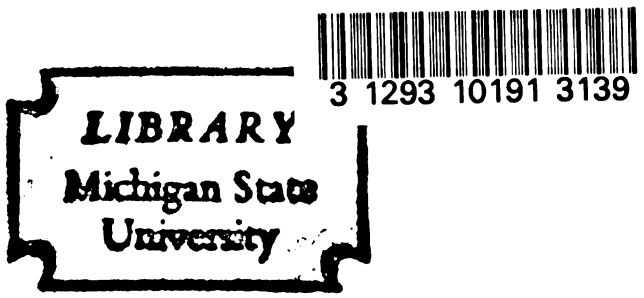

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THE EFFECT OF SELECTED DISCOURSE VARIABLES ON THE VISUAL PROCESSING OF LEFT- AND RIGHT-EMBEDDED SENTENCES BY COMPETENT ADULT READERS

By

Daniel Loren Pearce

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ABSTRACT

THE EFFECT OF SELECTED DISCOURSE VARIABLES
ON THE VISUAL PROCESSING OF
LEFT- AND RIGHT-EMBEDDED SENTENCES
BY COMPETENT ADULT READERS

By

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Purpose of the Study

The purpose of the study was to obtain and analyze data concerning the visual processing of competent adult readers while reading sentences within paragraphs to discover whether the processing of those sentences varied as a result of thematic factors within the preceding paragraph and syntactic structure within the target sentences. The study focused on the processing of left-embedded and right-embedded structures in foregrounded paragraphs, backgrounded paragraphs, and inferred paragraphs. The behaviors measured were number of total movements, number of forward fixations, number of regressions, duration of forward fixations, duration of regressions, duration of gaze, and total reading time.

Materials

Materials used in this study consisted of thirty-six separate paragraphs. Each paragraph was constructed around

a target sentence. There were six target sentences, each of which had a left-embedded form and a right-embedded form. The six pairs of target sentences (left-embedded form and right-embedded form) were of the same length (nine words), were of active voice, and employed no dependent clauses with the exception of the target embedding. Each of the target sentences was set in three conditions of paragraphs. The first condition explicitly introduced, thematized, and foregrounded the information in the target sentence (called the foregrounded condition). Within a foregrounded paragraph, the target sentence always appeared on the eighth line. The second condition of paragraphs was identical to the foregrounded paragraph; however, two sentences of semantically neutral filler to background the concepts in the target sentence were introduced immediately prior to the target sentence (called the backgrounded condition). Within the backgrounded paragraphs, the target sentence always appeared on the tenth line. The third condition consisted of paragraphs that were coherent in nature; however, no information within the target sentence was explicitly introduced prior to the target sentence (called the inferred condition).

Population and Procedures

The sample subjects used in this study consisted of thirty-six volunteer, adult, university graduate students. All participants were native English speakers. Subjects

read seven selections silently: an EDL paragraph; a foregrounded, left-embedded paragraph; a foregrounded, right-embedded paragraph; a backgrounded, left-embedded paragraph; a backgrounded, right-embedded paragraph; an inferred, left-embedded paragraph; and an inferred, right-embedded paragraph. Their eye movements were recorded with the EDL Biometrics Reading Eye II.

Findings

Data concerning the visual processing behaviors were tested with analysis of variance. Statistically significant differences were found among the six conditions for each of the seven visual processing behaviors. Each of the conditions was then compared with each of the other conditions using Tukey's post hoc procedures.

Analysis of the data indicated that competent adult readers made statistically significant behavioral adjustments in their reading to accommodate either the information structure of the material or the syntactic structures of the sentence being read.

Implications of the Study

The results of the study indicated the following:

1. An examination of the means for the areas of visual behaviors within the six conditions support the interactionist theories of reading

comprehensions. The means for the visual processing behaviors were consistent in difficulty when they were rank ordered. The means indicated that the left-embedded syntactic structures in the inferred condition always presented the most processing difficulty. The structures with the lowest means were always the right-embedded structures in the foregrounded condition.

2. The results of the study supported the position that the given-new strategy is a microprocess in sentence comprehension.
3. The results of the study do not appear to support the hypothesis that special psychological status is given to the current topic of a discourse.

DEDICATION

To my family,

especially my parents and grandparents,

for their support and encouragement

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CHAPTER I

IDENTIFICATION OF THE PROBLEM

Reading comprehension is a process which occurs when a reader reconstructs an author's intended meaning. While an internal process, the structuring of information within the reader's mind is dependent upon and directly related to the information within the discourse and various components of written discourse. In written discourse, the text is structured to cue sentence and intersentence relations for the reader. The reader's task is to use those cues to reconstruct a representation of information within his mind similar to that which the author intended. The more coherent a discourse is then the easier is the reader's structuring and processing of information. Specifically, the microprocesses of discourse comprehension involved in sentence understanding are posited to be directly related to factors of textual coherence.

Speaking in a broad sense, one might say that to be acceptable, a discourse must be coherent. Within a discourse the sentences have a common context of information, and the full meaning of any sentence can be determined only in the context of information provided by other sentences. The more coherent a discourse, the closer is the

relationship existing between the content of one sentence and the information within the other sentences. A discourse then may have varying degrees of coherence. Linguistic analyses of coherence have been done at differing levels (Halliday, 1967; Chafe, 1970, 1972, 1973, 1974; Gutwinski, 1976; Halliday and Hasan, 1976; and Van Dijk, 1977). While various factors related to coherence have been identified, a commonality exists in the sense that much of the discussion on coherence seemingly centers on the importance of redundancy of information within a discourse. This general factor, which can be termed repetition of information, is concerned with the introduction of information and the subsequent redundancy of that information within a discourse as an important aspect of passage coherence.

Various authors, using different terminology, have stressed the importance of repeated information within a passage for the coherence of that passage. Halliday (1967) makes the distinction between <u>given</u> and <u>new</u> information and credits given, or repeated, information as an important factor relating the information in a sentence to the rest of the passage. Chafe (1970, 1972, 1973, 1974) speaks of <u>old</u> information and of <u>new</u> information within a sentence in much the same way Halliday refers to given and new information. Chafe was also concerned with the status of concepts that are referenced at several points after those concepts are first introduced as an aspect of coherence. He used the term <u>foregrounding</u> to refer to the possible status of

concepts at points in the text after those concepts are introduced. A concept is foregrounded if the conventions of the language community allow the presumption that a concept is actively in mind at a certain point (or sentence). If that is not the case, then a concept is termed backgrounded at that certain point (or sentence). Foregrounding and backgrounding are factors that help determine the acceptability of sentences in a discourse and, consequently, contribute to the coherence of a passage. Kintsch (1977) cites argument repetition, which is the repeated reference to the same concepts and individuals, as being a necessary, although not sufficient, condition for coherence. Consequently, there exists a sense of commonality among various linguists and psychologists that information redundancy, whether termed thematization, foregrounding, or given information, is an important facet of discourse coherence.

Repeated information within the discourse also is posited to play a central role in the microprocesses involved in sentence comprehension. A process analysis of the role of repeated information in sentence understanding has been produced and is called the given-new strategy. Herbert Clark in various articles (Clark, 1977; Clark and Haviland, 1977; Haviland and Clark, 1974) has commented and elaborated on the memory model underlying this strategy and on the strategy itself. Basically, Clark maintains that sentences contain both given information, which the reader already knows, and new information, which the reader does

not know. Given or old information, whose primary role is integrative, plays a central role in the processing and comprehension of each sentence. The reader, in processing and comprehending a sentence, goes through a three step procedure. First, the reader isolates the given and new information in the current sentence. Secondly, the reader searches his memory for a direct antecedent that matches the sentence's given information. Finally, the reader revises the direct antecedent within his memory by attaching the new information identified in the second step.

Clark states that there are, however, situations when the given information within a sentence will not precisely match any of the direct antecedents within memory. Sometimes, the reader is able to construct an inferential bridge between the given information and a direct antecedent. Constructing an inferential bridge requires more processing time then when there is a precise match between given information and a direct antecedent. Finally, there are times when the reader will not be able to find any way of bridging the gap between given information and any of the direct antecedents within memory. Then the reader must construct a new memory node for the incoming information. The addition of a new memory node occurs only after the existing direct antecedents within memory are searched; consequently, the establishment of a new memory node will require more processing time than when a precise match exists between the given information and a direct

antecedent. Clark maintains that the ease and speed with which a sentence is understood is directly related to the integration of information from the sentence with direct antecedents within memory and the steps required in this integration.

Both Carpenter and Just (1977b) and Lesgold, Roth, and Curtis (1979) agree with the processes Clark outlines. However, they maintain that while the primary role of given information is integrative, specifically relating the propositions within the current sentence being processed to a direct antecedent in memory, not all the direct antecedents have equivalent status. Only a limited number of propositions or direct antecedents can be actively kept in mind at once. The reader possesses an active memory that has a limited capacity. Implicit in this psychological construct of an activated subset of memory (Anderson, 1976) is that factors determine which of the direct antecedents are kept in active memory and that the integration of information will take longer when the direct antecedent is not in the current active memory (e.g., Lesgold, Roth, and Curtis, 1979). Various heuristics are proposed to determine which direct antecedents are within active memory and govern the search for direct antecedents. Carpenter and Just (1977b) argue that special psychological status is given to the current topic of a discourse. Kintsch and van dijk (1978) suggest that recent and high level propositions (in the

macrostructure) within a discourse are favored for retention in active memory.

Evidence exists that supports both Carpenter and Just's (1977b) and Kintsch and van Dijk's (1978) hypotheses. Therefore, structuring the prior passage or discourse so that a concept is actively within a reader's memory should allow quicker integration of information and easier understanding of a sentence in reading. Consequently, increased passage coherence through factors such as thematizing the given information in a sentence and foregrounding the given information within a sentence should result in easier understanding of a sentence in reading since the necessary direct antecedents are actively in mind. On the other hand, more complex processes should be required in passages not as coherent. Sentence understanding should take longer as a result of these more complex processes.

Recent theoretical and research efforts within cognitive psychology and related fields by those concerned with discourse comprehension (e.g., Haviland and Clark, 1974; Carpenter and Just, 1977a, 1977b; Clark and Haviland, 1977) have stressed the role of textual coherence (including intersential relationships), thematic factors, and semantic factors in sentence understanding during reading. These efforts, and the paradigm underlying these efforts, are in apparent contrast to much of the psycholinguistic theory and research of the 1960s that maintained that the sentence was the largest unit necessary for studying a language

issue (Katz and Fodor, 1963) and that syntactic parsing was the primary process involved in comprehension of each sentence. This conflict may well be more superficial than real. Both discourse variables and syntactic processing seem to be operating in the reading process.

Gibson and Levin (1975), Hurtig (1977), and Perfetti and Lesgold (1977) maintain that processes other than only propositional determination are involved in the comprehension process. They maintain that while various discourse variables, which are primarily semantic in nature, influence the processing of a sentence, at the sentence level these semantic factors interact with the syntactic structure of the sentence being read. They have all put forward interactionist theories of reading comprehension in which not only does the syntactic parsing of a sentence influence the processing of a sentence, but, they posit, the syntactic structure interacts with discourse variables and plays differing roles according to the processing required; hence, the name interactionist theories of comprehension. The interactionist theory of reading comprehension put forward by Perfetti and Lesgold (1977) will be elaborated upon because theirs is the most developed in terms of attempting to accommodate the microprocesses outlined above.

Perfetti and Lesgold (1977), while accepting the principle of discourse variables and adopting a model of sentence understanding that is essentially similar to the given-new strategy, maintain that sentence structure plays

a role in sentence comprehension. Central to their theory is that a sentence has two levels of organization, thematic and structural. They posit that thematic organization within the passage affects the processing of information because of the limited capacity of the reader (i.e., equal access does not exist for all the antecedent memories). Thematization within the passage allows the reader more rapid access to the appropriate antecedent memory (i.e., that memory is foregrounded or put into active memory). This, in turn, facilitates the integration from the sentence being read (i.e., the given-new strategy). According to their model of comprehension, when something is read, it is held in short term memory. Some of this held information is rapidly lost because the various information processing structures compete for a limited capacity memory. Sentence structure, which is primarily syntactic, serves the function of information processing through organization of the elements within a sentence and provides maximum utilization of a capacity-limited system (at least where the syntactic structure is familiar).

Consequently, their model suggests that the integration of information within a sentence is affected by both thematic factors within the passage and sentence and by the structure of the sentence being read. They also maintain that the role of sentence structure varies according to the processes needed to integrate information. Where the information within the sentence is easily integrated, the effect

of syntactic structure within the sentence is minimal. However, where that is not the case, the structure of a sentence should increasingly facilitate or impede ease of sentence understanding.

The interactionist theory of reading comprehension put forward by Perfetti and Lesgold (1977) posits that specific discourse variables within a passage and a sentence should interact with sentence structure during the sentence understanding process. This paradigm allows for the prediction of sentence understanding as a result of textual coherence and the microprocesses necessary to structure memory. When discourse coherence is greater and information within a sentence is previously explicitly introduced, thematized, and foregrounded, then sentence understanding should be faster. On the other hand, when information within a sentence is not explicitly introduced (necessitating the reinstatement of a concept into active memory), then sentence understanding should be slower. Furthermore, ease of sentence understanding should also vary as a result of the syntactic structure of the sentence being read. This variation between easily processed syntactic structures and less easily processed syntactic structures should become greater and more pronounced as more processing is required to understand a sentence.

Purpose

The purpose of this study was to examine competent adult readers' cognitive processing while reading sentences containing embedded structures within paragraphs to discover whether the processing of those sentences varied as a result of thematic factors within the preceding paragraph and syntactic structure within the sentences. Specifically, the areas of investigation were the effects of foregrounding of information, explicitness of information, and backgrounding of information within a paragraph on syntactic processing.

Bader, Pearce, and Thompson (1980) studied the effects of related and unrelated discourse on the processing of left- and right-embedded sentences. This earlier study, however, did not systematically vary the information of the passages. The present study examined whether variations in the coherence of paragraphs affects both left- and right-embeddings equally. Furthermore, this study also examined the mental operations involved in sentence understanding from the paradigm of an active-memory of limited capacity and of sentence comprehension as a given-new strategy.

Research Questions

The following research questions were formulated to guide the investigation:

1. Is there a difference in the visual processing of target sentences among the six conditions?

2. Is there a difference in the visual processing of left- and right-embedded structures in the foregrounded conditions?
3. Is there a difference in the visual processing of left- and right-embedded structures in the backgrounded conditions?
4. Is there a difference in the visual processing of left- and right-embedded structures in the inferred conditions?
5. Is there a difference in the visual processing of right-embedded structures in the foregrounded conditions and right-embedded structures in the backgrounded conditions?
6. Is there a difference in the visual processing of left-embedded structures in the foregrounded conditions and left-embedded structures in the backgrounded conditions?
7. Is there a difference in the visual processing of left-embedded structures in the foregrounded conditions and right-embedded structures in the backgrounded conditions?
8. Is there a difference in the visual processing of left-embedded structures in the backgrounded conditions and right-embedded structures in the foregrounded conditions?
9. Is there a difference in the visual processing of right-embedded structures in the foregrounded

conditions and right-embedded structures in the inferred conditions?

10. Is there a difference in the visual processing of left-embedded structures in the foregrounded conditions and left-embedded structures in the inferred conditions?
11. Is there a difference in the visual processing of left-embedded structures in the foregrounded conditions and right-embedded structures in the inferred conditions?
12. Is there a difference in the visual processing of left-embedded structures in the inferred conditions and right-embedded structures in the foregrounded conditions?
13. Is there a difference in the visual processing of right-embedded structures in the backgrounded conditions and right-embedded structures in the inferred conditions?
14. Is there a difference in the visual processing of left-embedded structures in the backgrounded conditions and left-embedded structures in the inferred conditions?
15. Is there a difference in the visual processing of left-embedded structures in the backgrounded conditions and right-embedded structures in the inferred conditions?

16. Is there a difference in the visual processing of left-embedded structures in the inferred conditions and right-embedded structures in the backgrounded conditions?

These research questions were expanded and restated in null hypothesis form for statistical testing.

Definition of Terms

Terms in the study were used according to the following definitions:

1. Competent adult readers. Competent adult readers refers to graduate students at Michigan State University.
2. Syntactic structures. Syntactic structures refers to sentences in which the relative clause follows and modifies either the sentence subject or the sentence object.
3. Right-embedded sentence. A right-embedded sentence is a sentence containing a relative clause that follows and modifies the sentence object. Ex.: "The boy hit the ball that was white."
4. Left-embedded sentence. A left-embedded sentence is a sentence containing a relative clause that follows and modifies the sentence subject. Ex.: "The boy that was white hit the ball."

5. Foregrounded condition. A foregrounded condition refers to paragraphs in which information within the target syntactic structure is explicitly introduced and thematized immediately prior to that target syntactic structure.
6. Backgrounded condition. A backgrounded condition refers to paragraphs in which information within the target syntactic structures is explicitly introduced; however, two sentences of semantically neutral filler are introduced immediately prior to that target syntactic structure.
7. Inferred condition. An inferred condition refers to paragraphs that are coherent in nature; however, no information within the target syntactic structure is explicitly introduced prior to that target syntactic structure.
8. Visual processing. Visual processing refers to the visual processing behaviors which served as the dependent variables. There were seven component measures of visual processing:
    a. Number of total fixations
    b. Number of forward fixations
    c. Number of regressions
    d. Duration of forward fixations

e. Duration of regressions

f. Duration of gaze

g. Total reading time

Organization of Subsequent Chapters

Chapter II will contain a review of pertinent, related research in the following areas:

1. Studies on the relationship between visual processing behavior and reading comprehension.
2. Studies on the effect of syntactic structures on the eye-voice span.
3. Studies on the relationship between reading comprehension and syntactic structures.
4. Studies on the relationship between visual processing behavior and syntactic structures.
5. Studies on the relationship between information structure and the understanding of sentences.

Chapter III will present a description of the materials and procedures employed in this study. The design of the study will be presented.

Chapter IV will report the results of the data collected, compared, and analyzed for this study.

Chapter V will include a summary of the investigation, appropriate conclusions, implications, and recommendations for further research.

CHAPTER II

REVIEW OF RELATED RESEARCH

The review of related research is organized under five major headings:

1. Studies on the relationship between visual processing behaviors and reading comprehension.
2. Studies on the effect of syntactic structures on eye-voice span.
3. Studies on the relationship between reading comprehension and syntactic structures.
4. Studies on the relationship between visual processing behavior and syntactic structure.
5. Studies on the relationship between information structure and the understanding of sentences.

Studies on the Relationship Between Visual Processing Behaviors and Reading Comprehension

Huey (1908) credits Javal (1879) with calling attention to the fact that, during the reading act, the eye does not continuously sweep across the page. Instead, eye movement during reading is discontinuous, consisting of movement and pauses, with the eyes "hopping" from one position to another

position. During reading, eye movement behavior consists of the movement itself, called a saccade, and a pause, called a fixation. Most of the time during reading is spent fixating, and only six to ten percent of the time is spent in actual eye movement (Tinker, 1958). Fixations in reading have been distinguished as being either forward or regressive, depending on whether the movement of the eye is forward or backward in the text. The pattern of these eye movements has been hailed as a lens into the private experience of reading. As far back as 1922, Judd and Buswell stated that

> Eye-movements are but external manifestations of an inner condition which is set up in the central nervous system. Whenever there is a jerky, irregular eye-movement and a short span of recognition, there is a central nervous process which is also irregular and of short duration. Modern psychology has made its most fruitful advances by recognizing the intimate relation of external behavior and its accompanying conditions in the nervous sytem to conscious experience. Eye-movements are as direct measures of the mental state as the rate of a pulse is a measure of the heart-beat (1922, pp. 21-22).

Research into the eye movements of readers is quite extensive, and different comprehensive reviews of the literature exist (Tinker, 1946, 1958; Taylor, 1965; Levy-Schoen and O'Regan, 1979). These reviews conclude that during reading, a variation in eye movement is neither sporadic nor accidental. Instead, there are relationships among eye movements, what is being read, and reading ability. Within this accumulated research, certain studies specifically support the notion that eye movement behavior is related to

reading comprehension and indicative of ease or difficulty of processing. The present discussion of research will be limited to these studies.

Buswell (1937) studied the reading of adults in Chicago. Part of his comprehensive study involved the photographing of selected subjects' eye movement patterns during the reading of short selections. These selections varied in difficulty. Buswell found that as the reading material became more difficult, the number of fixations increased. He also found that difficult words and phrases received more fixations than simple words.

The notion that fixation patterns are directly related to the difficulty of the material being read receives support from Taylor's (1959) study. Taylor examined the eye movement patterns of eighth graders' reading material below their grade level, material at their grade level, and material at the high school level which was above their grade level. Little difference was found in the eye movement patterns during the reading of easy material and material at grade level. However, when the subjects read the high school material, both the number of fixations and the duration of those fixations increased significantly.

Tinker (1951) conducted research that examined the duration of fixations, exposure time needed for perception, and the relationship between fixation duration and the material being read. Through tachistoscopic presentation, he determined the exposure needed for perception; then he

determined that the average fixation duration for adults during reading was higher than the exposure needed for perception. On the basis of this finding, Tinker (1958) said that "...pause duration includes perception time plus thinking time" (p. 218). His experiment further supported this position by finding that pause duration varied with the nature of the material being read. For instance, the average fixation duration was higher for scientific prose than for easy prose.

As was previously mentioned, fixations during reading are characterized as either forward fixations or regressions. Walker (1933) reported the poorer readers' eye movements seemed to be characterized by more regressions. In his study of adults' reading abilities, Buswell (1937) stated that regressions were characteristic of an immature reader. Bayle's (1942) research, however, challenges this view. Bayle systematically examined the regressions in eye movement behavior of ninth and tenth grade students during the reading of selected material. Six general patterns of regressions were identified. Regressions, or certain kinds of regressions among the general patterns, were characteristic of even mature and skilled readers. Regressions did not signify an immature reader. Instead, regressions appeared when the reader recognized that either his perceptions were inadequate or his flow of thought was interrupted. Bayle states that regressions

> ...represent a mode of adjustment to difficulty in interpretation. As such, they must be regarded as necessary parts of the reading process under those conditions where detailed search for memory is required (1942, p. 35).

In a more recent study, Carpenter and Just (1977a) examined the total amount of time a reader looks at a text, regardless of the number of fixations. This total time is called gaze duration. The investigators were interested in measuring the amount of mental processing required of people looking at a picture, then having to read a sentence, and then deciding whether the sentence was true or false. The task difficulty of having to read the sentence and deciding its truthfulness was found to be very closely related to the total gaze duration on that sentence. In a subsequent article, discussing comprehension measuring techniques, Carpenter and Just (1977b) maintain, on the basis of their study, that

> ...most of the analytic power of mental chronometry can be applied to gaze durations as well as to total response latencies (p. 116).

In summary, eye movement research indicates that a reader's eye movements are flexible and sensitive to the material being read. Furthermore, there is strong evidence that eye movements during reading are indicative of the cognitive processing involved in reading a passage. Apparently, measures of eye movements compare favorably to other current methodologies in use to assess mental operations.

Studies on the Effect of Syntactic Structures on Eye-Voice Span

The first area of research supporting interrelationships among syntax, grammatical structure, and reading involves the eye-voice span studies (EVS). EVS is the distance, usually measured in words, that the eyes are ahead of the voice in oral reading. The EVS is measured by covering or removing the text from which a subject is reading when the subject's voice reaches a predetermined word in his oral reading. The number of words correctly uttered after the removal of the text (the "lights out" position) is the EVS.

EVS research has a history dating to the 1890s. Early studies reported the following: (a) EVS increases with age (Buswell, 1920); (b) the more difficult the text, the shorter the EVS (Buswell, 1920; Fairbanks, 1937); and (c) good readers have a longer EVS than poor readers (Quantz, 1897; Buswell, 1920). While different researchers considered the above findings in regard to the reader's position in the line of print and the sentence, it was not until the 1960s that the researchers in the Project Literacy Project at Cornell University used EVS to explore the specific effects of the grammatical structure of the text on the nature of the EVS.

Levin and Turner (1968) examined the EVS of subjects at six different grade levels ranging from second graders to college undergraduates. The subjects read from

unstructured word lists; passive sentences of three word phrases; and active sentences of two, three, and four word phrases. The findings support the hypothesis that both grammatical structure and ability affect reading. Across all ages, the mean EVS for unstructured word lists was 2.19 words. The mean for all sentence types was significantly higher at 3.91 words. Further, the average EVS increased from the second grade to the college level. When the better readers at the second grade were separated from the slower readers, the slower readers had a mean span of 2.74 words. While this span was closest to the unstructured word list average of 2.19 words, it still showed some use of grammatical structure. Consequently, it appears even the youngest and poorest readers use syntax and grammatical knowledge in their reading.

Levin and Turner also examined the tendency for subjects to read in phrases. The number of times a subject read to the end of a phrase unit for each sentence type was recorded. All age groups, except the second graders, ended their EVSs at phrase boundaries at a statistical level well above chance. There was also an inclination for readers who did not accurately report the text to change the sentence structure or the last word reported in such a way to make a phrase boundary.

Schlesinger (1968) had hypothesized that the phrase was the central unit of reading and that skilled readers processed phrase units when reading. He confirmed his

prediction with Hebrew-speaking adults. Levin and Turner's (1968) work tended to confirm the reality of phrases for English-speakers by finding that EVSs extended to phrase boundaries. The question of constraints within phrases, rather than just the presence or absence of constraints or phrase boundaries, was investigated by Levin and Kaplan (1968). They wanted to know whether different kinds of grammatical structure affected the reader's information processing.

Levin and Kaplan (1968) compared active and passive sentences within which the constraints and, consequently, predictability differed. Constraints for four and five word phrases in both active and passive sentences were determined for each sentence. EVS scores for college students were obtained for various points within the different types of sentences. The results on four and five word phrases were similar. There were, however, differences between active and passive sentences. First, there was a longer EVS following the verb in the passive sentences than in the active sentences. Second, the EVS was longer for the passive sentences at the point where the active and passive sentences began to be differently constrained. These results support the hypothesis that greater constraints or, predictably, between sentence parts result in a larger amount of information's being processed in a "chunk." The size of the "chunks," which readers use in scanning sentences, varies

in accordance with the syntactic structure and the predictability of those structures.

Levin, Grossman, Kaplan, and Yang (1972) measured the EVS in left-embedded and right-embedded sentences read by college undergraduates. A left-embedded sentence is one in which adjectival modifiers are contained between the subject and the main verb of the sentence. In a right-embedded sentence, a relative clause modifies the object of the main verb. An analysis of left-embedded and right-embedded sentences was performed using a modified cloze procedure to determine intrasentence constraints. Responses to right-embedded frames were less variable and more predictable. Consequently, right-embedded sentences should be more predictable than left-embedded sentences and have a longer EVS.

Results confirmed this prediction: EVSs for the right-embedded sentences were significantly longer than those for the left-embedded sentences. Furthermore, EVS within the sentences varied according to the differing amount of constraint existing at a particular point within each of the sentences. The larger EVS for the more predictable right-embeddings together with the active-passive findings (Levin and Kaplan, 1968) support the hypothesis that syntactic structure affects the reading of a sentence.

The results of the EVS studies tend to confirm that phrase structure in syntax influences information processing during the reading of a sentence. However, the results of the EVS studies are open to criticisms and alternate

interpretations that limit their generalizability. The first is that EVS is a "guessing game" where readers guess at words without actually seeing them. The accurate prediction beyond clause boundaries is precluded by the release of syntactic constraints. Levin and Kaplan (1970) dismiss this because of the extremely low occurrence of substitution errors in their study. The second alternative interpretation, and this cannot be so easily rejected, is that readers might keep their eyes at a constant distance ahead of their voice regardless of what they are reading. The words reported reflect a reader's short-term memory system, and failure to report words reflects a loss of unintegrated information. Thus, the EVS could be a memory report phenomenon, not a perceptual or processing phenomenon (Wildman and Kling, 1978-79). Finally, the entire body of research is open to criticism because EVS involves oral reading. The generalizability of oral reading to the silent reading process--whether they are the same, indeed, whether or not oral and silent reading have access to the same linguistic competence--is a continuing debate (Groff, 1979).

Studies on the Relationship Between Reading Comprehension and Syntactic Structures

The second area of research that has investigated the relationship between grammatical structure and reading includes studies that have attempted, through various measures of comprehension, to determine the effect different

syntactic structures have on a sentence or a passage. Unlike those studies that used the eye-voice span as a measure, these studies are diversified in the tasks used to assess reading. However, there is a commonality among these studies in the sense that all of them have attempted to assess the effect syntactic structures have on a reader's comprehension of a specific material.

While it would be inaccurate to claim that interest in syntax or the complexities of language processing started with any one man, clearly Chomsky's (1957) theory of transformational-generative grammar served as a catalyst for new efforts in studying language-related fields including reading. Under the influence of Chomsky, the 1960s saw research in oral language development that suggested that language development was orderly and rule governed (e.g., Braine, 1963; Brown and Fraser, 1964; Stickland, 1962). These findings combined with those of oral reading studies (e.g., Clay, 1968, 1969; Goodman, 1968), which demonstrated that even young beginning readers brought syntactic knowledge to reading and that many of their oral reading errors were syntactically defensible. This served to spur interest in the question as to whether a child's knowledge of syntax in written materials was related to his knowledge and use of syntax within spoken language. At the same time, interest was also directed to the relationship between specific grammatical structures and comprehension.

The effect of having to decode unfamiliar structures was studied by Ruddell (1965) in younger children. Using the high and low frequency basic sentence patterns found by Stickland (1962) in the speech of elementary school children as a basis, materials were written in those patterns and given to fourth graders. Cloze procedures were used to measure comprehension of those materials. Significantly higher comprehension scores were obtained on materials that were written with high-frequency patterns of oral language structure than with less-commonly used patterns. Ruddell's findings were replicated by Tatham (1970) with second and fourth graders.

That sentence transformations—their very presence and type--can cause reading difficulty was demonstrated by Fagan (1971) who analyzed the kind and proportion of selected transformations in three basal reading series used in Canadian schools in grades four, five, and six. Within those passages analyzed, four major types of transformations were found: embedding; conjoining; deletion; and simple negative, passive, and question transformations. Based on his findings, Fagan wrote cloze passages and administered them to students in grades four, five, and six.

The data from these cloze passages revealed that embedding and deletion transformations caused more difficulty than the other types. Fagan also learned that type of transformations was more closely related to reading difficulty of the sentence than the number of transformations.

Furthermore, there was a consistent difficulty order for the types of difficult transformations over the three grades used in this study. Overall, Fagan found significant differences in the way students managed different types of structural complexities.

Albert Marcus (1969) hypothesized that the ability to extract the literal meaning from different sentence transformations may account for some comprehension difficulty. To test his hypothesis, he examined the ability of intermediate and junior high students to silently read and literally comprehend individual sentences, representing different syntactic structures. He developed a diagnostic test, A Test of Sentence Meaning, containing sentences and corresponding transformations that covered the four basic grammatical structures of structural linguistics: modification, prediction, complementation, and coordination. In a multiple choice format, 102 test items consisting of seventeen syntactic structures, covering each of the four basic grammatical structures, were constructed. The transformations included embedded sentences, passive transformations, reductions of coordinate and subordinate clauses, relocation of modifiers, and nominalizations. Vocabulary and sentence length were controlled as well as internal punctuation.

The resulting test items required that the reader be able to comprehend both the deep structure and the surface structure to respond correctly. The test was given to 421 students in grades five, six, seven, and eight in both

middle class and disadvantaged area schools. To control for possible confounding effects of poor word identification skills, all the subjects had been screened to assure that they possessed adequate word attack skills.

Test results indicated increasing skill in sentence comprehension by grade level. While on the basis of the findings no prediction as to exact order of difficulty for the various structures was possible, both the average number of items answered correctly and the mean percent for each of the seventeen structures increased from fifth to the eighth grade. Marcus' analysis of the data indicated difficulty comprehending such function words as prepositions, correlatives (conjunctions), and relative pronouns. Marcus also noted that embeddings in which the subordinate clause interrupted the normal subject-predicate order were more difficult to comprehend than complex sentences with an undisturbed normal pattern order of subject-predicate. While a direct comparison of Marcus' results and Fagans' is not possible, Marcus' findings that syntactic comprehension increased by grades and that some structures are easier to comprehend than others, especially embeddings, are consistent with those reported by Fagan.

A study by Bormuth, Manning, Carr, and Pearson (1970) supports the hypotheses that not only do syntactic structures affect comprehension, but also that specific syntactic structures differ in comprehension difficulty. In a detailed study they investigated three different categories

of syntactic forms' (intersentence, intrasentence, and anaphora) effects on comprehension. Materials containing structures from each of these three categories were constructed, consisting of twenty-five intrasentence structures, sixteen intersentence structures, and fourteen anaphoric types. Each of the target structures was embedded in a specially written paragraph. Comprehension for each construction was measured by a wh-type of open ended question immediately after each paragraph with the students' writing their answers. The only exceptions were the anaphoric constructions, which were tested by a multiple-choice format. The material was given to 240 fourth grade students in three semi-rural midwestern schools.

Reasoning that the percentages of students' responding correctly could be interpreted as an index of structural difficulty, the investigators found differences existed both among the categories and between the specific structures within the categories. Among the three categories, the intersentence comprehension questions were significantly more difficult than both the intrasentence and anaphoric structure questions. The differences between the anaphoric and intrasentence categories were not significant. Within each of the three categories, the differences existing between specific structures were all significant. However, the ordering of both the intersentence structures and the anaphoric constructions may have been the result of specific

questions, not necessarily differences in difficulty between constructions.

Bormuth, et al., concluded that the

> ...most startling result of the study was the fact that so many students in a population normally considered to have no serious achievement problems were unable to demonstrate a comprehension of the most basic syntactic structures (1970, p. 356).

They also noted that

> ...the major categories of structures may be hierarchically related, as shown by the fact that they differed in difficulty. This ordering of difficulty was roughly the same as one would derive from linguistic theory (1970, p. 356).

Bormuth, et al.'s study is reflective of much of the psycholinguistic research of the late 1970s and early 1970s. Not only was the study of syntax, specifically of a transformational nature, regarded as an important factor in the study of comprehension; but there was also the feeling that linguistic analysis combined with continued experimentation (much like the Bormuth, et al., study) would eventually result in the discovery of a hierarchy of structure difficulty much like the ones Bormuth and his colleagues projected (Carroll, 1972). However, this purely syntactic interpretation based on the form of a sentence alone was challenged by Alan Lesgold (1974) who questioned the validity of interpreting Bormuth, et al.'s results as only being reflective of difficulty of syntactic processing. Lesgold cautioned that the results might have been due to uncontrolled variance of imagery, semantic factors of the constructions, or

the paragraphs themselves rather than any inherent differences existing within the syntactic structures. The exact measuring of syntax by itself, he cautioned, might well be impossible. His study tends to support his hypothesis.

In a study designed as a follow-up to the Bormuth, et al., study (1970), Lesgold (1974) examined fourteen anaphoric constructions, nine of which were used in the Bormuth, et al., study with the following exceptions: (a) only anaphoric forms were measured; (b) the number of semantically plausible answers and positioning of the target structures within each passage were controlled and counterbalanced; (c) oral instead of written responses were elicited; and (d) the population, eighty third and fourth graders, was smaller. The results of the study resulted in a different difficulty ordering than that of the Bormuth, et al., study. Lesgold found that the difficulty ordering of anaphoric constructions was not stable and that the results of any orderings reflected semantic factors, not just knowledge of a particular structure alone.

Lesgold's questioning of a purely syntactic view of language processing is supported by an extensive study by P. David Pearson (1976). In this study, three theoretical positions on how linguistic variables might affect reading comprehension were determined. The first position was based on readability research. The second was a deep structure model based on transformational generative grammar.

The third position was the chunk model, which was semantic in nature and based on conceptual representational structures or semantic chunks. The differences between the readability and deep structure models on which structures would be hardest to comprehend were minimal.

The crucial differences were between the semantic and the deep structure models. These two models had dramatically opposed theoretical positions. What the chunk model predicted would be simple, the deep structure model predicted would be difficult. The deep structure predictions were based on the transformations necessary to go from the surface structure to the deep structure of a sentence. The chunk model predicted that semantic chunks rather than atomistic deep structure components constituted the language data which the mind processed. Comprehension was a process of synthesizing those semantic chunks together.

Pearson's study consisted of three separate experiments, two of which had three parts. The first experiment examined the effects syntactic complexity had on children's reading comprehension of causal and modifying relations through the use of wh-type questions. The second and third experiments were conducted to clarify certain ambiguous results of the first experiment. The second experiment examined children's preferences of syntactically different ways of expressing a common idea. The statements were read and ranked by children for simplicity and clarity of form. The third experiment examined the aided recall of causal

relations. Children read different syntactic forms; then, they retold what they had read with guided prompting to aid retelling. The retellings were analyzed to see whether a relationship existed between the retelling and the type of structure that had originally been read.

The results of the study in terms of gross right and wrong were not significant. However, when the answers were analyzed by the type of question read, a definite response pattern became apparent. These findings could best be explained by the chunk or semantic theory. Generally speaking, the way reading material is processed appears to begin with the semantic representation of the total relations involved rather than a syntactic description of the units. Comprehension appears to be more closely related to the semantic synthesis and integration existing within a sentence than to the syntactic form of the sentence. Pearson (1976) states that

> When the semantic relation is held constant and the test question is held constant and when the test question is relevant to the relation whose form is varied, either comprehension is equally efficient across forms or else the more subordinated and longer sentence forms elicit better comprehension (p. 99).

Pearson's study tends to discount syntax's role in reading. Caution should be taken, however, before generalizing from these findings that syntax or the form of the sentences does not affect reading comprehension. The results and conclusions of the Pearson study are not based on differences in the comprehension of structures but,

instead, on indications based on questions asked and retellings. Furthermore, the subjects used in this study were a stratified sample of average and above average readers from the third and fourth grades, a fact that limits the data's generalizability. However, what the Pearson and Lesgold studies together project is the inadequacy of viewing sentence processing as only involving the form of a structure.

In summation, the overall findings of those studies that have used various measures of comprehension are inconclusive and somewhat contradictory on the effect various syntactic structures have on reading comprehension. Research on syntactic variables has arrived at different difficulty ordering for syntactic structures, suggesting that an exact ordering of syntactic variables only based on the form of the structure might be impossible. Nevertheless, research seems to confirm that syntactic factors interact with semantic factors to affect reading comprehension. In addition, some structures, such as embeddings, appear to be consistently represented as being one of the more difficult structures to comprehend. The lack of consensus within these studies might have been due to the differing methodologies used to assess comprehension and the task differential existing between the measurements. A second possible explanation over the lack of consensus within these studies is that semantic factors within the various studies differed. Consequently, the results of the studies could

reflect a confounding of semantic and information factors. Therefore, it seems reasonable to investigate the interaction between semantic factors and syntactic structures and their effect on the processing of information involved in reading comprehension.

Studies on the Relationship Between Visual Processing Behavior and Syntactic Structures

The third area of research supporting an interrelationship between syntactic structures and reading comprehension are those studies that have analyzed eye movements during the reading of selected linguistic structures. As was reported in another section, the study of the relationship between reading ability and a reader's eye movements dates back to the turn of the century. This research has established that a relationship exists between cognitive processing and eye movement patterns. However, the research using eye movements to assess the effect of linguistic factors is sparse. Only recently has eye movement analysis been used to investigate the reading and processing of specific syntactic structures.

The first published analysis of eye movements to assess linguistic factors was done by Mehler, Bever, and Carey (1967) who examined the way linguistic units affected eye-fixation patterns. Graduate students read sentences which varied by ambiguity and were embedded at the end of a short passage. Ambiguity within the target sentences

existed at the surface level, surface and deep structure, and at the deep structure level only. The findings were that all three levels of ambiguity affected eye movement patterns. On the basis of their findings, Mehler, et al., formulated the general eye-fixation rule that the reader fixates on the first half of each constituent. Thus, the linguistically defined immediate constituent determines both the pattern and unit of fixation and, consequently, the processing of information when reading.

Mehler, et al.'s study was important in the sense that it was the first to attempt to measure linguistic factors and their effect on eye movement patterns; nevertheless, as Wanat (1976) points out, major limitations exist which limit the validity and generalizability of this study. First, in order to meet the criterion the authors established (correct comprehension of the ambiguous sentence), almost half of the original data was discarded. Secondly, no differentiation was made among regressions, forward fixations, or duration of fixation since only fixation points were considered. Finally, the ambiguous sentences used in the study are seldom encountered in normal reading situations. Consequently, the results of Mehler, et al.'s study may have been atypical.

Klein and Kurkowski (1974) compared the total number of eye movements required for the silent reading of right-branching and self-embedded sentences in isolation. The findings were that eye movements were

affected by both linguistic structure and mental set, supplied by a purpose question before reading. Unfortunately, only total movements were reported; and data were not given on fixations, regressions, or duration of fixation, thereby limiting an analysis of how linguistic structure affects processing. An additional limitation of this study is that the self-embedded sentences were contrived and seldom, if ever, encountered in normal reading situations.

Wanat (1976) demonstrated that eye movement patterns are affected by linguistic structure and supplied much of the existing information on mature readers' processing of linguistic structures. University students read different syntactic structures in isolation; half were read silently, half were read orally. Eye movement patterns were recorded and analyzed for fixations, regressions, the duration of each, and the locus of each. Significant differences were found to exist in the eye movement patterns of oral and silent reading and between linguistic structures. Among those significant differences, Wanat found that forward fixation time differentiated between left- and right-embedded sentences. This difference was attributed to the less predictable immediate constituent structure of the left-embedded. This finding agrees with data reported by Levin, Grossman, Kaplan, and Yang (1972) and tends to substantiate the findings of the eye-voice span studies.

Badar, Pearce, and Thompson (1980) examined mature readers' processing of left-embedded and right-embedded

sentences within an unrelated sentence condition and within a paragraph condition. As in the Wanat study, significant differences were found to exist between the left-embedded and right-embedded sentences in the amount of processing required. Significant differences were also found between the processing of structures embedded in unrelated sentences and structures within coherent discourse. Consequently, previous context, when that context is thematically related to the information within the target sentence, appears to influence and ease the processing of syntactic structures.

The generalizability of this study's findings concerning the effect of discourse on the processing of syntactic structures is currently limited to the finding that coherent discourse aided the processing of syntactic structures, but differences still existed in the visual processing of left- and right-embedded sentences. This study made no attempt to assess the effect of varied constraints within the discourse upon the processing of those syntactic structures. Therefore, unanswered questions remain concerning how passage factors affect the processing of syntactic structures and whether certain passage factors affect different syntactic structures equally.

In summary, studies have analyzed the effects of different syntactic structures on visual processing behavior during reading. While these studies are relatively few in number, they do tentatively support the finding of both the eye-voice span studies and those studies that have measured

the comprehension of different syntactic variables that certain syntactic structures are processed easier than other structures. Perhaps the most important aspect of this agreement is that eye movement analysis is a methodology that is not subject to the criticisms leveled against the eye-voice span studies or the limitations inherent within the task differential measurements used in the direct comprehension studies. At the same time, the limited number of studies that have analyzed visual processing behaviors during the reading of linguistic structures means that the generalizability of the findings of the existing research is limited. Furthermore, the scope of the existing studies is somewhat limited and different areas remain that need to be investigated. Among these areas is the need for studies examining the effect various information structures within the discourse and within the target structure themselves have on the cognitive processing of different syntactic structures.

Studies on the Relationship Between Information Structure and the Understanding of Sentences

Studies have been conducted in recent years that have examined specific information structures within a passage and a sentence and their relationships to the understanding of sentences. The most recent studies have accepted the given-new strategy as either part of the theoretical base or as an explanation for results. Beyond this there exists

a wide diversity in textual aspects examined or, more accurately, of the posited microprocesses studied. At the same time, the majority of the cited studies seems to fall into two general groupings: those that kept the target sentence constant and varied the preceding passage and those that systematically varied the target sentence.

Haviland and Clark (1974) in a series of three chronometric experiments investigated sentence understanding as a product of information in a preceding sentence. These three studies were conducted to specifically investigate their postulated given-new strategy. All three experiments consisted of presenting college students with pairs of sentences to read. Within these paired sentences, the first (the content sentence) always provided a context for the second (the target sentence). The sentences were presented sequentially on a screen. The subjects pressed a button to cause the sentences to appear and disappear. The first experiment presented pairs of context and target sentences where the target sentences always contained a definite noun phrase. In half the cases, the context sentence preceding the target sentence contained a direct antecedent that explicitly mentioned the noun phrase within the target sentence. An example of this condition, called the direct antecedent condition, is the following:

> We got some beer out of the trunk.
> The beer was warm.

In the other condition, called the indirect antecedent condition, the context sentence did not explicitly mention the noun phrase in the target sentence. An example is the following:

> We checked the picnic supplies.
> The beer was warm.

The critical variable within this experiment was the presence or absence of the direct antecedent within the context sentence and its effect on the comprehension of the target sentence. Sixteen paid university students were each given fifty-seven pairs of sentences, twenty-three practice trials followed by thirty-four test trials. The test trials consisted of half direct and half indirect pairs. Comprehension time was found to be significantly faster for target sentences when they were preceded by a direct antecedent than when they were preceded by an indirect antecedent.

The second experiment replicated the first experiment except that the context sentences in the indirect antecedent condition were altered. The context sentences were altered so the noun in the target sentence appeared in the context sentence but not in a way to introduce the existence of the specific noun in the target sentence. An example is the following:

> Ed wanted an alligator for his birthday.
> The alligator was his favorite present.

The rationale was that without an antecedent for "the alligator" the second sentence should take longer to read.

Furthermore, repetition of the critical noun in both the context sentence and the target sentence could be ruled out as the cause of the significant difference in the first experiment between the indirect antecedent condition and the direct antecedent condition. The results of this experiment were the same as those of the first experiment. Comprehension time for the target sentences was significantly faster for the target sentences when they were preceded by a direct antecedent than when they were preceded by an indirect antecedent.

The third experiment changed the referent of the context sentence from the noun of the target sentence to an adverb in the target sentence. The adverbs presupposed something had happened; that is, they presented given information. Besides the direct and indirect antecedent conditions in which the context sentence in the direct antecedent condition presented the given information and in the indirect antecedent condition in which specific information was not presented, a third condition with a negative context sentence was introduced. The target sentence was most quickly comprehended when preceded by a direct antecedent than when preceded by either an indirect antecedent or a negative comment.

Haviland and Clark (1974) contend that these studies support the notion that comprehension is at least partially a matter of integrating new information within a sentence into memory. When the previous sentence formed antecedent

information within the reader's memory matching the given information within the target sentence, then comprehension of that target sentence was easier. The other conditions required more processing because the given information within the target sentence was not as useful in identifying an appropriate antecedent memory. Aspects of these studies are significant for two reasons. First, they establish that preceding sentences do more than establish a general context effect. The information structure within a preceding sentence directly affects the speed of comprehension of a subsequent sentence. Secondly, the sentences used in these studies are simplistic and findings based on pairs of sentences, presented one at a time, are limited in their generalizability to processes involved in prose passages where the passages are either of unfamiliar content or of longer length. However, the psychological processes proposed should remain relatively constant. Consequently, predictions about the comprehension of sentences in other material can be made on the basis of preceding context and the information within the target sentence.

Carpenter and Just (1977b) have verified that given information within a sentence is a determining factor in speed of sentence comprehension by demonstrating that given information within a sentence is related to foregrounded information. Working from the premise that given information within a sentence facilitated sentence comprehension, they theorized that information incorrectly identified as given

should adversely affect sentence comprehension. To test this hypothesis, thirty-two paragraphs were constructed that shared certain structural properties. The opening sentence always described how a person interacted with some unspecified member of a group. The target sentence, which followed the opening sentence, always provided new information as to the identity of the member of the group. Cleft and pseudocleft sentences were used. The demarcation of the given information within the target sentence was varied while holding lexical content and information constant. Consequently, each target sentence identified given information that either matched or did not match the opening sentence. The relationship between the opening sentence of the paragraph and the target sentences was further manipulated by interposing zero to three related filler sentences between the opening sentence (with its given information) and the target sentence.

Twelve college students were used as subjects. A paragraph was presented on a screen, one sentence at a time; and the subject indicated whether that sentence contradicted any previous sentence within the paragraph by pushing a button. The next sentence in the paragraph would not appear until a judgment had been made. Response latency measures for the target sentences showed that readers took significantly less time to integrate the target sentence when its given-new structure matched the content of the opening sentence within the paragraph than to integrate target

sentences that did not match the opening sentence. Furthermore, some advantage was maintained for the information matching sentences regardless of how many filler sentences intervened between the opening sentence and the target sentence.

Carpenter and Just's finding provides specific data supporting the hypothesis that given information within a sentence is used to integrate new information into antecedent memories. In this study, the relevant preceding information was the same for the different paragraphs. What determined the speed of response was the relationship between the sentence being processed and the context to which the sentence referred. In other words, where the given information within the target sentence, or what the reader identified as the given information, matched foregrounded concepts, then there was quicker integration of sentence information and faster understanding of that sentence.

While the generalizability of Carpenter and Just's findings to sentences other than seldom encountered forms is limited, findings are consistent with the findings of other researchers. The finding that sentence response time, for both the matched and mismatched conditions, was fastest when there were no filler sentences agrees with Lesgold, Roth, and Curtis (1979) who found that foregrounding information facilitated sentence comprehension and that backgrounding information slowed sentence comprehension speed. Carpenter and Just's finding that given information caused

a sentence to be comprehended faster than new information is consistent with the findings of Haviland and Clark (1974) who found that a sentence with given information is comprehended faster than a sentence with no redundant or given information.

Certain aspects of the given-new strategy (and the paradigm suggested by Haviland and Clark), as well as other psychological processes posited to be involved in the integration and comprehension of information during reading, were investigated in a series of five experiments using prose material by Lesgold, Roth, and Curtis (1979). Working from the premise that within a reader's mind equal access does not exist for all antecedent memories, Lesgold, Roth, and Curtis posited that the integration of information (i.e., the given-new strategy) also requires a process of reinstating an existing antecedent memory back into active memory for the integration of information to occur. They investigated foregrounding and backgrounding of information while reading to study

> (a) what processes cause part of what is learned from a discourse to come into activated memory at a given point; (b) under what conditions those processes function; and (c) how the processing of a sentence differs as a function of whether that sentence refers to anything in activated memory (Lesgold, Roth, and Curtis, 1979, p. 292).

While the specific processes investigated are of minimal importance in terms of this review, this series of studies is important because of its results which support

the hypothesis that thematization and foregrounding of information immediately prior to a target sentence affects the speed of sentence comprehension.

The series of experiments, five in all, used chronometric measures of target sentence comprehension to examine specific aspects of foregrounding of information and its effect on the speed of target sentence comprehension. Controlling for passage differences, the response time of university students for target sentence comprehension was measured as a function of the preceding information within a passage. The passages used in all the experiments were coherent in nature; and the target sentence, which was held constant across all conditions, occurred at the end of each of the passages. The passages used in all the conditions, within all five experiments, were constructed so that the first sentence of the passage introduced a critical concept into the passage (the critical antecedent). This same critical antecedent occurred within the subsequent target sentence. The different conditions were achieved by varying the content between the introduction of the critical antecedent and that concept's final appearance in the target sentence. Some passages were constructed so they actively continued to refer to the context in which the critical antecedent was presented. Other passages introduced one or more related topics into the passage, thereby, presumably, removing the critical antecedent from the reader's active memory (backgrounding the concept). Those passages which

introduced related topics were also systematically varied. Some kept the critical antecedent backgrounded until the target sentence; others foregrounded the concept in the sentence immediately preceding the target sentence. The techniques used to foreground the critical antecedent were varied. The rationale was that since the target sentence was the same in the different conditions, sentence comprehension should be a product of the preceding context and the effectiveness of the various foregrounding techniques at reinstating the critical antecedent into memory.

The results of these experiements verified the hypothesis that target sentence comprehension time would vary according to the preceding passage. Target sentence comprehension time was significantly faster when the critical antecedent was foregrounded as opposed to being backgrounded. The introduction of related topics within a passage did not affect sentence comprehension time when the critical referent was reintroduced into the passage in the sentence preceding the target sentence. Comparing the effectiveness of various foregrounding techniques, Lesgold, et al., found that the subject of the target sentence appearing in the preceding sentence

> ...may result in a significant facilitation of target comprehension speed, similar to the facilitation produced by comprete repetition of the antecedent information (p. 299).

They agree with Haviland and Clark (1974) who found that mention of the specific noun in the preceding context sentence directly facilitated target sentence comprehension.

Two aspects of these studies merit additional discussion. The first of these involves a comparison of the results of Experiment 2 and Experiment 3. Experiment 2 had six conditions and resulted in target sentence comprehension speed scores for each of these conditions. Experiment 3 was conducted to determine whether only the sentence preceding the target sentence played a role in sentence comprehension and whether the ease with which a sentence was comprehended depended only on the relationship between the target sentence and its immediate predecessor. Measures of sentence understanding were obtained for each of the context conditions of Experiment 2 using the last sentence of each of the different conditions as a context for the target sentence. When the results of Experiment 3 were compared to the results of Experiment 2, there were differences in the time it took to read each sentence. This finding could be explained by each experiment's having a different population. However, the pattern of responses in Experiment 2 and in Experiment 3 also differed. The pattern of these differences suggest "...that more than the immediate preceding sentence influence comprehension time..." (Lesgold, Roth, and Curtis, 1979, p. 301). These results strongly suggest that the introduction and thematization of concepts

in preceding prose, as well as the immediate preceding sentence, directly affect sentence comprehension.

The second aspect involves part of Experiment 4 whose results directly support the given-new strategy. Various passages were modified by eliminating any prior introduction of direct antecedents for the given segment of the target sentence. This was done in two ways. First, all prior instances of the subject noun of the target sentence were eliminated. Secondly, the sentence preceding the target sentence, which served to foreground the information, was made more general and less directly relevant to the target. Therefore, within those modified passages, the subject of the target sentence could, according to the given-new strategy, only be tied to the passage content through a bridging inference. Mean response sentence comprehension speeds were obtained for the six foregrounding and backgrounding passages, which had not been modified, and for the modified passages. Comparisons of sentence comprehension speed for the "intact" passages and the "modified" passages clearly support the premise of inferencing with significantly more time's being required to read the target sentence prefaced by an indirect antecedent than the same sentence prefaced by an exact antecedent. This difference replicates Haviland and Clark's (1974) finding, except that this time the material involved was a preceding passage, not just a single preceding sentence.

The notion that thematization of information contained in a sentence within the preceding passage facilitates sentence comprehension is supported by Perfetti and Goldman (1975) who investigated the discourse functions of themization and topicalization on the recall of a sentence. Narrative passages were constructed, each of which concluded with a test sentence. Each of the test sentences contained a transitive verb and two nouns, for example "...the admiral captured the bandit." The narrative passages varied which of the two nouns from the test sentence had its referent more frequently involved in the preceding narrative (thematization). Consequently, a sentence could conclude two different passages, and those two different passages described the same event. They varied only in that one narrative contained more propositions about the thematized noun. The test sentences were also varied as to the semantic role of the nouns, i.e., whether the noun was an agent or recipient; and topicalization, i.e., whether the noun was a topic or comment. These narrative passages were given to college undergraduates to read. Target sentence retention was measured through the written recall to a noun prompt. The results upon analyzing the recalls showed that a word with a thematized referent was a better recall prompt than a word with a non-thematized referent. Also, an agent noun was a better prompt than a recipient.

To repeat, the method used by Perfetti and Goldman to measure sentence retention could limit the generalizability

of their findings to sentence comprehension. Their results could possibly be a manifestation of the mind's organizing acts for retelling and not an actual reflection of the information processing involved in the comprehension of the test sentences. The results of this study are not in and of themselves proof that either thematization within a passage or topicality within the sentence affects the understanding or processing of a sentence when that sentence is being read. However, the results are consistent with the findings of Lesgold, Roth, and Curtis (1979) who found that foregrounding the information within a sentence (which can be a form of thematization) increased the speed of sentence comprehension.

In summary, the studies discussed in this section indicate that information structure within the preceding passage, and within the target sentence itself, influences sentence comprehension. Unfortunately, the number of studies that have investigated the effect of textual information are very few, a fact which precludes firm conclusions as to sentence comprehension, discourse variables, or the adequacy of the postulated psychological process. At the same time, the existing research seems consistent in the sense that all of the reported findings support the posited given-new strategy. Specifically, it appears that explicit redundant information within a reading passage facilitates sentence comprehension. Further, structuring prior discourse so a

concept is actively foregrounded, as opposed to being backgrounded, facilitates sentence comprehension.

CHAPTER III

METHODOLOGY OF THE STUDY

The content of this chapter describes the methodology employed in conducting this study. This chapter will be presented in seven major sections. First, a description of the sample subjects used in the experiment will be given. Second, the materials used will be described. Third, the apparatus used to collect data will be given. The fourth section will specify the procedures used in data collection. The fifth section will discuss the study's design. The sixth section will present the hypotheses being examined. The last section will discuss the data analysis. A summary of the chapter will be included.

Population

The sample subjects used in this study consisted of thirty-six volunteer adult university graduate students at Michigan State University. All participants were native English speakers.

Materials

Materials used in this study consisted of thirty-six separate paragraphs. Each paragraph was constructed around a target sentence. There were six target sentences, each of which had a left-embedded form and a right-embedded form.

The six pairs of target sentences (left-embedded form and right-embedded form) were of the same length (nine words), were of active voice, and employed no dependent clauses with the exception of the target embedding. Each of the target sentences was set in three conditions of short paragraphs. The first condition consisted of paragraphs that explicitly introduced, thematized, and foregrounded the information in the target sentence (called the foregrounded condition). These paragraphs were ten lines in length, and the target sentence always appeared on the eighth line. The second condition consisted of paragraphs that were identical to the foregrounded paragraphs; however, two sentences of semantically neutral filler to background the concepts in the target sentence were introduced immediately prior (lines eight and nine) to the target sentence (called the backgrounded condition). These backgrounded paragraphs were twelve lines in length, and the target sentence always appeared on the tenth line. The third condition consisted of paragraphs that were coherent in nature; however, no information within the target sentence was explicitly introduced prior to the target sentence (called the inferred condition). The thirty-six paragraphs consisted of six foregrounded, left-embedded paragraphs; six foregrounded, right-embedded paragraphs; six backgrounded, left-embedded paragraphs; six backgrounded, right-embedded paragraphs; six inferred, left-embedded paragraphs; and six inferred, right-embedded paragraphs.

Each of the thirty-six paragraphs used in this study had been evaluated by two judges before being used in the study. The two judges were both doctoral students in reading. Each paragraph had been evaluated for the following criteria: (a) that it met the requirements of its treatment condition, (b) that it was written on a topic that could be presumed to be familiar to Michigan residents, and (c) that it was written using vocabulary that a sixth grade student could be presumed to know and be able to successfully read.

Apparatus

The paragraphs were typed in IBM pica, single spaced type on 3½x5" cards and presented with the EDL/Biometrics Reading Eye II, an electronic instrument that employs a photoelectric method to record eye movements on heat sensitive graph paper. The heat sensitive graph paper was scored for the visual processing data.

Procedure

The subjects were tested individually. The subjects were read a prepared set of instructions informing them of the general operation of the Reading Eye II (see Appendix C). They were told that they would be asked to read several different selections during the recording process. They were instructed to read naturally and to pay attention to the material on the cards so that they might be able to paraphrase the selections afterwards. The subjects were not asked to paraphrase; the instructions were used to focus the attention of the subjects on the task.

After the subjects' eyes were aligned properly, they were instructed to close their eyes after finishing reading a selection. The experiment included seven reading selections: an EDL paragraph; a foregrounded, left-embedded paragraph; a foregrounded, right-embedded paragraph; a backgrounded, left-embedded paragraph; a backgrounded, right-embedded paragraph; an inferred, left-embedded paragraph; and an inferred, right-embedded paragraph. At the conclusion of the experiment, subjects were asked whether they encountered any reading difficulties or whether they reread any portion of the seven selections. Their responses were recorded.

Design

The basic design of the study consisted of six, 6x6 Latin squares. Each of the six Latin squares was constructed in the following manner. The horizontal dimension contained the six target sentences. The vertical dimension was a list of six subjects. The numbers one through six in each row indicated the order of the key sentences with the following coding scheme:

1. Left-embedded: The quarterback that Detroit needed won the final game.
   Right-embedded: The quarterback won the final game that Detroit needed.

2. Left-embedded: The snow that skiers wanted permitted the downhill race.
   Right-embedded: The snow permitted the downhill race that skiers wanted.

3. Left-embedded: The rain that farmers needed saved the corn crops.
   Right-embedded: The rain saved the corn crop that farmers needed.

4. Left-embedded: The company that students opposed halted the strip mining.
   Right-embedded: The company halted the strip mining that students opposed.

5. Left-embedded: The Indians that fishermen opposed halted the gill netting.
   Right-embedded: The Indians halted the gill netting the fishermen opposed.

6. Left-embedded: The blonde that Mike left took the payroll money.
   Right-embedded: The blonde took the payroll money that Mike left.

An example of one of the Latin squares is as follows:

Subject	Sentence Order
1	1,3,5,6,4,2
2	3,1,6,5,2,4
3	5,6,4,2,1,3
4	6,5,2,4,3,1
5	4,2,1,3,6,5
6	2,4,3,1,5,6

(See Dines and Keedwell, 1974, pp. 130-137, for the actual Latin squares used.) The order of sentence presentation varied for each subject. For example, for subject #1 the order was 1,3,5,6,4,2. This means that subject read key sentence 1 first ("The quarterback..."), then key sentence 3 ("The rain..."), then key sentence 5, etc.

A second counterbalanced 6x6 Latin square was superimposed on the basic design. Within the second 6x6 Latin square, the horizontal dimension consisted of the six paragraph conditions. The numbers one through six in each row indicated the order of the paragraph conditions with the following coding scheme:

1. Foregrounded, left-embedded
2. Foregrounded, right-embedded

3. Backgrounded, left-embedded
4. Bakcgrounded, right-embedded
5. Inferred, left-embedded
6. Inferred, right-embedded

The vertical dimension was labeled one through six, with the number one's referring to the first Latin square of the basic design, the number two's referring to the second Latin square of the basic design, etc. The entries in each row of the second counterbalanced Latin square represented the order of presentation of the paragraph conditions for the Latin square of the basic design corresponding to that row (see Table 3.1 for an example of the second counterbalanced Latin squre). For example, within the first row of the

Table 3.1. Second Counterbalanced Latin Square.[a]

Latin Squares of the Basic Design	Conditions					
	FL	FR	BL	BR	IL	IR
First Latin Square	1	2	6	3	5	4
Second Latin Square	2	3	1	4	6	5
Third Latin Square	3	4	2	5	1	6
Fourth Latin Square	4	5	3	6	2	1
Fifth Latin Square	5	6	4	1	3	2
Sixth Latin Square	6	1	5	2	4	3

[a]The numbered entries in this Latin square represent the order of presentation.

KEY: FL Foregrounded, left-embedding
FR Foregrounded, right-embedding
BL Backgrounded, left-embedding
BR Backgrounded, right-embedding
IL Inferred, left-embedding
IR Inferred, right-embedding

second counterbalanced Latin square, the order was 1,2,6,3, 5,4. This means that the six subjects who comprised the first Latin square of the basic design were given the paragraph conditions in the following order: foregrounded, left-embedded; foregrounded, right-embedded; inferred, right-embedded; backgrounded, left-embedded; inferred, left-embedded; and backgrounded, right embedded. This design controlled for an order or presentation effect by guaranteeing that each six subjects received the paragraph conditions in a different order.

The final design then controlled for order of presentation of paragraph conditions and the differences in the content sentences. Each of the key sentences was read an equal number of times in each of the conditions. The order of presentation of the target sentences was systematically varied. The treatment by subject design is presented in Appendix B.

Hypotheses

1. There will be no difference in the visual processing of target sentences among the six conditions.
2. There will be no difference in the visual processing of left- and right-embedded structures in the foregrounded conditions.

3. There will be no difference in the visual processing of left- and right-embedded structures in the backgrounded conditions.
4. There will be no difference in the visual processing of left- and right-embedded structures in the inferrred conditions.
5. There will be no difference in the visual processing of right-embedded structures in the foregrounded condition and right-embedded structures in the backgrounded condition.
6. There will be no difference in the visual processing of left-embedded structures in the foregrounded condition and left-embedded structures in the backgrounded condition.
7. There will be no difference in the visual processing of left-embedded structures in the foregrounded condition and right-embedded structures in the backgrounded condition.
8. There will be no difference in the visual processing of left-embedded structures in the backgrounded condition and right-embedded structures in the foregrounded condition.
9. There will be no difference in the visual processing of right-embedded structures in the foregrounded condition and right-embedded structures in the inferred condition.

10. There will be no difference in the visual processing of left-embedded structures in the foregrounded condition and left-embedded structures in the inferred condition.
11. There will be no difference in the visual processing of left-embedded structures in the foregrounded condition and right-embedded structures in the inferred condition.
12. There will be no difference in the visual processing of left-embedded structures in the inferred condition and right-embedded structures in the foregrounded condition.
13. There will be no difference in the visual processing of right-embedded structures in the backgrounded condition and right-embedded structures in the inferred condition.
14. There will be no difference in the visual processing of left-embedded structures in the backgrounded condition and left-embedded structures in the inferred condition.
15. There will be no difference in the visual processing of left-embedded structures in the backgrounded condition and right-embedded structures in the inferred condition.
16. There will be no difference in the visual processing of left-embedded structures in the

inferred condition and right-embedded structures in the backgrounded condition.

Data Analysis

The data were analyzed for statistical significance by using analysis of variance, subprogram MANOVA of SPSS (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975) as adapted for use on the CDC 750 computer at Michgan State University. The variables that reached significance were examined using Tukey's post hoc procedure.

The independent variables are the foregrounded, left-embedded condition; foregrounded, right-embedded condition; backgrounded, left-embedded condition; backgrounded, right-embedded condition; inferred, left-embedded condition; and inferred, right-embedded condition. The dependent variables are the visual processing behaviors which include total number of fixations, number of forward fixations, number of regressions, duration of forward fixations, duration of regressions, gaze duration, and total reading time.

Summary

This chapter has described the methods and procedures used in the study.

The eye movements of competent adult readers were recorded while the subjects read paragraphs with left- and right-embedded sentences in foregrounded, backgrounded, and inferred conditions. Their performance on target

sentences was to be analyzed and compared to determine whether it varied by syntactic structure or paragraph condition.

The eye movements were photographed with the EDL/Biometrics Reading Eye II, and the materials used in the machine were thirty-six paragraphs. Each paragraph was typed in IBM pica type on a 3½x5" card.

The statistical procedures were designed in association with the research consultants at Michigan State University. In Chapter IV, the data are presented, analyzed, and organized.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Introduction

The purpose of the study was to obtain and analyze data concerning the visual processing of left- and right-embedded structures in foregrounded paragraphs, backgrounded paragraphs, and inferred paragraphs by competent adult readers. The areas of examination focus on the effect on information within discourse in processing left- and right-embedded structures.

The methodology for the collection and treatment of data was described in the previous chapter. This chapter will present the statistical analysis of the findings as they relate to the hypotheses constructed for the study.

Hypotheses and Statistical Tests

The data concerning the visual processing behaviors of competent adult readers were analyzed using analysis of variance, subprogram MANOVA (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975). The data from each of the seven component measures of visual processing were analyzed separately. The variables that reached significance were examined using Tukey's post hoc procedure.

Hypothesis 1

Ho 1: There will be no difference in the visual processing of target sentences in the six conditions.

The hypothesis was tested with an analysis of variance for each dependent variable (see Table 4.1).

Table 4.1. Analysis of Variance of Differences in the Visual Processing of the Target Sentences Among the Six Conditions.[a]

Dependent Variables	df	MS	F	P
Total Number of Fixations				
C	5	36.3629	7.915	<.01
O	5	21.37407		
I:O	30	13.75556		
CXO	25	4.594074		
Residual	120	4.30833		
Number of Forward Fixations				
C	5	10.86018	6.7400	<.01
O	5	9.91574		
I:O	30	6.80833		
CXO	25	1.61129		
Residual	120	1.80278		
Number of Regressions				
C	5	8.11574	2.9450	<.05
O	5	3.42685		
I:O	30	4.17130		
CXO	25	2.75574		
Residual	120	1.59074		
Duration of Forward Fixations				
C	5	47.5638	5.0561	<.01
O	5	19.33894		
I:O	30	38.28630		
CXO	25	9.40213		
Residual	120	8.25351		

Dependent Variables	df	MS	F	P
Duration of Regressions				
C	5	26.11435	4.6990	<.01
O	5	11.85532		
I:O	30	13.20370		
CXO	25	5.55740		
Residual	120	4.03721		
Duration of Gaze				
C	5	140.671	8.9163	<.01
O	5	55.601		
I:O	30	71.55639		
CXO	25	15.77688		
Residual	120	13.92400		
Total Reading Time				
C	5	272.9039	8.3129	<.01
O	5	170.09005		
I:O	30	128.31435		
CXO	25	32.828935		
Residual	120	23.816785		

[a]Six conditions are foregrounded, left-embedded; foregrounded, right-embedded; backgrounded, left-embedded; backgrounded, right-embedded; inferred, left-embedded; inferred, right-embedded.

KEY: C Conditions
O Order
I Individuals

The data indicated that there were significant differences in the visual processing of the syntactic structures in the six conditions. These differences occurred in total number of fixations, $F=7.915$, $p < .01$, number of forward fixations, $F=6.4700$, $p < .01$, number of regressions, $F=5.0561$, $p < .01$, duration of regressions, $F=4.6990$, $p < .01$, duration of gaze, $F=8.9163$, $p < .01$, and total reading time,

F=8.3129, $p < .01$. The differences justified rejecting Hypothesis 1. The significant differences for each of the visual processing behaviors justified comparing the visual processing for each of the six conditions with each other using Tukey's post hoc procedure.

Hypothesis 2

Ho 2: There will be no difference in the visual processing of left- and right-embedded structures in the foregrounded conditions.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.2).

Table 4.2. Tukey's Post Hoc Procedure: Visual Processing of Left- and Right-Embedded Structures in Foregrounded Conditions.

Variables	FL:M	FR:M	Difference	q
Number of Total Movements	9.5556	8.1389	1.4167	(-.0694, 2.9028)
Number of Forward Fixations	7.3611	6.6667	.6944	(-.7135, 1.5745)
Number of Regressions	2.1944	1.4722	.7222	(-.6187, 2.1221)
Duration of Forward Fixations	11.5833	9.6389	1.9444	(-.1821, 4.0709)
Duration of Regressions	2.8958	1.7083	1.1875	(-.4470, 2.8220)
Duration of Gaze	14.4792	11.3472	3.1320	(.3781, 5.8859)*
Total Reading Time	21.7500	17.6181	4.1319	(.1593, 8.1045)*

*$p < .05$

The data indicated there were significant differences in the visual processing of left- and right-embedded structures in the foregrounded conditions. The differences occurred in the areas of duration of gaze, q=(.3781, 5.8859), $p < .05$, and total reading time, q=(.1593, 8.1045), $p < .05$. On the basis of the data, Hypothesis 2 was rejected.

Hypothesis 3

Ho 3: There will be no difference in the visual processing of left- and right-embedded structures in backgrounding conditions.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.3).

Table 4.3. Tukey's Post Hoc Procedure: Visual Processing of Left- and Right-Embedded Structures in Backgrounded Conditions.

Variables	BL:M	BR:M	Difference	q
Number of Total Movements	9.2500	8.5556	.6944	(-.7917, 2.1805)
Number of Forward Fixations	7.0000	6.8333	.1667	(-.7134, 1.0468)
Number of Regressions	2.2500	1.7222	.5278	(-.16231, 1.6787)
Duration of Forward Fixations	10.9154	10.3153	.6762	(-1.4503, 2.8027)
Duration of Regressions	3.2292	2.1667	1.0625	(-.5720, 2.6370)
Duration of Gaze	14.1806	12.4819	1.6987	(-1.0552, 4.4526)
Total Reading Time	21.0903	17.6181	3.4722	(-.5004, 7.4448)

There were no significant differences in the visual processing of left- and right-embedded structures in backgrounded conditions. On the basis of the data, Hypothesis 3 was not rejected.

Hypothesis 4

Ho 4: There will be no difference in the visual processing of left- and right-embedded structures in inferrred conditions.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.4).

Table 4.4. Tukey's Post Hoc Procedure: Visual Processing of Left- and Right-Embedded Structures in Inferred Conditions.

Variables	IL:M	IR:M	Difference	q
Number of Total Movements	11.000	9.7778	1.222	(-.2639, 2.7083)
Number of Forward Fixations	8.1944	7.4167	.7777	(-.1024, 1.6578)
Number of Regressions	2.8056	2.3611	.4445	(-.7064, 1.5955)
Duration of Forward Fixations	12.9375	11.6042	1.3333	(-.7932, 3.4598)
Duration of Regressions	4.1111	3.2083	.9028	(-.7317, 2.5373)
Duration of Gaze	17.0486	14.8125	2.2361	(-.5178, 4.9900)
Total Reading Time	25.6389	22.6319	3.0070	(-.9656, 6.9796)

There were no significant differences in the visual processing of left- and right-embedded structures in inferred conditions. On the basis of the data, Hypothesis 4 was not rejected.

Hypothesis 5

Ho 5: There will be no differences in the visual processing of right-embedded structures in the foregrounded condition and right-embedded structures in the backgrounded condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.5).

Table 4.5. Tukey's Post Hoc Procedure: Visual Processing of Foregrounded Right-Embedded Structures and Backgrounded Right-Embedded Structures.

Variables	BR:M	FR:M	Difference	q
Number of Total Movements	8.5556	8.1389	.4167	(-1.0694, 1.9028)
Number of Forward Fixations	6.8333	6.6667	.1666	(- .7135, 1.0467)
Number of Regressions	1.7222	1.4722	.2500	(- .9009, 1.4009)
Duration of Forward Fixations	10.3153	9.6389	.6764	(-1.4501, 2.8029)
Duration of Regressions	2.1667	1.7083	.4574	(-1.1771, 2.0919)
Duration of Gaze	12.4819	11.3472	1.1347	(-1.6192, 3.8886)
Total Reading Time	19.4236	17.6181	1.8055	(-2.1671, 5.7781)

There were no significant differences in the visual processing of right-embedded structure in the foregrounded condition and right-embedded structures in the backgrounded condition. Hypothesis 5 was not rejected.

Hypothesis 6

Ho 6: There will be no difference in the visual processing of left-embedded structures in foregrounded condition and left-embedded structures in backgrounded condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.6).

Table 4.6. Tukey's Post Hoc Procedure: Visual Processing of Foregrounded Left-Embedded Structures and Backgrounded Left-Embedded Structures.

Variables	FL:M	BL:M	Difference	q
Number of Total Movements	9.5556	9.2500	.3056	(-1.1805, 1.7917)
Number of Forward Fixations	7.3611	7.0000	.3611	(- .5190, 1.2134)
Number of Regressions	2.1944	2.2500	.0556	(-1.0953, 1.2065)
Duration of Forward Fixations	11.5833	10.9154	.6679	(-1.4586, 2.7944)
Duration of Regressions	2.8958	3.2292	.3334	(-1.3011, 1.9679)
Duration of Gaze	14.4792	14.1806	.2986	(-2.4553, 3.0525)
Total Reading Time	21.7500	21.0903	.6597	(-3.3129, 4.6323)

There were no significant differences in the visual processing of foregrounded, left-embedded structures and backgrounded, left-embedded structues. On the basis of the data, Hypothesis 6 was not rejected.

Hypothesis 7

Ho 7: There will be no difference in the visual processing of left-embedded structues in the foregrounded condition and right-embedded structures in the backgrounded condition.

The hypothesis was tested using Tukey's post hoc procedures (see Table 4.7).

Table 4.7. Tukey's Post Hoc Procedure: Visual Processing of Foregrounded Left-Embedded Structures and Backgrounded Right-Embedded Structures.

Variables	FL:M	BR:M	Difference	q
Number of Total Movements	9.5556	8.5556	1.000	(- .4861, 2.4861)
Number of Forward Fixations	7.3611	6.8333	.5278	(- .3523, 1.4079)
Number of Regressions	2.1944	1.7222	.4722	(- .6787, 1.0231)
Duration of Forward Fixations	11.5833	10.3153	1.2680	(- .8585, 3.3945)
Duration of Regressions	2.8958	2.1667	.7291	(- .9054, 2.3636)
Duration of Gaze	14.4792	12.4819	1.9973	(- .7566, 4.7512)
Total Reading Time	21.7500	19.4236	2.3264	(-1.6462, 6.2950)

There were no significant differences in the visual processes of left-embedded structures in the foregrounded condition and right-embedded structures in the backgrounded condition. On the basis of the data, Hypothesis 7 was not rejected.

Hypothesis 8

Ho 8: There will be no significant difference in the visual processing of left-embedded structures in the backgrounded condition and right-embedded structures in the foregrounded condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.8).

Table 4.8. Tukey's Post Hoc Procedure: Visual Processing of Backgrounded Left-Embedded Structures and Foregrounded Right-Embedded Structures.

Variables	BL:M	FR:M	Difference	q
Number of Total Movements	9.2500	8.1389	1.1111	(-.3750, 2.5972)
Number of Forward Fixations	7.000	6.6667	.3333	(-.5468, 1.2134)
Number of Regressions	2.2500	1.4722	.7778	(-.3731, 1.9287)
Duration of Forward Fixations	10.9154	9.6389	1.2765	(-.8500, 3.403)
Duration of Regressions	3.2292	1.7083	1.5209	(-.1136, 3.1554)

Variables	BL:M	FR:M	Difference	q
Duration of Gaze	14.1806	11.3472	2.8334	(.0795, 5.5873)*
Total Reading Time	21.0903	17.6181	3.4722	(-.5004, 7.4448)

* $p < .05$

The data indicated there was a significant difference in the visual processing of left-embedded structures in the backgrounded condition and right-embedded structures in the foregrounded condition. This difference occurred in the area of duration of gaze, q= (.0795, 5.5873), $p < .05$. This difference justified rejecting Hypothesis 8.

Hypothesis 9

Ho 9: There will be no difference in the visual processing of right-embedded structure in the foregrounded condition and right-embedded structures in the inferred condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.9).

Table 4.9. Tukey's Post Hoc Procedure: Visual Processing of Foregrounded Right-Embedded Structures and Inferred Right-Embedded Structures.

Variables	IR:M	FR:M	Difference	q
Number of Total Movements	9.7778	8.1389	1.6389	(.1528, 3.125) *
Number of Forward Fixations	7.4167	6.6667	.7500	(-.1301, 1.6301)

Variables	IR:M	FR:M	Difference	q
Number of Regressions	2.3617	1.4722	.8889	(-.2620, 2.0398)
Duration of Forward Fixations	11.6042	9.6389	1.9653	(-.1612, 4.0918)
Duration of Regressions	3.2083	1.7083	1.5000	(-.1345, 3.1345)
Duration of Gaze	14.8125	11.3472	3.4653	(.7114, 6.2192)*
Total Reading Time	22.6319	17.6181	5.0138	(1.0412, 8.9864)*

*$p < .05$

The data indicated there were significant differences in the visual processing of right-embedded structures in the foregrounding condition and right-embedded structures in the inferred condition. The difference occurred in the areas of number of total movements, $q=(.1528, 3.125)$, $p < .05$, duration of gaze, $q=(.7114, 6.292)$, $p < .05$, and total reading time, $q=(1.0412, 8.9864)$, $p < .05$. Therefore, Hypothesis 9 was rejected.

Hypothesis 10

Ho 10: There will be no difference in the visual processing of left-embedded structures in the foregrounded condition and left-embedded structures in the inferred condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.10).

Table 4.10. Tukey's Post Hoc Procedure: Visual Processing of Foregrounded Left-Embedded Structures and Inferred Left-Embedded Structures.

Variables	IL:M	FL:M	Difference	q
Number of Total Movements	11.000	9.5556	1.4444	(-.0417, 2.9305)
Number of Forward Fixations	8.1944	7.3611	.8333	(-.0468, 1.7234)
Number of Regressions	2.8056	2.1944	.6112	(-.5397, 1.7621)
Duration of Forward Fixations	12.9375	11.5833	1.3542	(-.7723, 3.4807)
Duration of Regressions	4.1111	2.8958	1.2153	(-.4192, 2.8498)
Duration of Gaze	17.0486	14.4792	2.5694	(-.1845, 5.3233)
Total Reading Time	25.6389	21.7500	3.8889	(-.0837, 7.8615)

The data indicated there were no significant differences in the visual processing of left-embedded structures in the foregrounded condition and left-embedded structures in the inferred condition. Hypothesis 10 was not rejected.

Hypothesis 11

Ho 11: There will be no difference in the visual processing of foregrounded, left-embedded structures and inferred, right-embedded structures.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.11).

Table 4.11. Tukey's Post Hoc Procedure: Visual Processing of Foregrounded Left-Embedded Structures and Inferred Right-Embedded Structures.

Variables	FL:M	IR:M	Difference	q
Number of Total Movement	9.5556	9.77778	.2222	(-1.2639, 1.7083)
Number of Forward Fixations	7.3611	7.4167	.0556	(.8245, .9351)
Number of Regressions	2.1944	2.3611	.1667	(- .9842, 1.3176)
Duration of Forward Fixations	11.5833	11.6042	.0209	(-2.1056, 2.1474)
Duration of Regressions	2.8958	3.2083	.3125	(-1.322, 1.9470)
Duration of Gaze	14.4792	14.8125	.3333	(-2.4206, 3.0872)
Total Reading Time	21.7500	22.6319	.8815	(-3.0911, 4.8545)

The data indicated there were no significant differences in the visual processing of left-embedded structures in the foregrounded condition right-embedded structures in the inferred condition. Hypothesis 11 was not rejected.

Hypothesis 12

Ho 12: There will be no difference in the visual processing of left-embedded structures in the inferred

condition and right-embedded structures in the foregrounded condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.12).

Table 4.12. Tukey's Post Hoc Procedure: Visual Processing of Inferred Left-Embedded Structures and Foregrounded Right-Embedded Structures.

Variables	IL:M	FR:M	Difference	q
Number of Total Movements	11.000	8.1389	2.8611	(1.3750, 4.3472)*
Number of Forward Fixations	8.1944	6.6667	1.5277	(.6476, 2.4078)*
Number of Regressions	2.8056	1.4722	1.3334	(1.1825, 2.4843)*
Duration of Forward Fixations	12.9375	9.6389	3.2986	(1.1721, 5.4251)*
Duration of Regressions	4.1111	1.7083	2.4028	(.7683, 4.0373)*
Duration of Gaze	17.0486	11.3472	5.7014	(2.9475, 8.4653)*
Total Reading Time	25.6389	17.6181	8.0208	(4.0482, 11.9934)*

* $p < .05$

The data indicated there were significant differences in the visual processing of left-embedded structures in the inferred conditionand right-embedded structures in the foregrounded condition. These differences occurred in total movements, q=(1.3750, 4.3472), $p < .05$, number of forward fixations, q=(.6476, 2.4078), $p < .05$, number of

regressions, q=(.1825, 2.4843), p <.05, duration of forward fixations, q=(1.1721, 5.4251), p <.05, duration of regressions, q=(.7683, 4.0373), p <.05, duration of gaze, q=(2.9475, 8.4553), p <.05, and total reading time, q=(4.0482, 11.9934), p <.05. On the basis of the data, Hypothesis 12 was rejected.

Hypothesis 13

Ho 13: There will be no difference in the visual processing of right-embedded structures in the backgrounded condition and right-embedded structures in the inferred condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.13).

Table 4.13. Tukey's Post Hoc Procedure: Visual Processing of Inferred Right-Embedded Structures and Backgrounded Right-Embedded Structures.

Variables	IR:M	BR:M	Difference	q
Number of Total Movement	9.7778	8.8856	.8922	(-.5939, 2.3783)
Number of Forward Fixations	7.4167	6.8333	.5834	(-.2967, .9357)
Number of Regressions	2.3611	1.7222	.6389	(-.5120, 1.7898)
Duration of Forward Fixations	11.6042	10.3153	1.2889	(-.8376, 3.4154)
Duration of Regressions	3.2083	2.1667	1.0416	(-.5929, 2.6761)

Variables	IR:M	BR:M	Difference	q
Duration of Gaze	14.8125	12.4819	2.3306	(-.4233, 5.0845)
Total Reading Time	22.6319	19.4236	3.2083	(-.7643, 7.1809)

There were no significant differences in the visual processing of right-embedded structures in the backgrounded condition and right-embedded structures in the inferred condition. Hypothesis 13 was not rejected.

Hypothesis 14

Ho 14: There will be no difference in the visual processing of left-embedded structures in the backgrounded condition and left-embedded structues in the inferred condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.14).

Table 4.14. Tukey's Post Hoc Procedure: Visual Processing of Backgrounded Left-Embedded Structures and Inferred Left-Embedded Structures.

Variables	IL:M	BL:M	Difference	q
Number of Total Movements	11.000	9.2500	1.7500	(.9583, 3.9305)*
Number of Forward Fixations	8.1944	7.0000	1.1944	(-.3143, 2.0745)*
Number of Regressions	2.8056	2.2500	.5556	(-.5953, 1.7065)
Duration of Forward Fixations	12.9375	10.9514	1.9861	(-.1404, 4.1126)

Variables	IL:M	BL:M	Difference	q
Duration of Gaze	17.0486	14.1806	2.8680	(.1141, 5.6219)*
Total Reading Time	25.6389	21.0903	4.5486	(.5760, 8.5212)*

*$p < .05$

The data indicated there were significant differences in the visual processing of left-embedded structures in the backgrounded condition and left-embedded structures in the inferred structures. The differences occurred in the areas of number of total movements, $q=(.9583, 3.9305)$, $p < .05$, number of forward fixations, $q=(.3413, 2.0745)$, $p < .05$, duration of gaze, $q=(.1141, 5.6219)$, $p < .05$, and total reading time, $q=(.5760, 8.5212)$, $p < .05$. Therefore, Hypothesis 14 was rejected.

Hypothesis 15

Ho 15: There will be no difference in the visual processing of left-embedded structures in the backgrounded condition and right-embedded structues in the inferred condition.

The hypothesis was tested using Tukey's post hoc procedure.

Table 4.15. Tukey's Post Hoc Procedure: Visual Processing of Backgrounded Left-Embedded Structures and Inferred Right-Embedded Structures.

Variables	BL:M	IR:M	Difference	q
Number of Total Movements	9.2500	9.7778	.5278	(- .9583, 2.0139)
Number of Forward Fixations	7.0000	7.4167	.4167	(- .4634, 1.3268)
Number of Regressions	2.2500	2.3611	.1111	(-1.0398, 1.2620)
Duration of Forward Fixations	10.9514	11.6042	.6528	(-1.4737, 2.7793)
Duration of Regressions	3.2292	3.2083	.0209	(-1.6136, 1.6554)
Duration of Gaze	14.1806	14.8125	.6319	(-2.1220, 3.3858)
Total Reading Time	21.0903	22.6319	1.5416	(-2.4310, 5.5142)

The data indicated there were no significant differences in the visual processing of left-embedded structures in the backgrounded condition and right-embedded structures in the inferred condition. Therefore, Hypothesis 15 was not rejected.

Hypothesis 16

Ho 16: There will be no difference in the visual processing of left-embedded structures in the inferred condition and right-embedded structures in the backgrounded condition.

The hypothesis was tested using Tukey's post hoc procedure (see Table 4.16).

Table 4.16. Tukey's Post Hoc Procedure: Visual Processing of Inferred Left-Embedded Structures and Backgrounded Right-Embedded Structures.

Variables	IL:M	BR:M	Difference	q
Number of Total Movements	11.0000	8.5556	2.4444	(.9583, 3.3905)*
Number of Forward Fixations	8.1944	6.8333	1.3611	(.4810, 2.2412)*
Number of Regressions	2.8056	1.7222	1.0834	(-.0675, 2.2343)
Duration of Forward Fixations	12.9375	10.3153	2.6222	(.4957, 4.7487)*
Duration of Regressions	4.1111	2.1667	1.9444	(1.8128, 7.3206)*
Duration of Gaze	17.0486	12.4819	4.5667	(1.8128, 7.3206)*
Total Reading Time	25.6389	19.4236	6.2153	(2.2427, 10.1879)*

*$p < .05$

The data indicated there were significant differences in the visual processing of left-embedded structures in the inferred condition and right-embedded structures in the backgrounded condition. The differences occurred in the areas of number of total movements, $q=(.9583, 3.9305)$, $p < .05$, number of forward fixations, $q=(.4810, 2.2412)$, $p < .05$, duration of forward fixations, $q=(.4957, 4.7487)$,

p .05, duration of regressions, q=(.3099, 7.3206), $p < .05$, duration of gaze, q=(1.8128, 7.3206), $p < .05$, and total reading time, q=(2.2427, 10.1879), $p < .05$. The basis of the data, Hypothesis 16 was rejected.

Summary

Hypothesis 1 was tested with analysis of variance. The result was Hypothesis 1 was rejected.

Hypotheses 2 through 16 were tested using Tukey's *post hoc* procedure. The results were:

Hypothesis 2:	rejected
Hypothesis 3:	accepted
Hypothesis 4:	accepted
Hypothesis 5:	accepted
Hypothesis 6:	accepted
Hypothesis 7:	accepted
Hypothesis 8:	rejected
Hypothesis 9:	rejected
Hypothesis 10:	accepted
Hypothesis 11:	accepted
Hypothesis 12:	rejected
Hypothesis 13:	accepted
Hypothesis 14:	rejected
Hypothesis 15:	accepted
Hypothesis 16:	rejected

CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Summary

The purpose of the study was to obtain and analyze data concerning the visual processing of left-embedded and right-embedded structures in foregrounded paragraphs, backgrounded paragraphs, and inferred paragraphs by competent adult readers. The behaviors measured were number of total movements, number of forward fixations, number of regressions, duration of forward fixations, duration of regressions, duration of gaze, and total reading time.

A theoretical framework was established, based on psycholinguistic theory and visual processing research in the areas of discourse structures and syntactic structures. A review of the research surveyed:

1. The relationship between visual processing behaviors and reading comprehension.
2. The effect of syntactic structures on eye-voice span.
3. The relationship between reading comprehension and syntactic structures.
4. The relationship between visual processing behaviors and syntactic structures.

5. The relationship between information structure and the understanding of sentences.

The eye movements of thirty-six graduate students, designated as competent adult readers, were recorded with the EDL/Biometrics Reading Eye II. Materials designed for this study were used. The subjects read an EDL paragraph, a left-embedded structure in the foregrounded condition, a right-embedded structure in the foregrounded condition, a left-embedded structure in the backgrounded condition, a right-embedded structure in the backgrounded condition, a left-embedded structure in the inferred condition, and a right-embedded structure in the inferred condition.

Data concerning the visual processing behaviors were tested with analysis of variance. Statistically significant differences were found among the six conditions for each of the seven visual processing behaviors. Each of the conditions was then compared with each of the other conditions using Tukey's post hoc procedure. The statistical findings on the comparisons between each of the conditions are summarized in Table 5.1.

Table 5.1. Statistical Findings on Comparisons Between Conditions.

Conditions	Dependent Variables that Were Significant*
FLE > FRE	Duration of gaze Total reading time
BLE > FRE	Duration of gaze

IRE > FRE	Number of total movements Duration of gaze Total reading time
ILE > FRE	Number of total movements Number of forward fixations Number of regressions Duration of forward fixations Duration of regressions Duration of gaze Total reading time
ILE > BLE	Number of total movements Number of forward fixations Duration of gaze Total reading time
ILE > BRE	Number of total movements Number of forward fixations Duration of forward fixations Duration of regressions Duration of gaze Total reading time

*$p < .05$

The rationale of this study was to compare visual processing behaviors to determine whether a pattern existed in the visual processing behaviors of each condition. Differences existed among the mean scores for each visual processing behavior. While many comparisons among the six conditions did not reach statistical significance, those mean scores may suggest a pattern. Consequently, the mean scores of each of the visual processing behaviors for each of the six conditions in this study are presented in Table 5.2.

Table 5.2. Means for Visual Processing Behaviors.

	FR	FL	BR	BL	IR	IL
Number of Total Movements	8.1389	9.5556	8.5556	9.2500	9.7778	11.000
Number of Forward Fixations	6.6667	7.3611	6.8333	7.0000	7.4167	8.1944
Number of Regressions	1.4722	2.1944	1.7222	2.2500	2.3611	2.8056
Duration of Forward Fixations (in seconds)	.96389	1.15833	1.03153	1.09514	1.16042	1.29375
Duration of Regressions (in seconds)	.17083	.28958	.21667	.32292	.32083	.41111
Duration of Gaze (in seconds)	1.13472	1.44792	1.24819	1.41806	1.48125	1.70486
Total Reading Time (in seconds)	1.76181	2.17500	1.94234	2.10903	2.26319	2.56389

Discussion

Analysis of the data indicated that competent adult readers made statistically significant behavioral adjustments in their reading to accommodate either the information structure of the material or the syntactic structure of the sentence's being read. These behavioral adjustments are consistent with the interactionist theory of reading comprehension that contends that syntactic processing is not static but, instead, interacts with specific discourse variables within the passage during the sentence understanding process. Ease of sentence processing is apparently determined by several factors; among these factors are the information structure within the discourse and the sentence as well as the syntactic structure of the sentence's being read.

Although the results of this study could be allotted only limited statistical legitimacy, an examination of the means for the areas of visual behaviors within the six conditions support the interactionist theory (see Table 5.2). The means for each of the visual processing behaviors were consistent in difficulty when they were rank ordered. These means indicated that the left-embedded, syntactic structures in the inferred condition always presented the most processing difficulty. The next most difficult were the right-embedded, syntactic structures in the inferred condition. The sole exception occurred in duration of regressions where the backgrounded, left-embedded

scores were higher. The structures with the lowest means were always the right-embedded structures in the foregrounded condition. These scores indicated that the information structure of the paragraph and the target sentence are factors that influenced the ease of sentence processing. These scores also indicated that the syntactic structure of the sentence's being read was a factor regardless of the information structure of the paragraph. Within the foregrounded, backgrounded, and inferred conditions, the means for the left-embedded structures were always greater than the corresponding means for the right-embedded structures within each of those conditions. While the differences in the mean scores among each of the six conditions did not meet statistical significance, they were consistently in the direction predicted by interactionist theory. Possibly, either a larger sample of subjects or a more powerful statistical test than Tukey's post hoc procedure could have yielded additional statistically significant differences among the six conditions. Hays (1963) noted that planned comparisons are more powerful and, consequently, have a greater probability of finding significance than post hoc procedures.

The results of the study support the position that the given-new strategy is a microprocess in sentence comprehension through the finding that the introduction of given information prior to the target sentence resulted in easier sentence processing. This prior introduction occurred in

both the foregrounded and backgrounded conditions. Foregrounding of information especially facilitated the processing of right-embedded, syntactic structures. The foregrounded, right-embedded structures were significantly easier to process than all of the structures except the backgrounded, right-embedded, syntactic structures. One possible explanation for this lack of difference in processing is that, in both the foregrounded and backgrounded conditions, the given information was introduced prior to the right-embedded structures. The significant differences that existed between the foregrounded, right-embedded structures and the inferred, right-embedded structures could also be explained by the given-new strategy. This explanation offers one possible explanation for the significantly longer processing time required for the inferred, right-embedded structures. The right-embedded structures were processed faster in the foregrounded condition because of given information's being introduced immediately prior to the right-embedded structures. The increased time required, on the other hand, for the right-embedded structures in the inferred condition occurred because the readers lacked the appropriate antecedent within their memory structures, and they had to construct an inferential bridge between information within the right-embedded structures and antecedents within their memory structures. This bridging resulted in the increased processing time for the right-embedded structures in the inferred condition.

Differences between the foregrounded and inferred conditions also existed for the left-embedded structures, with the means for the inferred, left-embedded structures' being greater. While the differences between the foregrounded, left-embedded structures and the inferred, left-embedded structures did not meet statistical significance, the means of the seven visual processing measures were all larger for left-embedded structures in the inferred condition; and five of these seven measures approached statistical significance. Furthermore, significant statistical differences existed between the backgrounded, left-embedded structures and the inferred, left-embedded structures. The lesser processing time for the left-embedded structures in the backgrounded condition may have occurred because information within the left-embedded structures had been introduced prior to the target sentence. The differences that existed between the left-embedded structures between the foregrounded condition and the backgrounded condition with the inferred condition are consistent with the explanation put forward by the given-new strategy.

While the results of this study support the basic tenets of the given-new strategy as a microprocess involved in sentence comprehension, the results do not appear to support the hypothesis that special psychological status is given to the current topic of a discourse in sentence processing. Neither the backgrounded, right-embedded structures nor the backgrounded, left-embedded structures

significantly differed from their foregrounded counterparts. While there was a tendency for the mean scores for the backgrounded, right-embedded structures to be higher than the means for the foregrounded, right-embedded structures, none of those differences approached significance. Furthermore, this tendency did not exist in the differences between the backgrounded, left-embedded and the foregrounded, left-embedded structures. In five of the seven measures of visual processing, the foregrounded, left-embedded structures had higher means than the backgrounded, left-embedded structures. While this finding does not agree with the findings of Lesgold, Roth, and Curtis (1979), it should be noted that the possibility exists that additional filler sentences might have resulted in significant differences' being found between the backgrounded, syntactic structures and the foregrounded, syntactic structures. Furthermore, the Lesgold, Roth, and Curtis' studies employed a different methodology, chronometrics, to measure speed of sentence understanding, not visual processing behaviors during the reading of the sentences.

The results of this study support the hypothesis that the syntactic structure of a sentence serves the function of organization of elements within the sentence. Apparently, the information in left-embedded structures is not integrated into the reader's memory as easily as the information in right-embedded structures. This is shown by the larger means for the left-embedded structures compared to

the means for the right-embedded structures in the foregrounded, backgrounded, and inferred conditions. While the only differences that reached statistical significance were those in the foregrounded condition, the means for the left-embedded structures in both the backgrounded and inferred conditions were larger than the means for the right-embedded structures in both the backgrounded and inferred conditons. These apparent tendencies agree with the results of Bader, Pearce, and Thompson (1980) who reported significant differences between left-embedded structures and right-embedded structures in both the unrelated discourse condition and in the related discourse condition. However, this earlier study did not specifically control for discourse variables within coherent passages. It is not inconsistent with interactive theory to hypothesize that controlling for discourse variables within the passage would lessen but not remove the differences in the visual processing of left-embedded and right-embedded, syntactic structures.

The interactive theory may also be supported by comparisons between the inferred, left-embedded structures and the foregrounded, right-embedded structures. This is the only comparison that found significant differences in all seven visual processing behaviors. This is also the only comparison in which the left-embedded structures showed significantly more regressions and longer regressions. These findings of increased regressions and of longer duration for those regressions are not inconsistent with the

interpretation that the inferred condition required an increased memory search, and this interacted with the less organized and less easily processed left-embedded structures, since regressions can also be indicators of memory search. Carpenter and Just (1977) posited that regressions reflected both increased memory search by the reader and the reader's efforts to make sense out of the material. The pattern of increased regressions and the longer duration of those regressions for the inferred, left-embedded structures as compared to the foregrounded, right-embedded structures is consistent with the previous interpretation of the posited roles of both discourse structures and syntactic structures in the sentence comprehension process.

Implications of the Study

This study has contributed to our knowledge of the interaction between passage information structure and syntactic structures in sentence comprehension during the reading act. This study has established that competent adult readers make statistically significant behavioral adjustments to variations in passage coherence and sentence syntactic structure during the reading of a sentence. The study has established that both left- and right-embedded structures are more difficult to process when specific information within that structure is not introduced in the preceeding passage. These results support the role of given, or redundant, information as a factor in sentence comprehension.

The study established that left-embedded structures in the inferred conditions were the most difficult structures to process and that right-embedded structures in the foregrounded conditions were the easiest structures to process. The pattern of the data also seemed to indicate microprocesses involved in sentence processing that are consistent with interactionist theories of reading comprehension.

This study has explored language comprehension during reading and has contributed to basic knowledge on sentence comprehension during the reading of passages by competent adult readers. It would be premature at this point in the research to suggest educational or instructional implications of the research. Rather, emphasis should be placed on continuing the momentum generated by this and similar studies to broaden the base of knowledge in psycholinguistic processing.

Recommendations for Future Research

The findings of this study justify further investigation into the effects of discourse variables on sentence comprehension in psycholinguistic processing behavior. It is recommended that further research be conducted in directions that were suggested by the present study.

1. Research should be conducted to replicate the findings of this study using a larger number of subjects. The purpose of this research would be to determine whether the

directional tendencies noted in the mean scores could be replicated with a larger number of subjects. This research would also determine whether additional statistically significant differences existed between the means for each of the six conditions.

2. Research should be conducted that investigate whether special psychological status is given to the current topic of a discourse in sentence processing. Specifically, whether there is a difference between foregrounded and backgrounded information on sentence processing should be examined.
3. Research should be conducted examining whether differences in the microprocesses of sentence comprehension exist between competent and less competent adult readers.
4. Research should be conducted into whether or not a developmental sequence of visual processing behaviors during the reading of selected syntactic structures in foregrounded and inferred conditions exists between childhood and adulthood.

APPENDIX A

SENTENCES

APPENDIX A

Sentence #1

Foreground, right-embedding

The Detroit Lions had had a good year until their quarterback had been hurt. Detroit had then lost the next two football games. Then they had traded for a quarterback. Now Detroit needed to win the final game of the season in order to win the championship. The final game was a real thriller. The score was tied until the last quarter. Then a great play by the quarterback decided the final game. The quarterback won the final game that Detroit needed. He ran thirty yards for a touchdown when he could not find a receiver in the open.

Foreground, left-embedding

The Detroit Lions had had a good year until their quarterback had been hurt. Then Detroit had lost two football games in a row. Detroit needed a new quarterback. Finally, for the final game of the season, Detroit got the new quarterback they needed. The final game was a thriller. The score was tied until the last five minutes of play. Then a play by the quarterback decided the final game. The quarterback that Detroit needed won the final game. He ran thirty yards for a touchdown after not finding an open receiver.

Background, right-embedding

The Detroit Lions had had a good year until their quarterback had been hurt. Detroit had then lost the next two football games. Then they had traded for a quarterback. Now Detroit needed to win the final game of the season in order to win the championship. The final game was a real thriller. The score was tied until the last quarter. Then a great play by the quarterback decided the final game. The stands were filled with loudly cheering people. One estimate was that the stands held forty thousand people. The quarterback won the final game that Detroit needed. He ran thirty yards for a touchdown when he could not find a receiver in the open.

Background, left-embedding

The Detroit Lions had had a good year until their quarterback had been hurt. Then Detroit had lost two football games in a row. Detroit needed a new quarterback. Finally, for the final game of the season, Detroit got the new quarterback they needed. The final game was a thriller. The score was tied until the last five minutes of play. Then a play by the quarterback decided the final game. The stands were filled with loudly cheering people. One estimate was that the stands held forty thousand people. The quarterback that Detroit needed won the final game. He ran thirty yards for a touchdown after not finding an open receiver.

Inferred, left-embedding

Michigan has a city that had long wanted a winner in sports. For a while it looked as if the fans would finally have one, but injuries on the team made the chances of that happening seem rather remote. Fans talked about the team having holes in it and the outlook not being good. Still on a cold Sunday afternoon the fans turned out in large numbers to cheer and watch history being made. The quarterback that Detroit needed won the final game. He had come back and played hurt. Furthermore, he won the final game of the season.

Inferred, right-embedding

Michigan has a city that had long wanted a winner in sports. This year for a while it had looked as if the fans would be rewarded after their long wait. However, before that could happen, the team needed one more victory. Injuries on the team made the chances of that happening seem rather remote. Still, the fans were loyal and on a Sunday afternoon they received a very pleasant surprise. The quarterback won the final game that Detroit needed. He ran for a touchdown with less than five minutes left to play. This won the championship.

Sentence #2

Foreground, left-embedding

The skiers wanted snow. If it did not snow soon, the downhill race would not be held. The downhill race was a big yearly event that drew skiers from all over the world. Unfortunately, this year the slopes were bare and without snow there would be no race. Then the day before the race

it snowed. The blizzard closed the roads. However, no one minded the snow because of its effect on the downhill race. The snow that skiers wanted permitted the downhill race. The race was a success. Furthermore, the skiers had the slopes to themselves for two days because of the storm.

Foreground, right-embedding

The skiers wanted the downhill race. This year the downhill race was going to settle the argument of who was the best skier once and for all. Unfortunately, the slopes were bare and without snow there would not be a race to crown a champion. Then the day before the race it started to snow. The storm closed the roads. However, no one minded the snow's effect because of the downhill race. The snow permitted the downhill race that skiers wanted. The race was a success. The winner was crowned champion. Furthermore, all the skiers had a good time.

Background, left-embedding

The skiers wanted snow. If it did not snow soon, the downhill race would not be held. The downhill race was a big yearly event that drew skiers from all over the world. Unfortunately, this year the slopes were bare and without snow there would be no race. Then one day before the race it snowed. The blizzard closed the roads. However, no one minded the snow because of its effect on the downhill race. The roads were blocked by some high drifts. One of which people estimated as being over thirty feet in length. The snow that skiers wanted permitted the downhill race. The race was a success. Furthermore, the skiers had the slopes to themselves for two days because of the storm.

Background, right-embedding

The skiers wanted the downhill race. This year the downhill race was going to settle the argument of who was the best skier once and for all. Unfortunately, the slopes were bare and without snow there would not be a race to crown a champion. Then the day before the race it started to snow. The storm closed the roads. However, no one minded the snow's effect because of the downhill race. The roads were blocked by some high drifts. One of which people estimated as being over thirty feet in length. The snow permitted the downhill race that skiers wanted. The race was a success. The winner was crowned champion. Furthermore, all the skiers had a good time.

Inferred, left-embedding

A group of men had kept their faith during bad weather. They worked hard, and finally were rewarded. The year had started looking like a disaster in which the weather could spoil everything. Generally, it was agreed that this year could be the worst in memory. While worried, these men had continued to plan and work with the firm belief that things would change. Finally, nature cooperated. The snow that skiers wanted permitted the downhill race. The skiers' wish was granted. Furthermore, the champion was one of those that continued to work and practice.

Inferred, right-embedding

A group of men had kept their faith during bad weather, they worked hard, and finally were rewarded. The year had started looking like a disaster in which the weather could spoil everything. Generally, it was agreed that this year could be the worst in memory. While worried, these men had continued to plan and work with the firm belief that things would change. Finally, nature cooperated. The snow permitted the downhill race that skiers wanted. The race was exciting. Furthermore, the champion was one of those who had continued to work and practice.

Sentence #3

Foreground, left-embedding

The farmers needed rain to save their corn crops. If it did not rain soon, the crops would fail. Farmers then would be in trouble. They had to grow and sell corn, and to do that the farmers needed rain. Late one day a strong wind rose. Then the clouds came, it grew dark, and it started to rain. The rain was heavy but no one minded the soaking because of the rain's effect on the corn crops. The rain that farmers needed saved the corn crops. Reportedly, grown men were seen outside dancing in the rain because they were so happy.

Foreground, right-embedding

The farmers needed their corn crops. If it did not rain soon, their crops would dry up and fail. The farmers then would be in trouble. They had had two bad years in a row and could not afford another one. This year they had to grow and sell their corn. Then one afternoon it grew dark and started to rain. The rain was heavy but no one minded because of the rain's effect on the corn crops.

The rain saved the corn crops that farmers needed. Reportedly, grown men were seen outside dancing in the rain because they were so happy.

Background, left-embedding

The farmers needed rain to save their corn crops. If it did not rain soon, the crops would fail. Farmers then would be in trouble. They had to grow and sell corn, and to do that the farmers needed rain. Late one day a strong wind rose. Then the clouds came, it grew dark, and it started to rain. The rain was heavy but no one minded the soaking because of the rain's effect on the corn crops. In town several trees were uprooted, powerlines were knocked down, and people went without power for hours. The rain that farmers needed saved the corn crops. Reportedly, grown men were seen outside dancing in the rain because they were so happy.

Background, right-embedding

The farmers needed their corn crops. If it did not rain soon, their crops would dry up and fail. The farmers then would be in trouble. They had had two bad years in a row and could not afford another one. This year they had to grow and sell their corn. Then one day it grew dark and started to rain. The rain was heavy but no one minded because of the rain's effect on the corn crops. In town several trees were uprooted, powerlines were knocked down, and people went without power for hours. The rain saved the corn crops that farmers needed. Reportedly, grown men were seen outside during the bad storm dancing they were so happy.

Inferred, left-embedding

A group of men kept their faith during bad weather. They worked hard and were finally rewarded. The year had started out looking like a year that could not only ruin them but could also cause great harm in all of Iowa. While worried, these men had continued to work hard and trust that everything would turn out well. In the end, their work was not wasted and their prayers were answered. The rain that farmers needed saved the corn crops. Consequently, the farmers were able to grow and sell their corn. All because of hard work and rain.

Inferred, right-embedding

A group of men kept their faith during bad weather. They worked hard and in the end were able to pay their bills. The year had started out looking like a year that could both ruin them and cause great harm in all of Iowa. While worried, these men had continued to work and trust that everything would turn out well. In the end, their work was not wasted and their prayers were answered. The rain saved the corn crops that farmers needed. Consequently, the farmers were able to grow and sell their corn. All because of hard work and rain.

Sentence #4

Foregrounded, left-embedding

Students turned out in force to protest against a coal company that had started to strip mine an area. The students opposed the company because of its past history. A hearing was held in which the angry students said that if the company was allowed to continue they would destroy the area. The deciding factor in this hearing was a picture of the last place the company had strip mined. The company that students opposed halted the strip mining. Apparently, the company had not restored its last site. Consequently, they were banned from any strip mining.

Foregrounded, right-embedding

Students turned out in force to protest against a coal company that had started strip mining an area. The students opposed the strip mining because of the damage done to other areas of the state. A hearing was held in which both sides presented their cases. The hearing was decided when the angry students showed some pictures taken on the last place the company had strip mined. The company halted the strip mining that students opposed. The company agreed not to do any more strip mining in the state until they restored their other sites.

Background, left-embedding

Students turned out in force to protest against a coal company that had started to strip mine an area. The students opposed the company because of its past history. A hearing was held in which the angry students said that if the company was allowed to continue they would destroy the area. The deciding factor in this hearing was a picture of the last place the company had strip mined.

The Green River which once had had waterfalls, dark pools, and fish was now a dirty mud hole without any life. The company that students opposed halted the strip mining. Apparently, the company had not restored its last site. Consequently, they were banned from any strip mining.

Background, right-embedding

Students turned out in force to protest against a coal company that had started strip mining an area. The students opposed the strip mining because of the damage done to other areas of the state. A hearing was held in which both sides presented their cases. The hearing was decided when the angry students showed some pictures taken of the last place the company had strip mined. The Green River which once had had waterfalls, dark pools, and fish was now a dirty mud hole without any life. The company halted the strip mining that students opposed. The company agreed not to do any more strip mining in the state. The students were very happy.

Inferred, left-embedding

The business community called them radicals. However, the local newspaper which was conservative, and anything but radical, called them concerned and praised them. The paper also presented a detailed account of the hearing and printed several of the pictures that had been shown at the hearing. These pictures had caused quite a fuss and proved that one picture is worth at least a thousand words. The company that students opposed halted the strip mining. The company had destroyed other places and the students stopped them by showing pictures of those places.

Inferred, right-embedding

The business community called them radicals. However, the local newspaper which was conservative, and anything but radical, called them concerned and praised them. The paper also presented a detailed account of the hearing and printed several of the pictures that had been shown at the hearing. These pictures had decided the hearing. They also proved that a picture is worth at least a thousand words. The company halted the strip mining that students opposed. The students went out to the site of the strip mining and had a picnic. Much to the company's disgust.

Sentence #5

Foreground, left-embedding

Fisherman came each year to fish the area. Recently, however, some Indians had been gill netting in the area and fishing was not good. The fishermen were angry and opposed those Indians who would not stop gill netting. This led to several fights. The problem went to court where both fishermen and Indians turned out in force. There a judge ruled against the Indians saying gill netting was illegal. The Indians that fishermen opposed halted the gill netting. Within one year of the decision fishing in the area was returning to normal.

Foreground, right-embedding

Fishermen came each year to fish the area. Recently, however, some Indians had been gill netting in the area and fishing was no longer good. The fishermen were mad and opposed gill netting. This led to fights between the two groups. The problem went to court where both fishermen and Indians turned out in force. The court ruled that gill netting by anyone, including these Indians, was illegal. The Indians halted the gill netting that fishermen opposed. Within one year after this decision fishing in the area was returning to normal.

Background, left-embedding

Fishermen came each year to fish the area. Recently, however, some Indians had been gill netting in the area and fishing was not good. The fishermen were angry and opposed those Indians who would not stop gill netting. This led to several fights. The problem went to court where both fishermen and Indians turned out in force. There a judge ruled against the Indians saying gill netting was illegal. People came from all over. Storekeepers in town took advantage of this and doubled their prices on everything. The Indians that fishermen opposed halted the gill netting. Within one year of the decision fishing in the area was returning to normal.

Background, right-embedding

Fishermen came each year to fish the area. Recently, however, some Indians had been gill netting in the area and fishing was no longer good. The fishermen were mad and opposed gill netting. This led to fights between the two groups. The problem went to court where both fishermen

and Indians turned out in force. The court ruled that gill netting by anyone, including these Indians, was illegal. People came from all over. Storekeepers in town took advantage of this and doubled their prices on everything. The Indians halted the gill netting that fishermen opposed. Within one year after this decision fishing in this area was returning to normal.

Inferred, left-embedding

Natural resources do not last forever. Nature can only replace resources at a certain speed. When people use them rapidly, then resources become scarce and fights start over the use of resources. Such was the case last year with charges being made, tempers growing short, and nobody giving in. Finally, a large amount of money decided everything. Two million dollars was spent. The Indians that fishermen opposed halted the gill netting. Rather than see someone killed, the government bought the Indians' fishing rights, making both groups happy.

Inferred, right-embedding

Natural resources do not last forever. Nature can only replace resources at a certain speed. When people use them rapidly, then resources become scarce and fights start over the use and saving of resources. Such was the case last year with charges being made, tempers growing short, and nobody giving in. Finally, a large amount of money decided everything. Two million dollars was spent. The Indians halted the gill netting that fishermen opposed. A large group of fishermen bought from the Indians their right to gill net, making both fishermen and Indians happy.

Sentence #6

Foreground, left-embedding

A health club had been robbed. Mike, the owner of the club, had put the payroll money on his desk. A blonde lady had come in to ask about joining. Mike had taken her into his office to explain the benefits. However, the money was not put away, and Mike was called out of the office. The blonde was left alone. The temptation was too much for the blonde and resulted in the loss of the payroll money. The blonde that Mike left took the payroll money. The employees could not be paid that week. Consequently, they were rather angry. Mike was also angry, at himself.

Foreground, right-embedding

A health club had been robbed. Mike, the owner of the club, had left the payroll money on his desk. A blonde woman had come in to ask about joining. Mike had taken her into his office to explain the benefits. The payroll money was left on the desk when Mike was called out of the office for an emergency. The temptation proved too much for the blonde and resulted in the loss of the payroll money. The blonde took the payroll money that Mike left. The employees could not be paid when they expected to be paid. Consequently, they were rather angry.

Background, left-embedding

A health club had been robbed. Mike, the owner of the club, had put the payroll money on his desk. A blonde lady had come in to ask about joining. Mike had taken her into his office to explain the benefits. However, the money was not put away, and Mike was suddenly called out of the office. The blonde was left alone. The temptation was too much for the blonde and resulted in the loss of the payroll money. An employee had needed help with a machine that was new and the employee did not know how to operate it. The blonde that Mike left took the payroll money. The employees could not be paid that week. Consequently, they were rather angry. Mike was also angry, at himself.

Background, right-embedding

A health club had been robbed. Mike, the owner of the club, had left the payroll money on his desk. A blonde woman had come in to ask about joining. Mike had taken her into his office to explain the benefits. The payroll money was left on the desk when Mike was called out of the office for an emergency. The temptation proved too much for the blonde and resulted in the loss of the payroll money. An employee had needed help with a machine that was new and the employee did not know how to operate it. The blonde took the payroll money that Mike left. The employees could not be paid when they expected to be paid. Consequently, they were rather angry.

Inferred, left-embedding

The owner of a health club had an employee problem. The employees were mad and the owner did not blame them. But they would still have to wait a week. He reflected that this problem arose from stupidity and love of women. Both

the stupidity and love of women were his. He had just not thought. So when an employee had called him out of his office to help him repair a broken machine, he had gone. The blonde that Mike left took the payroll money. Consequently, the employees were not getting paid this week and they were angry.

Inferred, right-embedding

The owner of a health club had an employee problem. The employees were mad and the owner did not blame them. But they would have to wait a week. He reflected that this problem arose from stupidity and love of life in that order. He should never have walked out of his office the way he did. He had just not thought. So when an employee had called him from the office to repair a broken machine, he had gone. The blonde took the payroll money that Mike left. Because he had not put the payroll money away first, Mike, the owner, was in trouble. Mike swore off blondes.

APPENDIX B

TREATMENT BY SUBJECT DESIGN

APPENDIX B

Treatment Order: Foregrounded, left-embedded; foregrounded, right-embedded; inferred, right-embedded; backgrounded, left-embedded; inferred, left-embedded; and backgrounded, right-embedded

Subject #	Sentence Order
1	1, 3, 5, 6, 4, 2
2	3, 1, 6, 5, 2, 4
3	5, 6, 4, 2, 1, 3
4	6, 5, 2, 4, 3, 1
5	4, 2, 1, 3, 6, 5
6	2, 4, 3, 1, 5, 6

Treatment Order: Foregrounded, right-embedded; backgrounded, left-embedded; foregrounded, left-embedded; backgrounded, right-embedded; inferred, right-embedded; inferred, left-embedded

Subject #	Sentence Order
7	3, 6, 4, 1, 5, 2
8	6, 5, 1, 2, 4, 3
9	4, 3, 5, 6, 2, 1
10	1, 2, 6, 4, 3, 5
11	5, 1, 2, 3, 6, 4
12	2, 4, 3, 5, 1, 6

Treatment Order: Backgrounded, left-embedded; backgrounded, right-embedded; foregrounded, right-embedded; inferred, left-embedded; foregrounded, left-embedded; inferred, right-embedded

Subject #	Sentence Order
13	5, 6, 1, 2, 3, 4
14	6, 5, 2, 4, 1, 3
15	1, 2, 3, 5, 4, 6
16	2, 3, 4, 6, 5, 1
17	3, 4, 6, 1, 2, 5
18	4, 1, 5, 3, 6, 2

Treatment Order: Backgrounded, right-embedded; inferred, left-embedded; backgrounded, left-embedded; inferred, right-embedded; foregrounded, right-embedded; foregrounded, left-embedded

Subject #	Sentence Order
19	6, 2, 5, 4, 1, 3
20	2, 5, 6, 3, 4, 1
21	5, 6, 2, 1, 3, 4
22	4, 3, 1, 6, 2, 5
23	1, 4, 3, 2, 5, 6
24	3, 1, 4, 5, 6, 2

- -

Treatment Order: Inferred, left-embedded; inferred, right-embedded; backgrounded, right-embedded; foregrounded, left-embedded; backgrounded, left-embedded; foregrounded, right-embedded

Subject #	Sentence Order
25	5, 3, 6, 2, 4, 1
26	3, 5, 2, 6, 1, 4
27	6, 1, 5, 4, 3, 2
28	2, 4, 3, 1, 5, 6
29	4, 6, 1, 3, 2, 5
30	1, 2, 4, 5, 6, 3

- -

Treatment Order: Inferred, right-embedded; foregrounded, left-embedded; inferred, left-embedded; foregrounded, right-embedded; backgrounded, right-embedded; backgrounded, left-embedded

Subject #	Sentence Order
31	2, 1, 3, 4, 6, 5
32	1, 4, 2, 5, 3, 6
33	3, 5, 6, 1, 4, 2
34	4, 2, 5, 6, 1, 3
35	6, 3, 4, 2, 5, 1
36	5, 6, 1, 3, 2, 4

APPENDIX C

DIRECTIONS READ TO SUBJECTS BEFORE EXPERIMENT

APPENDIX C

You are going to be asked to read seven cards, one at a time, while your eye movements are being measured by this machine. This machine is called a Reading Eye II; it records eye movements on heat sensitive graph paper.

Please read naturally and pay attention to the material on each card since you might be asked to paraphrase that selection afterwards.

But first your eyes must be aligned to this machine so that your eye movements can be recorded.

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