times for the surface syntactic and underlying syntactic ambiguity were significantly different from the simple and complex lexical ambiguity. Given the data, the S appeared to be making a syntactic versus semantic judgment of ambiguity.

The finding of no difference in processing time between lexically ambiguous and non-ambiguous sentences in the non-cue condition suggested two possible explanations. The S could have perceived both meanings of the lexically ambiguous sentence but, since lexical ambiguity usually involves only one word or phrase, the S may have been able to "cue-in" on that one word, and not be forced to process the entire sentence. This "cueing-in" could have substantially reduced the perceptual latency.

"Cueing-in" on the locus of ambiguity represents the best model of linguistic processing of lexical ambiguity in the non-cue and possibly cue conditions. It was hypothesized, however, that complex lexical ambiguity would yield longer latencies than simple lexical ambiguity. The simple and complex lexical categories showed no difference in perceptual times to process. Two reasons are suggested for the failure to find a difference. The first explanation states that the distinction between simple and complex lexical ambiguity was artificial. No other researcher had made this distinction preferring to view lexical ambiguity as a unitary phenomenon. This explanation is illogical in that the complex lexical ambiguity required the S to process a structurally more complex sentence. By definition complex lexical ambiguity involved a phrase or constituent of a sentence whose

resolution determines the meaning of the entire sentence. This type of sentence requires the S to do more than simply "cue-in" on a single referent in the sentence. The distinction between simple and complex lexical ambiguity does not seem to be an artificial distinction.

Fodor, Bever, and Garrett (1974) suggested a second explanation, a sequential processing model of ambiguity. This model states that if a portion of a sentence has n possible meanings, only one of the n possible meanings will be processed. This one interpretation will be accepted by the S until other disambiguating material is encountered which contradicts the interpretation. Support for this model has been given by Carey, Mehler, and Bever (1970) and Foss, Bever, and Silver (1968). If only one meaning of the simple and complex lexically ambiguous sentences are computed, no difference would be found in the relative latencies of the lexical categories. This model predicts the lack of difference found in the present study.

A combination of subject cueing-in on the locus of lexical ambiguity, and the sequential processing model, best describes the comprehension strategy. This strategy allows the S to process the locus of ambiguity without fully comprehending the other components of the sentence or the other meanings of the sentence. Mistler-Lachman (1972) adopted this explanation of processing. She stated that immediate comprehension of a sentence might include initial word decoding, parsing, and invoking of the semantic memory system. Given the nature of lexical ambiguity and the demands of the task,

an appeal to the semantic memory might explain the relatively short latencies in the lexically ambiguous sentences. Additionally, no conclusive evidence exists which would substantiate the hypothesis that the lexically ambiguous sentences were disambiguated during the meaning judgment.

The longer latencies for syntactic surface and underlying structure processing are more difficult to explain. From the data it is clear that the S was not processing the syntactically-based sentences in the same way as the lexically-based sentences. As will be recalled, in the meaning judgment the surface and underlying sentences required significantly longer time to process than the unambiguous sentences. In addition, the surface and underlying syntactic sentences were not significantly different from each other in processing latencies. A sequential model does not predict the long latencies although it would predict the finding of no difference between the syntactic surface and underlying sentences. The "cueing-in on the locus of ambiguity" explanation may not apply because of the complex nature of the syntactic relationships in the sentences.

Fodor, Bever, and Garrett (1974) proposed a second simultaneous processing model of ambiguity. According to this model, if a portion of a sentence has n possible meanings each of the n structures is computed and carried in short-term memory. If no disambiguating material is encountered by the S all n analyses are retained. The sentence is comprehended in n ways as ambiguous. This particular model predicts that ambiguity will increase time to

process because of the n paths of analysis and computation that must be held in memory. Of the various models discussed, the simultaneous model may provide the best explanation for the syntactic data. The ambiguity in the syntactically-based sentences did contribute to the memory load.

A question remains about the finding of no difference in the latencies between the surface and underlying syntactic ambiguities. Contrary to the hypothesis, underlying syntactic ambiguous sentences did not yield longer latencies than the surface syntactic ambiguous sentences. In the non-cue condition the underlying ambiguity even showed a non-significantly shorter latency than the surface type.

According to the data, the resegmenting of the surface structure took as much time as the specification of the complex underlying relations in the underlying type. This finding is not entirely unexpected if the linguistic processing of syntactic structure is examined. According to the Standard Theory the underlying relations of an ambiguous surface string must be disambiguated before the surface structure can be resegmented. The syntactic analysis in both the surface and underlying ambiguous sentences is in the underlying structure. Thus, the primary processes of disambiguation are nearly identical for both types of syntactic ambiguity. Once the underlying structure has been disambiguated, the resegmentation of the surface structure is accomplished in a relatively short time.

The data indicated that the S was capable of comprehending the sentences semantically or syntactically depending on the demands

of the experimental materials. The S was capable of recognizing the type of ambiguity involved and cueing-in on the locus of ambiguity if lexical or using a simultaneous processing method of analysis if syntactic. The strongest argument for this explanation is that the unambiguous sentences fell between the syntactic and lexical categories. Sachs (1967) alluded to this dual comprehension underlying normal linguistic processing. The Ss were able to shift "cognitive gears" depending on the ambiguity involved. The results of the present study indicated that the Ss were able rapidly to determine whether a sentence was ambiguous or not, determine whether the ambiguity was syntactically-based or lexically-based, and then use the cognitive process which best fit the demands of the experiment. The complexity of the ambiguity was less important than whether it was syntactic or lexical in nature. This apparent ability of the S rapidly to shift processing strategies had not been noted in previous literature.

The picture verification condition showed somewhat more complicated effects than the meaning judgment. All types of ambiguity showed longer latencies than the unambiguous types. This effect was due to the demands of the experiment. The ambiguous sentences required the S to choose two pictures and the unambiguous sentences required the S to choose only one of the four pictures presented. In the picture verification task for the lexical ambiguity, the S was not as easily able simply to cue-in on the locus of ambiguity as in the meaning judgment. This may have resulted in significantly

longer latencies for the simple and complex lexical ambiguity versus the unambiguous sentences.

Between ambiguity types, the picture verification task showed results similar to the meaning judgment. The lexically-based sentences combined had significantly shorter latencies than the surface and underlying syntactic latencies. The S was again making an explicit distinction between syntactic and lexical ambiguity. The syntactic ambiguity involved either a rearrangement of the surface structure components or a specification of deep structure relationships. The pictures reflected the inherent complexity of the ambiguous syntactic relationships. The lexical ambiguity, however, involved a quicker decision process. This ambiguity usually involved either a single component of the sentence or a single constituent of the sentence. The S could rapidly scan the pictures which resolved this "simpler" type of ambiguity. The picture verification task also indicated that the latency for underlying ambiguity was not significantly different from the latency for surface ambiguity. The data also indicated that simple lexical ambiguity did not differ significantly from complex lexical ambiguity. The latencies, however, were in the hypothesized direction of longer latencies for the complex lexical ambiguity versus the simple type.

The simultaneous model of ambiguous sentence processing seems best to fit the data for the picture verification condition. As previously noted, this model predicts an increase in memory load with ambiguous sentences. Both meanings of the sentence must be available

to the S if he is to perform the verification task. The S may still make the basic distinction between the syntactic and lexical type of ambiguity yielding longer latencies in the surface and underlying syntactic ambiguity and shorter latencies in the simple and complex lexical ambiguity.

Cue Versus Non-cue

The hypothesized longer latencies in the cue condition were not confirmed by the present data. No model of linguistic processing immediately suggests itself. Logically, longer latencies should be obtained in the cue condition as the S actively searches for the ambiguity in the experimental sentences. The non-cue condition should have shown shorter latencies than the cue condition because the S would not be immediately aware of the ambiguity.

Two hypotheses are offered as possible explanations of the cue versus non-cue data. Although the S might not have been immediately aware of the ambiguity in the non-cue condition, over a number of trials the S could eventually have recognized the presence of ambiguity in the sentences. No data confirms this explanation because the first ten "practice" trials were not used in the data analysis. During the first ten trials the S may have recognized the ambiguity; therefore, by sentence 11 the non-cue condition would be the same as the cue condition. The second explanation might be that since the example of ambiguity given the subject was that of lexical ambiguity, the subject was "pre-set" for lexical ambiguity. The possibly rapid processing of such anticipated ambiguity as

explained above, might have equated the comprehension times between the two types of sentences in the cued condition. In the non-cued condition, the subjects may have been processing all the sentences equally, ignoring the presence of ambiguity.

Either of the above possibilities might explain the failure to find a cue versus non-cue difference. However, no data from the study either confirms or denies the plausibility of either hypothesis.

Conclusion

The present study gave partial confirmation to the psychological reality of deep and surface structure. In the meaning judgment task the underlying syntactic ambiguous sentences had longer latencies than the unambiguous types. These data are predicted by the postulating of a deep structure. The underlying syntactic ambiguous sentences added more to the cognitive processing than was evident from the surface structure. Longer latencies for the underlying ambiguous versus the unambiguous sentences could be predicted only if two possible propositions are hypothesized to underlie the ambiguous sentences. Similar findings were noted in the picture verification task.

The importance of the surface structure was also confirmed by the present study. The longer latencies found in the surface syntactic sentences versus the unambiguous sentences was previously explained in terms of the resegmentation of the surface structure constituents. Only if the underlying structure is disambiguated and the surface

structure resegmented can the ambiguity be resolved. It was this ambiguity resolution which contributed to the latencies in the surface syntactically ambiguous sentences. Again, similar findings were noted in the picture verification condition.

Finally, the present study emphasized the importance of an adequate production model for linguistic processing. The abstract competence model of grammar as developed by Chomsky (1965) provided new insights into the understanding of the structure of natural grammars. By definition, however, the competence model does not specify the processes underlying grammar use. The production model must account for such processes as: sentence recognition, perception strategies, sentence storage, linguistic disambiguation, and sentence retrieval from long-term memory.

SUMMARY

The present study examined the effect of various types of ambiguity on linguistic processing. Basic to the study were the concepts of deep and surface structure as originally hypothesized by Noam Chomsky.

Five types of sentences were used: unambiguous, syntactic surface ambiguous, syntactic underlying ambiguous, simple lexical ambiguous, and complex lexical ambiguous sentences. A total of 50 sentences, 10 of each type, were presented in a random order on a rear-projection screen. Four pictures were drawn for each of the sentences which either depicted the meaning or meanings of the sentence or were related in a general way to the theme of the sentence.

A total of 60 Ss were used in the study: 30 males and 30 females. Each S was tested individually on two different tasks: a meaning judgment and a picture verification task in one of two different instruction conditions. One instruction condition, the cue condition, told the S about the presence of ambiguity in the experimental materials and then gave an example of an ambiguous sentence. The instructions for the non-cue condition did not mention linguistic ambiguity and no example of ambiguity was given to the S. After being given the cue or non-cue instructions, the S was asked to press the button which he was holding in order to engage the first slide. After the sentence appeared, the S was asked to press the button again

when he understood the meaning of the sentence. Four pictures on a single slide appeared and the S was asked to choose the picture or pictures which gave a visual explanation of the sentence.

The latencies for both the meaning judgment and picture verification tasks were automatically recorded each time the S pressed the button. The latencies were defined as perception time (PT).

In addition to the perception times, omission errors in the picture verification task were recorded. Omission errors were defined as a single error in conjunction with a single correct response. This data reflected the S's failure to resolve both meanings of the ambiguous sentences.

The results were as follows: In the meaning judgment task the longest latencies occurred for the underlying and surface syntactic ambiguous sentences and the shortest latencies occurred for the lexically ambiguous sentences. The latencies for the unambiguous sentences were shorter than the latencies for the syntactic types and longer than the latencies for the lexical types. In the picture verification task, the latencies were as follows: syntactic ambiguous types, lexically ambiguous types, and unambiguous sentences. Finally, the non-cue condition showed more omission errors than the cue condition.

The results were discussed in terms of a proposed model of linguistic processing. This model combined a parallel processing model with a "cueing-in on the locus of ambiguity" model. The data

showed that an individual is able to distinguish between non-ambiguous, syntactically-based ambiguous, and lexically-based ambiguous sentences.

This data also showed that an individual is able to use different perception strategies depending on the type of linguistic material encountered and the type of task demanded of the individual.

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APPENDIX A

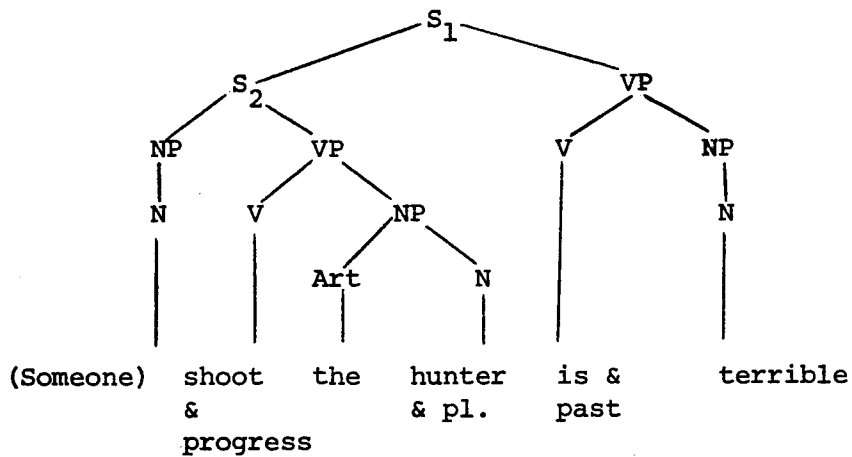
Tree diagram of an underlying syntactic ambiguous sentence.

The shooting of the hunters was terrible.

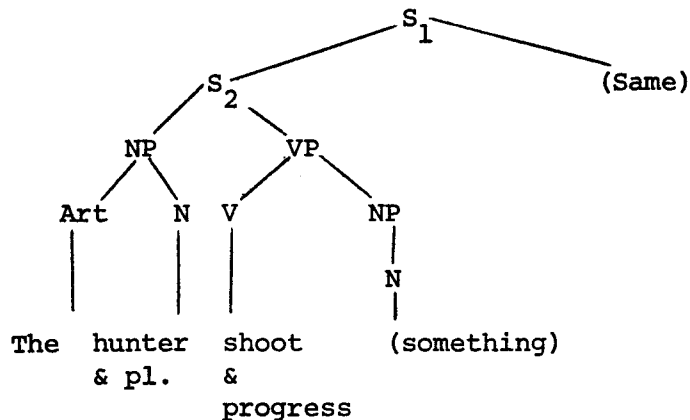
Meaning 1: St. 1 (Someone) shoot hunters.
St. 2 _____ is terrible.

Meaning 2: St. 1 Hunters shoot (something).
St. 2 _____ is terrible.

Meaning 1



Meaning 2



Source of ambiguity: the syntactic relationship of hunters to the embedded sentence.

Meaning 1: hunters is object of the verb in S_2 .

Meaning 2: hunters is subject of the verb in S_2 .

APPENDIX B

Stimulus sentences used in the experimental tasks.

Unambiguous sentences

The little girls had pretty new bath towels.
He was sleeping when the tornado hit.
The problem had not seemed easy in the statistics class.
You could see the elephants racing toward the jeep.
She was learning to bake cookies.
A cherry topped the sundae.
After the clown's antics Marion couldn't help laughing.
I want the new lamp and lampshade.
Johnson and Brown were the prisoners on trial.
Most little children love playing in the snow.

Surface syntactic ambiguous sentences

I was feeding her dog biscuits.
The boys ran out of the boxes.
The three masted British ships sailed south.
Friends gave her baby blankets.
You could see the animals running from the car.
Julia had never seen a real buffalo kill before.
The hostess greeted the girl with a smile.
The little girls bent old clothes hangers.
The stout major's wife waved at the ship.
Aunt Grace enjoyed telling her children stories.

Underlying syntactic ambiguous sentences

James Bond broke the window with the Russian.
Even the Russians could not stop praying.
The idea of Hitler was so awful they left the room.
The raiding of the Indians was pitiful.
Mario did not like fighting in the alley.
Aunt Hazel got me the last gift for nothing.
Dr. Emerson took the two Africans to kill them.
The shooting of the hunters was terrible.
The mayor asked the police to stop fighting.
The missionary is ready to serve.

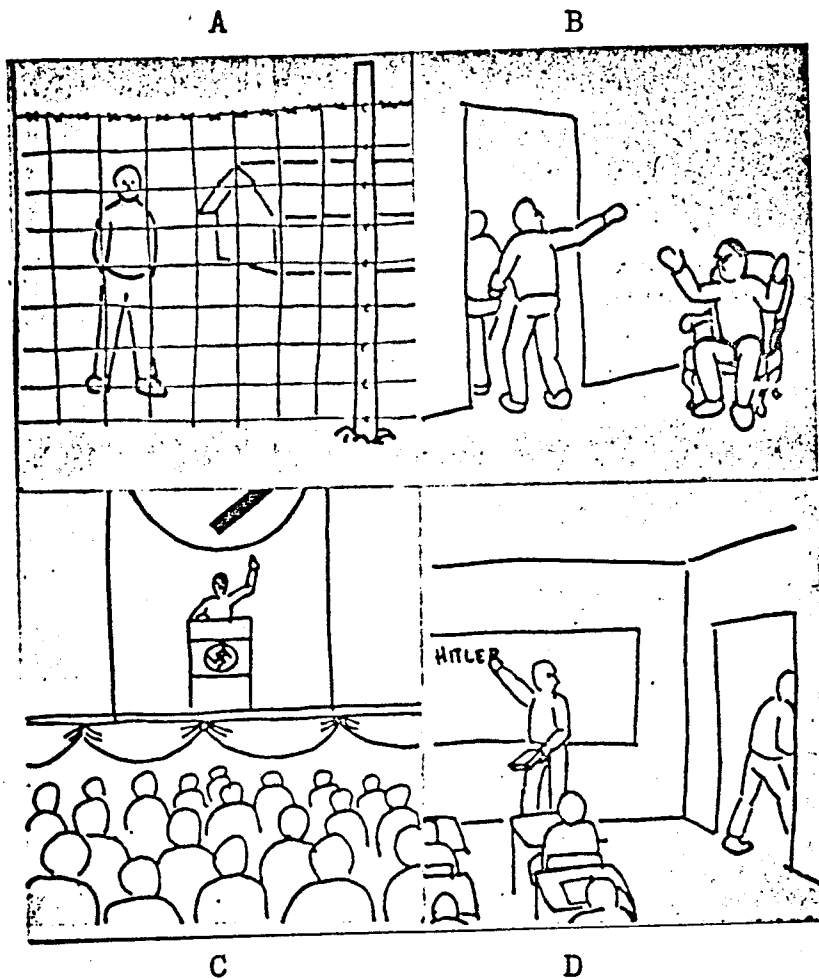
Simple semantic ambiguous sentences

Marcia bought beautiful new glasses.
The office of the president was vacant.
They always welcomed the cardinal in the springtime.
Dot's slip was embarrassing to her date.
The solution had not seemed easy in the chemistry class.
After several painful strokes he died.
A large crowd gathered to see the star.
He did not know the nickle was valuable.
Willard was not sure of the right fork.
Billy and Judy enjoyed the slides.

Complex semantic ambiguous sentences

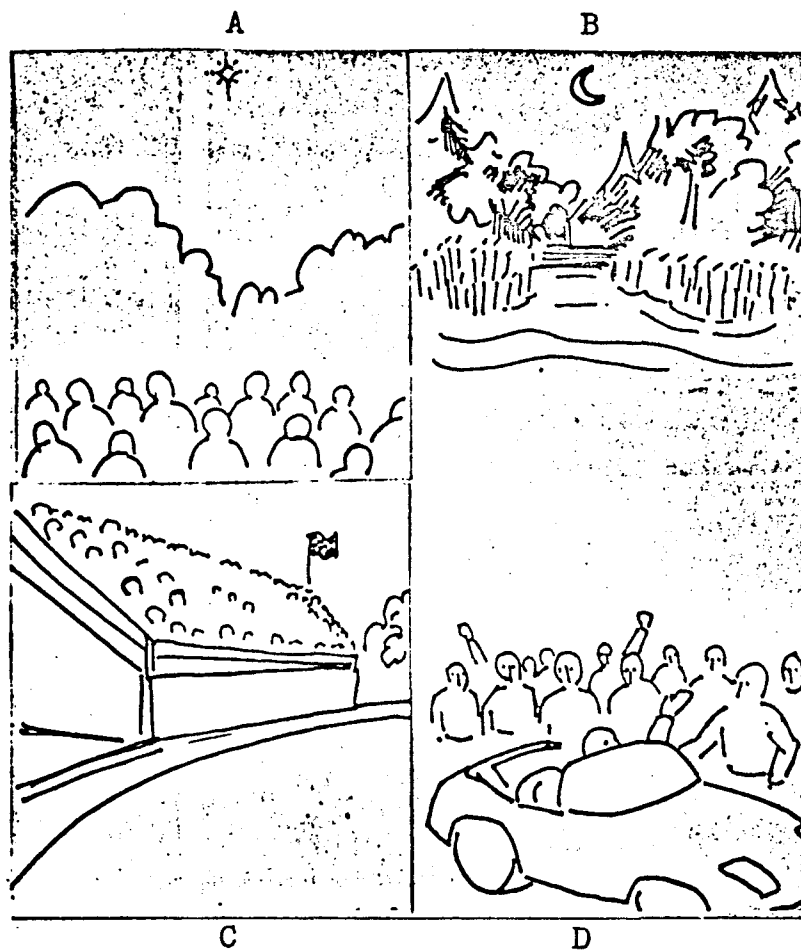
May and Joan didn't expect to improve their figures during
the course.
John's withdrawal will result in a loss of interest.
He did not expect the paper to cover everything.
On top of everything there was a tarpaulin.
Malcolm was struck by the point.
He wears a light sweater in the summer.
The end of the game is the loss of the king.
Andy replaced the cast.
Mrs. Davis did not seem anxious to press the suit.
The author wrote the story of the year.

APPENDIX C



Underlying Syntactic Ambiguous Sentence: The idea of Hitler
was so awful they left the room.

Correct Pictures: B and D

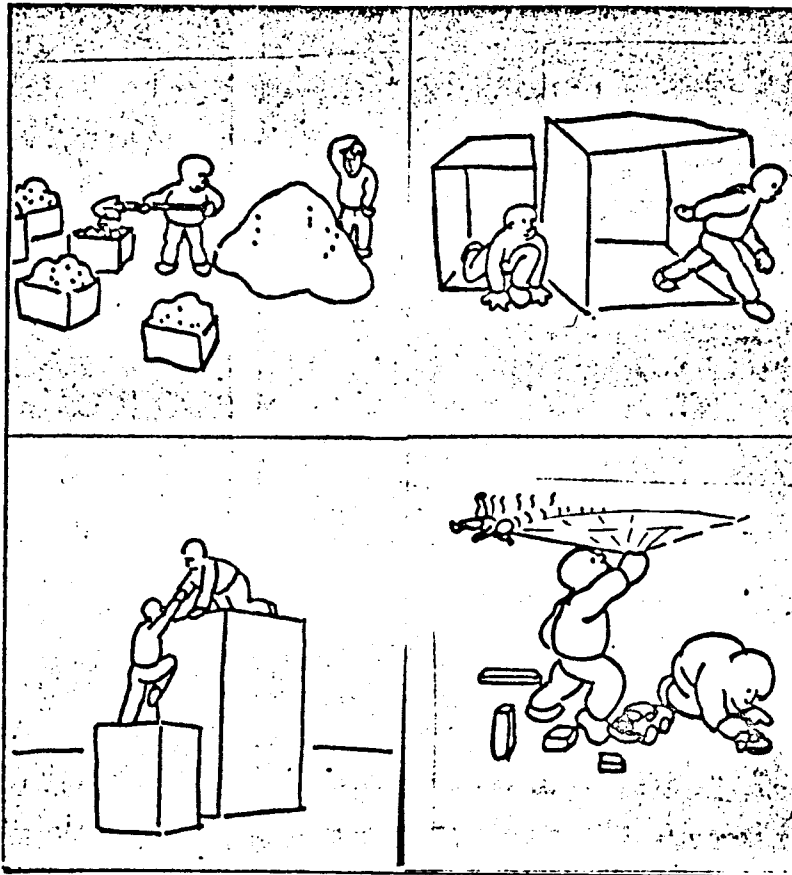


Simple Lexical Ambiguous Sentence: A large crowd gathered to see the star.

Correct Pictures: A and C

A

B



C

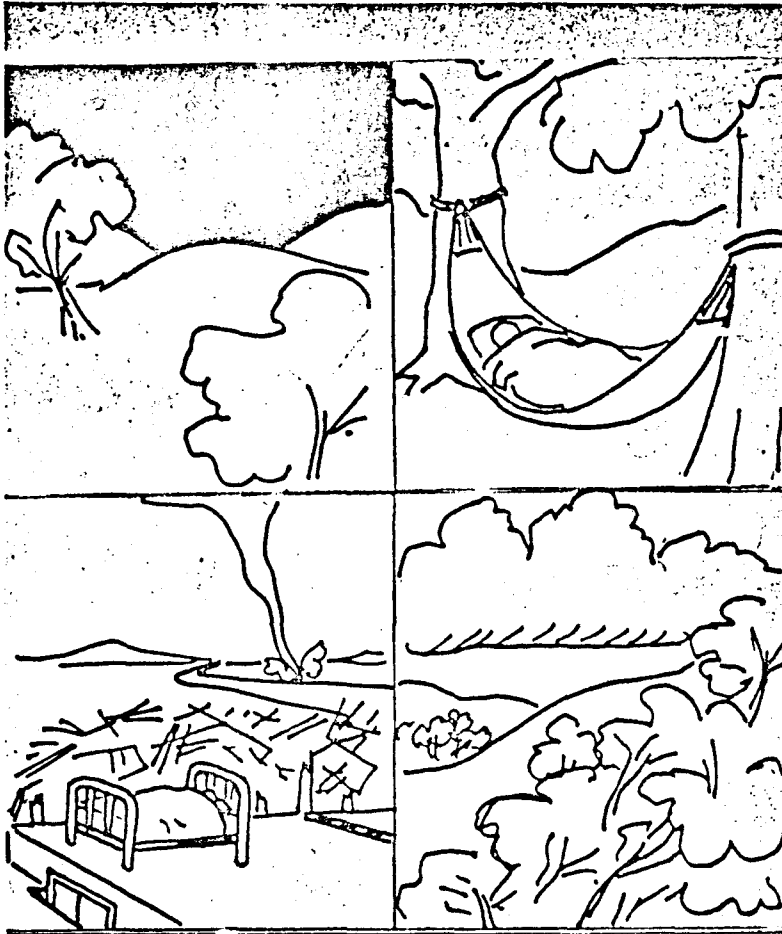
D

Surface Syntactic Ambiguous Sentence: The boys ran out of the boxes.

Correct Pictures: A and B

A

B



C

D

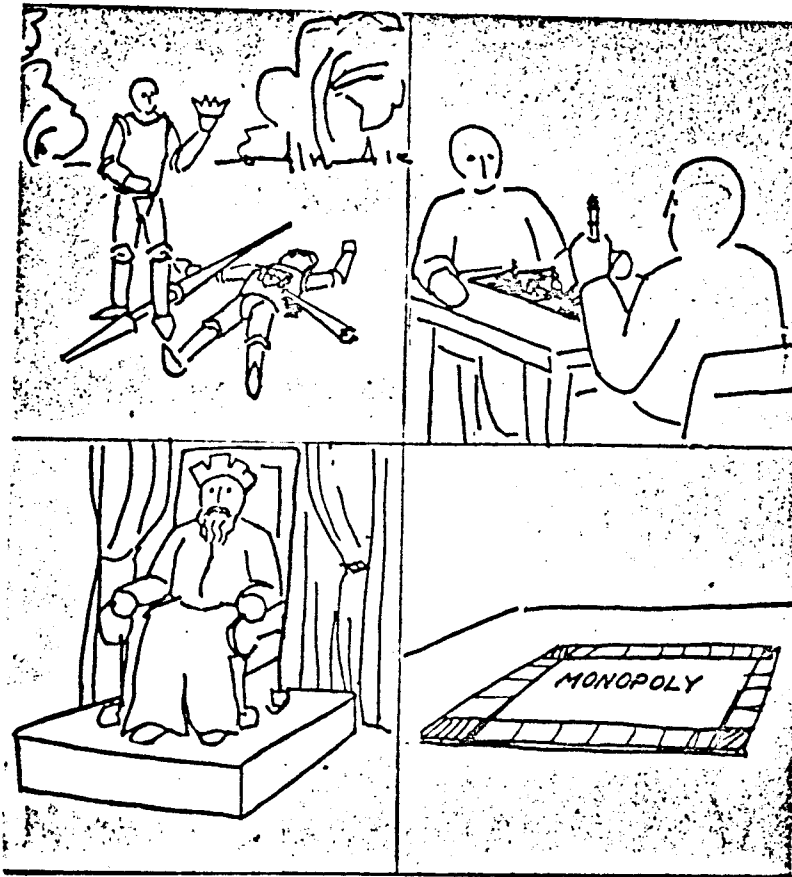
Unambiguous Sentence: He was sleeping when the tornado hit.

Correct Picture: C

A

94

B



C

D

Complex Lexical Ambiguous Sentence: The end of the game is
the loss of the King.

Correct Pictures: A and B

APPROVAL SHEET

The dissertation submitted by Richard C. Ney has been read and approved by the following Committee:

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The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

May 16, 1975
Date

John R. Crocker, S.J.
Director's Signature