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ON VISUAL PROCESSING AND RECALL
FOR COMPETENT ADULT READERS

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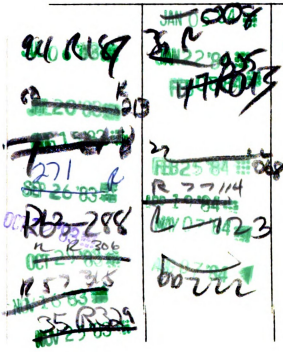

THE EFFECT OF SYNTACTIC STRUCTURES ON VISUAL PROCESSING AND RECALL FOR COMPETENT ADULT READERS

By

David R. Thompson

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ABSTRACT

THE EFFECT OF SYNTACTIC STRUCTURES ON VISUAL PROCESSING AND RECALL FOR COMPETENT ADULT READERS

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Purpose of the Study

The purpose of the study was to obtain and analyze data concerning the visual processing and recall of syntactic structures in connected discourse by competent adult readers. The study focused on the processing of the sentence succeeding a left- and right-embedded structure in cohesive paragraphs and the ability of the reader to recall both the embedded structures and the succeeding sentences.

Findings

The statistical tests supported the following findings:

1. There were no significant differences in the visual processing behaviors of competent adult readers on the sentence succeeding a left- and right-embedded structure in related discourse.

2. There were significant differences in the recall of left- and right-embedded structures in related discourse by competent adult readers.

3. There were no significant differences in the recall of the sentence succeeding left- and right-embedded structures in related discourse by competent adult readers.

4. There were no significant differences in the visual processing behaviors of competent adult readers and their recall of selected syntactic structures in related discourse.

Implications of the Study

The results of the study indicated the following:

1. An examination of the means for the visual processing behaviors of the sentence succeeding left- and right-embedded structures supports previous research on the cognitive processing of syntactic structures in related discourse. The means indicated that the sentence succeeding a left-embedded structure always presented the most processing difficulty.

2. The results of the study supported the position that difficulties in visual processing of text are a reflection of disruptions in cognitive processing. Bader, Pearce, and Thompson (1980) demonstrated the effects of left-embedded sentences on visual processing behavior, and the present study demonstrated the effects of left-embedded sentences on recall performance.

3. The results of the study support the view that the competent reader can alter visual processing behaviors to accommodate cognitive processing acts.

4. An examination of the means and confidence intervals for the visual processing behaviors and recall scores supports the information

processing theory of reading. Competent readers with good recall ability were flexible and adaptive to the demands of the text.

DEDICATION

To Deborah, whose encouragement
and support made it all
possible

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CHAPTER I

THE PROBLEM

Background

> In reading, when I come upon an unfamiliar word or phrase, I have a sensation of derailment. Some process that usually flows along smoothly has been interrupted. Some expected click of my mechanism has failed to occur. It has always seemed to be the principal task of psychology to discover the nature of this click. The meaningful linguistic form must set off some characteristic immediate effect in the person who understands. What is the substantial nature of this effect? (Brown, 1968, p. 82)

In essence, Brown has asked the question that has intrigued psychologists for centuries: What is the nature of the comprehension process? Today, the answer to this question remains one of the most challenging tasks facing mankind. The vast array of literature on reading comprehension includes many theories and speculative models of the events which interact to allow one to grasp meaning from print. Although there remains a great deal of disagreement among researchers regarding the actual components of comprehension, certain linguistic, sociological, physiological, and psychological factors seem to contribute to the process.

Recent research on reading comprehension has focused on two approaches, information-processing analysis and psycholinguistics, that have begun to shed new light on this complex act (see Gibson, 1972; Gough, 1972; Hochberg, 1970; Laberge and Samuels, 1976; Norman, 1976; Smith, 1971; Trabasso, 1972). The skilled reader can be viewed as an

information processor who combines his/her knowledge of the world with an awareness of the structure of language to make predictions about the probable meaning of words, phrases, and sentences. The comprehension act is seen as a series of successive stages in which linguistic information is processed from its input until apprehension has occurred. For the fluent reader, this processing takes place at remarkable speeds and has been recorded in mere fractions of a second (Gough, 1972). The most obvious result of these developments has been an increase in the number of experiments that have examined cognitive processes involved in acquiring knowledge from specific written tasks as well as the apparent effects of surface variables in combination with mental operations.

These developments have also revived an earlier model of assessment: the analysis of reading eye movements. Traditional studies of eye movements date back to the beginning of this century and were primarily concerned with identification of the number of fixations, duration of fixations, and the number of regressions for variables such as the skill of the reader and the difficulty of the material. In a review of eye movement studies by Tinker (1958), it was concluded that this type of research was reaching the stage of diminishing returns and that the future was not promising. Fortunately, the shift toward the analysis of reading comprehension through information-processing methods has altered Tinker's dire prediction. If one accepts the view that understanding a written message is not instantaneous but involves successive stages that can be analyzed in real time, eye movement research has a promising future. Researchers can monitor an individual's eye movements over carefully controlled

linguistic segments and gain insight into the cognitive processing behaviors of that individual. Furthermore, experiments can begin to examine models of information-processing in relation to eye movements and the complex interaction among eye movements, characteristics of the reader, and characteristics of the text.

In the last fifteen years, there has been a significant increase in studies involving eye movements, cognitive processing behaviors, and a wide variety of written materials. In fact, assessment of the information-processing behaviors of readers through eye movement analysis procedures appears to have begun to shed new light on the relationship of language forms to successful processing abilities. Additional research in this area will further our understanding of the interactive components involved in reading comprehension and provide essential information to assist future instructional decisions in reading education.

Importance of the Study

Recent research on eye movements and language comprehension has advanced our understanding of the relationship between fixation duration and processing time, the cause of regressive eye movements, the nature of the recognition span, and the effects of particular language structures on variables such as fixations, duration of fixations, and regressions. Even so, there remain many skeptics within the reading community that appear unfamiliar with these efforts and continue to subscribe to the limitations of the traditional eye movement studies. This study will lend further credence to the view that eye movements are a selective act and a reflection of the cognitive processing behaviors of the reader.

It is well known that the majority of past eye movement studies have been restricted to ambiguous strings of words, lists of words or brief phrases, and isolated sentences. In fact, few studies in this area have examined reading behavior using connected discourse. McConkie (1974) aptly spoke to this point when he noted that we must study individuals who are engaged in reading text to properly understand the way people read, since data from other tasks are unreliable indicators of what people do when reading. This study will, therefore, pursue the cognitive processing behaviors of competent adult readers when they are presented with cohesive paragraphs.

A third reason for this study is that assessment of the reader's ability to recall information from text known to affect visual processing can significantly advance our knowledge of the relationship between properties of the text and successful processing strategies. Finally, a study such as this can provide data that will be directly applicable to the classroom to assist in the definition of teaching strategies and to determine adequate performance expectations for students.

Statement of Purpose

Research has established that syntactic structures directly affect the reading and subsequent comprehension of a selection. Eye movement analysis procedures have furthered our knowledge of this relationship by enabling us to view the interaction of a written selection and the cognitive processing behaviors of the reader. The purpose of this study is to examine the information-processing behaviors of

competent adult readers when presented with selected syntactic structures during the reading of connected discourse.

Bader, Pearce, and Thompson (1980) studied the effects of connected discourse on the processing of left- and right-embedded sentences. They found that left-embedded sentences were significantly more difficult to process than right-embedded sentences. In addition, their adult readers required more total time to process the left-embedded structures in a paragraph and made more regressive eye movements. Bader, et al., posited that the greater number of regressions of longer duration reflected the lesser constraint in the left-embeddings and the increased memory load for the reader.

The extent to which the reader is able to compensate with the increased processing demands of the embedded construction was a primary concern in the present study. Specifically, this study has three purposes: first, to examine the visual processing patterns of competent adult readers which occur in the structure immediately following left- and right-embedded sentences; second, to assess the readers' ability to recall both the left- and right-embeddings and the succeeding structure; and third, to study the relationship between the reader's ability to recall selected syntactic structures and his/her visual processing behaviors.

Research Questions

The purpose of this study was to examine the information-processing behaviors of competent adult readers presented with selected syntactic structures during the reading of connected discourse. The major research questions are as follows:

1. Will the visual processing behaviors of competent adult readers differ in the sentence succeeding left- and right-embedded structures?
2. Will competent adult readers be able to accurately recall the left- and right-embedded structures?
3. Will competent adult readers be able to accurately recall the sentence succeeding left- and right-embedded structures?
4. Is there a relationship between the visual processing behaviors of competent adult readers and their recall of selected syntactic structures?

The preceding questions were expanded and restated in null hypothesis form for statistical testing. These are presented in Chapter III.

Delimitations

1. This study was limited to competent adult readers, and the findings must be generalized to this population.
2. The syntactic structures selected for use in this study were left- and right-embedded sentences and subject-verb-object sentences.
3. The paragraphs constructed for use in this study were designed by the author and conformed to the following constraints:
   a. Each paragraph must extend ten lines and be cohesive with respect to content.
   b. Each line must not extend over 59 spaces.

c. The embedded structure must be on the sixth line.

d. The seventh line must be a complete sentence and follow the s-v-o form.

e. The seventh line must contain information relevant to an overall understanding of the paragraph.

4. The subjects' eye movements were recorded with their knowledge and consent, and the eye movement recording device required each subject to restrict his/her head movements during the reading of written material.

Generalizability

It is important to note that the findings of this study may have an impact beyond the limits of the study itself. First, since the adults involved are from a population of competent readers, it might be concluded that the findings may hold for a large population of competent adult readers. Second, there is no reason to believe that selected syntactic structures can only affect competent adult readers. And, finally, the educational implications are applicable to all levels of reading development and a step toward the ultimate clarification of human language processing.

Definition of Terms

In order that the reader may better understand this study, an explanation of relevant terms is provided.

Information-Processing Behaviors

Information-processing behaviors refer to the various encoding and comparing operations that interact to result in the comprehension of written material.

Cognitive Processing Behaviors

Cognitive processing behaviors refer to those mental acts that occur during the comprehension act in reading.

Visual Processing Behaviors

Visual processing behaviors refer to those eye movements that comprise the visual component in information-processing: number of fixations, number of regressions, fixation duration, regression duration, and gaze duration.

Syntax

Syntax refers to the manner in which words are ordered to form the phrases, clauses, or sentences in a language.

Left-Embedded Sentence

A left-embedded sentence contains a relative clause following and modifying the sentence subject. Therefore, L.E. = subject + relative clause + verb + object.

Right-Embedded Sentence

A right-embedded sentence contains a relative clause following and modifying the object of the sentence. Therefore, R.E. = subject + verb + object + relative clause.

A prepositional phrase was added to each sentence so that the relative clauses would line up letter for letter. For example:

L.E. sentence: In the kitchen the cook that Martha trained hired the help.

R.E. sentence: The cook hired the help that Martha trained in the kitchen.

Cohesive Discourse

Cohesive discourse refers to a paragraph written in such a manner that words and sentences are related and develop a common theme or story.

Competent Adult Readers

Competent adult readers refer to university graduate students who volunteered to participate in the study. It was assumed that these individuals were competent readers on the basis of their educational level. All were native English speakers.

Recall

Recall refers to the subject's ability to accurately identify items from a previously presented stimulus.

Organization of Chapters

The content of Chapter I included a background of the problem, the importance of the study, the purpose of the study, research questions, the limitations of the study, the generalizability of the study, the definition of terms pertinent to the study, and presentation of the organization of subsequent chapters.

In Chapter II, a review of the literature related to the study is presented. It includes sections on the relationship between reading comprehension and syntactic structures, the relationship between visual processing behavior and reading comprehension, the relationship between visual processing behavior and syntactic structures, and the effect of syntactic structures on recall of information.

Chapter III describes the design and methodology used in this study.

Chapter IV organizes, analyzes, and presents the data and findings of the study.

Chapter V presents the conclusions, implications, and recommendations of the study based on the findings.

CHAPTER II

RELATED LITERATURE AND RESEARCH

The review of related literature and research in this chapter is organized under four major headings: (a) the relationship between reading comprehension and syntactic structures, (b) the relationship between visual processing behavior and reading comprehension, (c) the relationship between visual processing behavior and syntactic structures, and (d) the effect of syntactic structures on recall of information.

The Relationship Between Reading Comprehension and Syntactic Structures

> It seems obvious that meaning in speech and written language is related to perceiving the correspondence of the phrases, sentences, and so on to event structures of different orders of complexity (Gibson, 1972, p. 6).

Seventy-three years ago, Edmund Burke Huey (1908) anticipated the findings of contemporary linguists when he depicted the skilled reader as an "information-transformer" who alters the meanings or relations inherent in printed material into an organized cognitive arrangement. More recently, Huey's notions regarding the reading process have been amplified to focus on the reader's active contribution in order to gain meaning from print. The skilled reader is viewed as an individual who contributes his/her conceptual knowledge of both the language of the world with the graphemic information of text in order to

effectively extract meaning (Goodman, 1970; Smith, 1971; Gibson and Levin, 1975).

This complex interaction between reader and text gained considerable attention during the early 1960s due to the transformational-grammar theory of Noam Chomsky (1965). His theory is a formal description of the structural relations of sentences and the manner in which words and sentences are related to one another. Every sentence can be represented on a surface level and a deep structure level. For readers to gain meaning from print, they must be able to decode words and understanding their meanings, while at the same time being aware of the grammatical interrelationships which signify the underlying meaning of a particular sentence.

Over the years Chomsky's linguistic theory has spurred researchers to investigate a number of crucial aspects of the relationship between language structures and comprehension. Their efforts have concentrated on two broad areas. First, numerous studies have attempted to ascertain whether the human language processes have a mechanism which works according to the grammatical rules of English. A subsequent concern has been to identify the properties of such a mechanism and to determine whether it exists in the psychological reality of the user. The second area, which is of particular interest to this study, has centered on research geared toward establishing the effects of specific syntactic structures upon the comprehension abilities of the reader.

Guided by the basic tenet that the human user of language possesses a device which operates along the lines of rule-governed grammar, Yngve (1960) proposed a mechanism capable of producing language. A portion of his analysis concerned sentence complexity and quickly

became the basis for future research. Essentially, Yngve hypothesized that sentences of equal length and equivalent word content differ in their structural properties. These differences, in turn, have profound effects upon human processing abilities. For example, a self-embedded construction (i.e., "The house that the ball that the boy threw hit was deserted") was found to be more difficult to understand than its right-branching counterpart (i.e., "The boy threw the ball that hit the house that was deserted") because it imposed a severe load on short-term memory. Miller and Isard (1964) tested subjects with constructions such as these and found that the self-embedded phrase structure definitely emphasized the limited cognitive capacities of the human language user. However, Blumenthal (1966) criticized their study on the grounds that most subjects perceived the self-embedded sentences as ungrammatical structures and, therefore, did not attempt to process them in a normal fashion. Stolz (1967) replicated the portion of Miller and Isard's (1964) study dealing with self-embeddings and provided subjects with feedback concerning their ability to decode such a structure. His contention was that self-embedded sentences are, indeed, very difficult to process and are likely related to psychological limitations, but cannot be decoded by individuals unless they are familiar with the linguistic structure. Stolz found that the feedback condition enhanced the decoding process and cautioned researchers to be careful in their assumptions about what subjects "know" about English grammar.

Blaubergs and Braine (1974) reviewed and critized each of these studies on the grounds that the short-term memory contribution to the processing of self-embedded sentences had never been adequately

isolated for self-examination. Their subjects were, therefore, instructed as to the grammatical structure of a self-embedded sentence prior to engaging in the experiment. The results are supportive of Yngve's original claim that self-embedded sentences are more difficult to comprehend due to the demands they place upon short-term memory. It should be noted, however, that the breakdown in comprehension does not appear to begin until the self-embeddings exceed the three-degree level (one degree of complexity per embedded clause). Therefore, the overall implication of these research efforts is that in relatively "normal" reading conditions, individuals are not likely to be exposed to complex grammatical structures which will exceed their processing capacities. There is the likelihood, however, that a lack of familiarity with a particular grammatical structure will influence processing efficiency in a negative manner.

While the previously noted investigations were primarily aimed at delineating the role of short-term memory in language processing, educational researchers have also explored the interaction between reader and text in an effort to clarify the importance of syntactic structures to reading comprehension.

One area of particular interest to reading researchers was the way in which syntax affected the understanding one derived from print. Allen (1964) had noted that for a student to be able to read longer sentences intelligently "...he must be able to recognize the structure (or grammar) of such sentences" (p. 164). Fagan (1971) concurred, "For children to comprehend what they read, they must be able to understand the written language structures by which ideas, information, and concepts are conveyed" (p. 169).

Marcus (1971) contributed to our understanding of the role of syntax with his report on a diagnostic tool that measured intermediate grade students' comprehension of syntactic structures. Results of his test revealed that prepositional phrase modifiers and sentences containing relative clauses in the subject-verb-object pattern of independent clauses were among the most difficult to comprehend.

Fagan (1971) added to our information concerning syntactic processing through his investigation of the effect that transformations had on sentence comprehension. In his study, 440 fourth, fifth, and sixth grade pupils read passages containing different transformations. He found that appositives, ing-nominalizations, pronouns, common elements deletion, and negatives were the most difficult structures to comprehend. In addition, Fagan reported that the complexity of the transformation rather than the number of transformations in a sentence had the greatest effect on reading comprehension.

A related area that has received considerable attention in psycholinguistic and educational research has been the relationship of anaphoric structures to reading comprehension. Bormuth, Manning, Carr, and Pearson (1970) presented fourth graders with short passages containing anaphoric structures. After reading each passage, the children answered a question based on the target syntactic structure. Bormuth et al., derived a ranking of difficulty from their results indicating that structures such as personal pronouns ("Joe left the room. He had...") and semantic substitutes ("Those steel towers are antennas. These objects are...") are more difficult to understand than pro-verbs with so ("Joe may go. If so, we will..."). However, Lesgold (1974) disputed these findings and developed a different hierarchical

arrangement. Among the variations Lesgold's students recorded were findings that pro-clauses and pro-verbs with so are more difficult to comprehend than personal pronouns. Lesgold attributed these differences to the influence of background knowledge in reading comprehension.

A recent study, Barnitz (1980), examined the syntactic effects on reading comprehension of pronoun-referent structures by children in grades two, four, and six. Although the findings have much to say regarding the order and directional influences of specific pronoun-referents, they also appear to clearly indicate that syntactic aspects of anaphora do contribute to children's success with comprehension. Barnitz concludes that the role of syntax certainly plays an important role in children's acquisition of successful reading skills, but concurs with Lesgold's (1974) finding that knowledge of the world can also affect the comprehensibility of a sentence.

While the preceding discussion has emphasized the importance of syntax as a contributor to the comprehension act, researchers have also studied the manner by which the reader is influenced by grammatical structure. Levin and Kaplan (1970) commented, "...readers...do not attend equally to every element of the text. In fact, they sample the text, attending to some elements--letters, syllables, words, phrases, and so forth--sometimes in great detail, at other times less densely" (p. 119). Schlesinger's (1968) studies reported that people tend to read to the end of units, chains, or phrases, which are both syntactic and semantic wholes.

A study by Levin and Kaplan (1970) attempted to clarify the method by which readers processed information. They replicated

Schlesinger's (1968) study with subjects from six grade levels in an effort to determine whether skilled readers chunked sentences into phrase units. Another purpose of their study was to test this notion developmentally. Four types of sentences were used:

1. Active sentences composed of two-word phrases.
2. Active sentences made up of three-word phrases.
3. Active sentences made up of four-word phrases.
4. Passive sentences made up of three-word phrases.

Levin and Kaplan used the eye-voice span (EVS) measurement technique because they felt it allowed for a relatively natural method of examining the internal processes during reading. In reading aloud, the EVS is the distance usually measured in words, that the eye is ahead of the voice. Two procedures are involved in EVS. First, eye movements are recorded while the subject is reading aloud. Then, the text is removed and the subject is asked to report as much of the text as he can remember, beyond the point at which he no longer saw the text.

All of the subjects in the Levin and Kaplan study except second graders read in phrase units regardless of the varying boundaries and different types of sentences. In addition, this chunking tendency grew no stronger between fourth grade and adulthood. A possible explanation for the second graders is that they were still reading in a word-by-word fashion and had not yet developed the ability to group according to phrases. Regardless, the data seem to suggest that a reader's sensitivity to grammatical structure simplifies the task of reading and enhances comprehension.

Kolers (1973) also reported on the relationship between grammar and context. His readers made fewer errors over the final three-fifths of the sentences and exhibited more difficulty perceiving the relations a sentence expresses than the things being related. This finding is in agreement with a Levin, Grossman, Kaplan and Yang (1972) study involving right- and left-embedded sentences. Subjects were asked to read sentences with various portions deleted and to fill in the blanks so as to form grammatical sentences. Their results indicate that readers anticipate an embedding more often after a main verb than before it. Also, the EVS of these individuals supported the notion than an individual processes phrases, or chunks, in relation to the grammatical structure of the sentence.

In summary, there appears to be a consensus among researchers that the successful reader must anticipate the structural properties of a sentence in order to comprehend the intended message. However, there is evidence to suggest that some syntactic structures are more difficult to process and are likely to affect readers in a variety of ways depending on variables such as age and wordly knowledge. Future investigations are necessary to clarify the role of syntax in language processing and passage comprehensibility. In the meantime, any analysis of the interplay between reader and text must acknowledge the potent role that syntax plays in reading.

The Relationship Between Visual Processing Behavior and Reading Comprehension

The research on eye movements during reading is fairly extensive and dates back to the turn of the century (see Tinker, 1958; Levy-Schoen and O'Regan, 1979, for reviews of research). Personal

introspection into the reading experience would lead one to perceive that the eyes move smoothly and continuously along the line of print. To the contrary, the actual motor activity has been documented as being essentially discontinuous and featuring a succession of pauses and jumps. Huey (1908) conducted the initial full-scale investigations into the apparent nature of eye movements during reading. However, he credits the research of Emile Javal and a series of articles published in 1878-1879 as being the earliest recorded documentation of eye movement behavior.

Over the years a variety of methods have been employed to record and measure eye movements. Needless to say, recent technological advances have resulted in sophisticated instruments capable of gathering data under well-controlled experimental conditions (see Young and Sheena, 1979, for a review of current eye movement recording methods). The literature on the characteristics of eye movements has also discerned several types of movements:

1. Forward Fixation: The pause the eye makes while the reader recognizes letters, words, or phrases. The size of the pause (duration) is dependent upon characteristics of the reading material as well as the reader and varies from about .22 seconds for easy reading material to .32 seconds for reading objective test items (Dechant and Smith, 1977).

2. Regressive Fixation: The pause the eye makes after a return to a previously fixated piece of material. It is a movement that goes in the opposite direction from the line of print and is likely to occur when the flow of thought has been interrupted or when perceptions are recognized as being inaccurate (Bayle, 1942).

3. Interfixation Movements: The quick, short movement the eye makes as it travels between pauses. No information is taken in by the reader at this time.

4. Gaze Duration: The total amount of time a reader looks at a unit of text. Gaze duration is related to the

> difficulty of the reading task and is likely to include numerous fixations, regressions, and interfixation movements (Carpenter and Just, 1977).

5. Return Sweeps: The movement the eye makes after a line is read and the reader moves to the next line.

Any survey of the available research will reveal an abundance of data concerning the relationship of language processing behaviors to the eye movements of readers. For example, Carmichael and Dearborn (1947) wrote:

> Reading involves patterning movements of the eyes and adjustments of the eyes themselves into appropriate view, in a suitable temporal order, symbols which are perceived as words or phrases. These words and processes which are related to them then evoke images, ideas and action and lead to states called by such names as comprehension and enjoyment (p. 44).

Moreover, earlier investigations (Judd and Buswell, 1922; Walker, 1933; Frandsen, 1934; Anderson, 1937) indicated that eye movements were responsive to the central processing operations of the reader. Judd and Buswell (1922) measured the eye movements of fifth grade pupils reading a series of increasingly difficult passages. They found that the number of fixations and the length of fixations were affected by the difficult material. Some students tended to increase the number of fixation pauses in an area recognized as being difficult due to the additional mental requirements. Other students simply compensated for the difficult materials by lengthening the amount of time spent fixating on a particular word part or phrase. A third type of adjustment also occurred. Individual readers varied their strategy for the difficult passages between increased number of fixations and longer fixation pauses. Judd and Buswell attributed these variations among students to the fact "that all of the more complex processes are highly individuated" (p. 13).

Walker (1933) studied the adaptive behaviors of good readers to alterations in the nature of the material being read. The duration of each fixation increased with the difficulty of the reading material and the requirements of comprehension. In addition, regressive movements increased in more difficult passages leading Walker to conclude that the increased demands in comprehension were causing the subjects to make more rechecks on the material previously read.

By documenting the eye movements of both good and poor readers confronted with the same reading task, Anderson (1937) showed that good readers differed from less skilled readers in their flexibility of responses to difficult material. Although each group exhibited an increase in the number of fixations, the duration of the fixations, and the number of regressions, the better readers made significantly greater adjustments to the difficult material. The poorer readers, on the other hand, recorded negligible eye movement alterations regardless of the textual demands.

Computerized eye tracking equipment has allowed for a more thorough analysis of the processing behaviors of individuals and the differences between various types of reading. Goltz (1975) reported on "competent" and "less competent" college students' eye movements during the reading of historical texts. The skilled readers used shorter fixation pauses regardless of the difficulty of the material or the comprehension requirements. This same group adjusted to the increased processing demands of complex material by simply lengthening the duration of their fixations. In comparison, the less competent readers exhibited constant fixation pause durations, but began to make a greater number of fixations as the material increased in difficulty.

In the case of regressions, Goltz noted that the competent reader tended to make a regression immediately after shortening prior fixations. From this, he inferred that the skilled reader anticipates difficult conditions and begins to adjust processing behavior before a regression. The unskilled reader, on the other hand, made a regression immediately after lengthening prior fixations. This was interpreted as an attempt to process the more difficult information through an expansion of regular fixation patterns and having to regress as a result of cognitive difficulties. It should be noted that these results are likely to be somewhat restricted, primarily due to the type of material being read. However, it would also seem evident that the research on the visual processing patterns of readers has yielded different findings due to variables such as the individual, the text, the purpose for reading and the measurement apparatus.

Another area of concern to researchers of eye movements has been to determine the size of an area from which a person picks up information during a fixation in reading. The general assumption behind these investigations is that reading only takes place during fixations. Therefore, it seems natural to inquire as to the amount of information available during a fixation pause and how that information is integrated by the reader from one fixation to the next.

The region from which visual information is gathered is called the perceptual span. Determining the size and characteristic nature of this area has long intrigued researchers (see Huey, 1908). Some of the earliest studies involved tachistoscopic presentations of letters or words to subjects, followed by testing to see how many of the items could be recalled. It was believed that since the material was

presented very quickly, the subject would not be able to make an additional eye movement. Therefore, the amount of material viewed during one exposure was analogous to a single fixation in reading. Critics have properly noted, however, that there is no available evidence to support this notion and "it is very likely that normal reading and tachistoscopic reports vary enough to induce different strategies in subjects" (Raynor, 1975, p. 66).

Taylor (1965) adopted another method to identify the size of the perceptual span. By studying the eye movement photographs of over 12,000 readers, he reported the average span of vision in reading English at about four to five letters around a fixation point. His calculations were based on the number of fixations per 100 words of text. The subjects ranged from first grade to college age. Taylor's method of estimating the perceptual span, albeit an improvement on tachistoscopic research, is based on the assumption that successive fixations do not overlap the same amount. Subsequent research (Raynor and McConkie, 1977) has demonstrated that this assumption is probably false.

A computer-based method has recently been developed that seems to allow subjects to engage in the normal act of reading for meaning while data are extracted regarding the perceptual span. The text to be read was displayed on a television screen controlled by a digital computer. The reader's eye movements were simultaneously recorded and measured by the same computer, which was programmed to make the appearance of the text contingent upon the position of the eyes while reading. The computer displayed the text on the television screen so that each letter and space was replaced by a capital X. When the reader began and

the computer had determined that the eye was fixated at the beginning of the first line, all the Xs around the center of the fixation were replaced with the actual letters in the text so that the reader could see them. When the eyes moved to the next fixation position, the earlier part of the text reverted to Xs, and the letters around the new fixation were uncovered. The computer program could be manipulated to vary the number of letters to be uncovered in a single glance and to record data such as the focus of a fixation and its duration (Rayner and McConkie, 1977).

A series of experiments have since been conducted with this equipment and extensively reported on in the literature concerning perceptual processes in reading (Rayner, 1975, 1977, 1979; McConkie, 1976, 1979; Rayner and McConkie, 1977; O'Regan, 1979). The evidence suggested that word shape and specific letters can be distinguished as far as 10-12 character spaces from a fixation; whereas, the meaning of words can be identified no more than four letter positions to the left of the center of vision and no more than about 10-12 letters positions to the right. Such data have led Rayner and McConkie (1979) to conclude that reading takes place in a relatively linear fashion, with the reader rarely identifying more than two or three words per fixation.

Information was also extracted from these studies concerning the positioning of an eye fixation and the integration process over separate fixations. Readers seem to avoid fixating the last few letters of the word in a sentence, the punctuation mark and space between sentences, and the first few letters in the next sentence (Rayner and McConkie, 1979). The word <u>the</u> tended to be skipped more often than several three letter verbs occurring in the same context and resulted

in fewer and shorter fixations (O'Regan, 1979). Also, there appears to be some relationship between fixations and word-length patterns, which has been interpreted as being reflective of the types of cognitive processes occurring at specific points in the text. Rayner (1975) examined the reader's ability to integrate information from two separate fixations into a single representation. He attributed this occurrence to higher order mental operations and observed that certain visual or semantic discrepancies introduced between fixations would prohibit the integrative process. Apparently the decisions concerning where to direct the eye and how long it should remain for a fixation are connected to central processing abilities of the individual. Research of the type described heretofore may be headed toward answering vital questions about the perceptual span in reading and the nature of fluent reading.

A related study designed to provide evidence that the eyes reflect the internal processing abilities of the individual was conducted by Haber, Haber, and Furlin (1980). Subjects were presented with portions of a passage that ended in midsentence. The reader had to guess the next word. Additional portions of the text would then appear, again ending in the middle of a sentence, and the subjects had to guess what the next word was. Sometimes the word to be guessed was merely indicated by blank spaces, sometimes by the number of letters in the correct word, and sometimes by both the number of letters and the shape of the word. Regardless of the difficulty of the text, the reader's guessing accuracy was increased by knowledge of the correct number of letters and the shape of the word. The authors argued that the results are evidence of how readers can make use of word length information and

word shape information to help them extract the meaning of the text. The evidence also seems to suggest that the eye picks up information beyond the center of a current fixation. This provides additional support to the conclusions reached by Rayner and McConkie regarding the nature of the perceptual span.

In summary, the available eye movement research has indicated that the skilled reader's eye movements are flexible and adaptive to demands of the text being read. As the cognitive processing load increases, the reader responds by altering existing eye movement patterns and durations to accommodate the brain and to gain meaning from the printed materials. And, as Just and Carpenter (1976) have noted, "since eye fixations are sensitive to the structure of the internal representation being constructed or operated upon, they provide a valuable methodology for examining how linguistic material is interpreted" (p. 471).

The Relationship Between Visual Processing Behavior and Syntactic Structures

If eye movements are sensitive to specific features of text such as word length and shape, it is reasonable to assume that the linguistic structure of text can also influence visual processing behaviors. Moreover, an examination of the literature reveals that references to grammatical structure and eye movements are fairly extensive and date back to some of the earliest research efforts (Huey, 1908; Judd and Buswell, 1922).

Bayle's (1942) inquiry into regressive eye movements attributed many of the right-left shifts to reader difficulties with word order, word groupings, the juxtaposition of certain words, the absence of punctuation, shifts in the meanings of words, and in the

particularities of key sentence units (p. 17). Mackworth, as reported by Miller and Isard (1964), found that self-embedded sentences increased both the number of fixations and the number of regressions for subjects. In addition, the area of processing difficulty was centered around the string of seemingly unrelated verbs that the reader encountered near the end of the self-embedding. Unfortunately, the embedded structures selected for use in this study were abnormally long and unreflective of normal reading material.

Mehler, Bever, and Carey (1967) studied the relationship of surface phrase structure to eye fixation patterns of university students. Their attempt was to develop a precise rule that would explain eye fixation movements on the basis of surface syntactic structure. Subjects read sentences with varying types of ambiguity, and the data indicated that the reader fixates on the first half of each immediate constituent. Initially, the Mehler et al., finding was hailed as an important step in the area of psycholinguistic research. Gradually, however, limitations were discerned (Wanat, 1971). Mehler et al., discarded approximately half of their data and failed to distinguish between forward fixations and regressions. Their procedures also failed to take into account the duration of a fixation, making it impossible to determine which areas were the most time consuming to process. Finally, Mehler et al., used ambiguous sentences to test their subjects, which further limited the generalizability of their findings.

Syntactic structures such as active versus passive and right-embedding versus left-embedding have been studied in terms of their comprehensibility and relative effects on eye movements. Wanat (1971), Klein and Kurkowski (1974), Bader, Pearce, and Thompson (1980), and

Bader, Zynda, Thompson, and Pearce (1981) looked for significant alterations in the way eyes are directed by reading such sentences. Wanat's subjects read varying syntactic structures in isolation. He found that the structurally less predictable left-embedding requires more visual attention. Although the number of fixations and regressions were equal between the left- and right-embeddings, the left-embedded forms required more total time to process. Moreover, in both structures, the greatest fixation time was allocated to the main verb of the sentence. On the other hand, subjects were differentiated only in terms of regressions on the active and passive sentences. Wanat posits that this is because of the structural predictability within the sentence frame as contrasted to the immediate constituent differences of the left- and right-embeddings. Therefore, forward fixations were not affected, but when grammatical expectations were not confirmed, regressive fixations occurred.

Klein and Kurkowski (1974) examined the total number of eye movements necessary to process right-branching and self-embedded sentences in isolation. On half of their trials, subjects were also forewarned that questions would follow the sentence presentation. Their results showed a greater number of eye movements for the self-embedded sentences and for the trials on which questions were asked. Unfortunately, only total movements were reported and no attempt was made to differentiate forward fixations, regressions, or gaze durations. An additional limitation is that the self-embedded sentences used in this study were atypical and not representative of the types found in normal reading situations.

Bader, Pearce, and Thompson (1980) investigated the processing of left- and right-embedded sentences under conditions of related and unrelated discourse. Their subjects were competent adult readers whose eye movements were monitored while reading the embedded structures in unrelated sentences and in cohesive paragraphs. They found that both context, supplied by preceding discourse, and syntactic structure affect cognitive processing. Unrelated sentences were processed more slowly than those that were part of a paragraph, while the left-embedded structures were processed more slowly than the right-embedded structures in both conditions. They also found that the left-embedded construction increased the number and duration of regression regardless of the contextual condition, but that forward fixations did not significantly differ. These results are in general agreement with Wanat's (1971) findings concerning processing time and number of forward fixations for self-embedded constructions. The findings concerning regressive eye movements are not in agreement, which Bader et al., attribute to differences in design, contextual elements, and reader task.

In a more recent study, Bader, Zynda, Thompson, and Pearce (1981) compared the abilities of sixth grade competent readers and adult competent readers to process syntactic structures under conditions of related and unrelated discourse. Eye movements were recorded while these subjects read left- and right-embedded structures in conditions presenting unrelated sentences and in cohesive paragraphs. They found that the ability to process syntactic and semantic elements is not fully developed in children 11 or 12 years old. The authors speculated that these young readers were attending more to semantic rather than syntactic elements which may be an adaptive characteristic of normal

growth toward reading maturity. They also noted that the younger readers seemed more like the adults in number of fixations and less like the adults in duration of fixations. An interpretation that Bader et al., made is that the number of fixations may be related to linguistic chunking while duration of eye movement may be related more to memory and memory search. It would seem that further studies are warranted to clarify the role of syntactic structures in reading comprehension and that developmental research might help us learn which characteristics of processing are normal at various ages.

The role of context in guiding eye movements was the subject of an earlier study by Morton (1964b). University students orally read 200-word passages of statistical approximations and the results showed that greater contextual constraint decreased the number of both forward and regressive eye movements. Morton noted that the better readers were able to utilize more contextual constraints and, thus, read faster as the difficulty of the passage increased. The major limitation to his study, however, is that statistical approximations as opposed to connected English text were used. Therefore, his results do not shed much light on contextual constraints and cognitive processing in normal reading.

Carpenter and Just (1977) examined the rapid psychological processes that integrate information across the sentences of a paragraph. Specifically, their study was designed to determine if regressions are selective acts and indicative of the inter-sentence relations provided by pronoun referents. Subjects read short paragraphs with varying linguistic cues to the pronoun referent. The results suggest that regressive fixations are at least partically due to the reader's effort to

successfully integrate the linguistic elements of the paragraph. The pronoun referents, although frequently triggering regressive eye movements, were judged to be one of many possible linguistic structures that play a role in the cognitive processing of connected discourse.

Shebilske and Reid (1979) also studied integrative comprehension processes through eye movement analysis. They asked college students to read a 1888 word narrative text and recorded the total gaze duration per sentence. By converting their data to words per minute for each sentence, they were able to detect variations in processing time for sentences that had to be integrated with others to form higher order conceptual units. Although their methodology was not concerned with numbers and locations of fixations or regressions, the data provide additional evidence that the cognitive processes that underlie comprehension can be analyzed during reading and that eye movements are reflective of these complex acts.

In summary, the research analyzing the effects of linguistic structure of visual processing behavior provides evidence of a strong relationship between the two variables, although the exact nature of the realtionship seems unclear. The different findings from one study to the next are partially due to variations in eye movement recording devices, but mostly due to the unusual number of approaches adopted by the researchers. Results obtained from ambiguous sentences or the reading of isolated sentences must differ from the more typical structures found in connected discourse. Additional variations can be attributed to differences in the individual, the structure of the text, and the purpose of the reader. Finally, a portion of the observed differences must reflect a problem inherent in any research on reading

comprehension. The absence of an agreed-upon model of the underlying processes, coupled with controversy over the nature and role of eye movement research, will not yield uniformity. Perhaps we are fortunate as the interim search for solutions, albeit ponderous at times, has constantly shifted directions and may be getting closer to unlocking the mysteries of the human language processor. There needs to be a continued effort to design studies that approximate natural reading conditions as a means of probing cognitive processing and reading comprehension.

The Effects of Syntactic Structures on Recall Performances

In the past few years, there has been an increased interest in studying the process of reading comprehension. Earlier research efforts had given us general notions regarding the complex interaction between reader and text, but often the results were inconclusive and questionable. The current revival has been attributed to numerous factors ranging from a shift in governmental funding policies for research grants to the psycholinguistic developments of the 1960s that have opened doors to the structural characteristics of text. Regardless of the cause, researchers and writers are fairly uniform in agreement that our energies must be channeled into the development of a clear-cut definition and a theory of reading comprehension. As Frase (1972) stated,

> It is a task that must be undertaken if we are to understand how the relationship among words that represent ideas in a text control and maintain conceptual processing, and consequently how they determine the knowledge that results from reading (p. 338).

For the purposes of this literature review, no attempt will be made to present the historical developments in reading comprehension

research that have been primarily aimed at establishing the components of the process, determining how the reader's facility in each of these components can be measured, and detecting how the reader's ability in each component can be improved through instruction. Instead, efforts will be devoted to describing comprehension recall as a means of measuring what people understand from written language and the effects of syntactic structures on individual performances (see Gibson and Levin, 1975, for a thorough review of comprehension research).

The most serious obstacle to the attainment of a detailed theory and workable definition is the inaccessible nature of the comprehension process. The fact that a person is able to gain meaning from a series of configurations through visual and mental manipulations is a remarkable achievement. The researcher is confronted with an indeterminable array of possible components, most of which are not directly observable and are not open to introspection. This fundamental limitation has resulted in a myriad of interpretations in the research on reading comprehension. For example, Carroll (1972) states that the available data suggest the existence of a continuum ranging from comprehension of simple sentence structures through inferential processes of considerable complexity, whose various stages can be identified by experimental techniques. Furthermore, Carroll identifies two processes that seem to co-occur with comprehension--memory and inference (or reasoning), and states that their mere existence is what makes it so difficult to assess comprehension.

By contrast, the psycholinguistic view (Bransford and McCarrell, 1974) does not see comprehension as a set of mental processes which can be defined independently of language. Instead, it involves certain

language features (surface structure cues, syntactic cues, and semantic cues) that operate on the comprehender's cognitive structure. The knowledge one possesses of one's language thus acts as a guide to specify the conditions under which an understanding can be formulated. An individual's prior knowledge of the world also makes an active contribution to the total process. This view of comprehension, then, explains how a person can have knowledge of a language and still fail to grasp the meaning of a passage because he/she is unable to make the necessary cognitive contributions. It also accounts for the manner in which individuals arrive at different understandings of the same material through variations in cognitive input.

For the purposes of this study, comprehension will be viewed as the end result of the interaction between reader and connected discourse. The crucial variables to a meaningful interaction are the linguistic properties of the written passage and the individual's short-term memory and semantic memory.

The present study was designed to investigate the effect of selected syntactic structures on visual processing behavior and recall performance. One of the most frequently used methods of data collection by those interested in probing short-term or semantic memory is to test how much a subject can remember about a previously presented stimulus. The two methods for tapping memory are free recall and recognition recall. In a free recall test, people have to produce or write down a sentence or passage they have been given previously. Sometimes they are prompted with a word or phrase--like the subject of a sentence--and asked to recall the corresponding sentence. In a recognition recall test, on the other hand, people are shown a sentence and

asked if it were one they had seen or heard before. They may be shown two or more sentences and asked to point to the one they had seen or heard previously.

Recognition recall is usually more accurate than free recall and offers the researcher a more controlled data assessment technique. One simply scores the recognition test for each item that was in the original material read. Naturally, the items selected for the recognition test must be high in information content and essential to an overall understanding of the sentence or passage. Low information words and phrases and non-essential details should not be included in recognition recall tests as their value to comprehension is uncertain.

Free recall, by comparison, is less accurate due to the varied responses produced by the subjects. As a result, researchers are confronted with difficulty in evaluation. There is no universal method of scoring a recall test for similarity to the original sentence or passage. In one instance, the exact words from the stimulus may be acceptable, while a suitable paraphrase may suffice in another. Even so, cognitive psychologists interested in the structural properties of human memory and comprehension have often adopted this procedure as a means for comparing the subject's recall with an observable stimulus. The current study employed a recognition recall test to assess memory for selected syntactic structures presented in connected discourse. This method was selected because it offered a more controlled data assessment technique and was judged to be more accurate than a free recall test.

Memory plays an integral part in reading and comprehension. Information is deposited and retained in memory for use at various stages

in the sequence of information processing. Psychologists have traditionally distinguished between short-term memory and long-term memory. Short-term memory is a place where exact wording is stored for brief periods of time. Long-term memory, on the other hand, is the place where more permanent information is stored. It deals generally with meaning rather than exact wording and, for the most part, has unlimited capacity.

The traditional view is that short-term memory corresponds roughly to what has been called the working memory. This is the area where the psychological content and isolated constituents of a sentence are placed. It is also the place where the interpretation of a sentence is first stored. As stated earlier, a portion of the present study was designed to investigate the recognition recall abilities of competent readers regarding selected syntactic structures. The available information on the memory process would indicate that the study will probe the short-term memory span for the targeted linguistic forms.

Short-term memory has limitations that play a central role in recall performance. First, the memory span is limited by the number of "chunks" it can hold, where a chunk is a meaningfully-coded unit (Clark and Clark, 1977). Therefore, when an individual is asked to recall digits, letters, or unrelated words, the memory span has been from about six to eight items depending on the individual. When the words make up larger constituents, as they do in sentences, the memory span for words increases dramatically--up to twenty or twenty-five words (Clark and Clark, 1977). This suggests that larger constituents, such as sentences and paragraphs, and the way they are interpreted play a crucial role in any form of recall. Second, short-term memory does not

preserve the words in the order in which they arrive and does not record exactly what is printed on the page. In recall tests people often make alterations in word order, leave words out, and sometimes change them altogether.

Research by Sachs (1967, 1974) has demonstrated that the original syntactic form of a sentence is stored only long enough for comprehension to occur. Subjects failed to recognize sentences with different words, surface structures, or deep structures as different from those in a given passage unless the meaning had been changed. In short, verbatim wording is lost very rapidly, but meaning is retained over much longer periods.

The implications of Sachs' research for recognition recall testing are obvious. A subject must have internalized the meaning of a sentence or passage in order to correctly identify it in a test situation. In addition, test foils must not be simple adjustments in word order, but must change the meaning from the original form. A failure to account for these variables would cast serious doubt on any experimental results.

Anderson (1974) also demonstrated the limitations of short-term memory or retrieval time. When an event was tested immediately after being read in a story and was still in short-term memory, subjects were better able to recall it verbatim. In fact, it took a two minute interval between the input of information and the recall test before verbatim performances began to differ significantly. Anderson concluded that people are able to retain some verbatim wording over longer intervals when they know they are going to be tested. Most likely, people also retain information central to the theme of the passage

for longer periods of time. In Anderson's study, when the test and the original sentence had the same subject, they were judged slightly faster.

A study by Tversky (1974) explored the relationships between eye fixation patterns and expected memory tasks. She found that there was no correlation between the recognition of an item and its recall. It seems that subjects varied their strategies depending on the requirements of the recall test. Tversky did substantiate that subject viewing patterns were somewhat related to their verbal recall performances. A greater number of word fixations were associated with better verbal recall. It is doubtful that these findings have relevancy to the present study because of the considerable difference in experimental conditions.

In summary, the use of a recognition recall test to assess an individual's comprehension of written material is a commonly adopted technique. Its acceptance as a valid measure of comprehension seems to rest with one's definition of the process by which we gain meaning from print. The popular view of the reader as one who combines his/her knowledge of the language and our world with the linguistic properties of the written material to understand allows for such an approach. The fact that literature on the effects of syntactic structures on recall is relatively sparse suggests a need for additional studies in this area to clarify the admittedly complex process.

Short-term memory acts as an immediate storage area for information along the road to comprehension. The available evidence suggests that verbatim wording and semantic interpretations are retained in short-term memory. However, short-term memory does not retain all the

surface structure of a sentence, the exact wording of many sentences, or the correct word order in sentences. Generally, the accuracy of retention depends on the interval period between the input of information and the recall test. The more time an individual has to work or a passage, the less of its form is retained, while the content or meaning is more permanently preserved.

Chapter Summary

This chapter reviewed the related literature and research in four sections. In the first section, literature and research were summarized which reported on the relationship between understanding syntactic structures and comprehending sentences. In addition, several studies were reviewed which identified syntactic structures which may contribute to reading comprehension problems.

The second section in this chapter cited research and literature concerned with the relationship between visual processing behaviors and reading comprehension. There was general agreement that the eye movements of a skilled reader are flexible and adaptive to the demands of the material being read. When the cognitive processing load increases, the reader will alter his/her eye movement patterns and durations to accommodate the brain and to gain meaning from the printed material.

The research and literature in the third section of this chapter reported on the relationships between the syntactic structure of text and the visual processing behavior of the readers. There was strong evidence of a relationship between selected linguistic structures and eye movement patterns such as forward fixations, regressive fixations, and gaze durations. Unfortuantely, the exact nature of the

relationship is unclear due primarily to the variety of approaches that researchers have adopted for the investigatory process.

The fourth section in this chapter summarized literature and research on the effects of syntactic structures on comprehension and recall. There appeared to be a general agreement that the use of a recognition recall test immediately following the reading of text can probe an individual's short-term memory. In addition, several studies were reviewed which showed that short-term memory retains the meaning of a sentence or passage, while the surface features are frequently not retained with great accuracy.

Since the majority of previous eye movement research on reading comprehension and the syntactic structure of text has been restricted to ambiguous strings of words, lists of words or brief phrases, and isolated sentences, it appears that there is a need for further research on visual processing behavior during the reading of connected discourse. Furthermore, there is also a need for a clearer understanding of the effects of selected syntactic structures on eye movement patterns and the cognitive processing behavior of the reader. This study was designed to demonstrate that selected syntactic structures influence the visual processing behavior and recall performance of the reader. The following chapter describes the methodology of the study.

CHAPTER III

METHODOLOGY OF THE STUDY

Introduction

This chapter explains the methodology employed in conducting the study. The data collection procedures were similar to those used by Bader, Pearce, and Thompson (1980) in their study of the effect of connected discourse on the processing of left- and right-embedded syntactic structures. The content of this chapter will be presented in seven major sections. First, a description of the sample subjects who participated in the experiment will be given. Second, the materials used will be described. Third, a description of the apparatus used to collect the data will be given. The fourth section will specify the procedures used in data collection. The fifth section will discuss the design of the study. The sixth section will present the hypotheses constructed for the study. The last section will discuss the data analysis procedures. A summary of the chapter will be included.

Population

Thirty-four university graduate students participated in the study. They were randomly selected from a pool of graduate students who volunteered to participate in an eye movement study. The assumption was made that all of the subjects were competent adult readers on the basis of their educational level. All were native English speakers.

Materials

The materials used in this study were four separate paragraphs, 16 recall displays, and a subject answer sheet. Each paragraph was constructed around a target sentence. There were two target sentences, each of which had a left-embedded form and a right-embedded form. The two pairs of target sentences (left-embedded form and right-embedded form) were of the same length (11 words), were of active voice, and employed no dependent clauses with the exception of the target embedding. A left-embedded sentence contained a relative clause following and modifying the sentence subject, while a right-embedded sentence contained a relative clause following and modifying the object of the sentence. Each target structure was written into a paragraph extending over ten lines that was cohesive with regard to semantic context. In each paragraph, the embedded sentence appeared on the sixth line. In addition, the sentence following the embedded structure was constructed to contain information essential to an understanding of the semantic message of the paragraph. This sentence appeared on the seventh line (see Appendix A).

Sixteen recall displays were used to evaluate the subjects' ability to recognize the structures contained in the paragraphs. A display contained one sentence. Each of four displays contained the embedded sentence presented in the paragraph condition. Four additional displays contained a test foil for each embedding (the opposite form of that which was presented to a subject). Each of four displays contained the sentence which succeeded the embedded structure. Four additional displays contained a test foil for these sentences. The foils contained the same subject and information as the original

sentence, but differed in syntactic order and in overall meaning (see Appendix B). The sentences were typed on IBM pica and transferred to an overhead transparency for presentation to the subjects.

A subject answer sheet was used to record responses to the recall test. Each answer sheet was numbered 1-8 and labeled YES/NO.

Apparatus

The paragraphs were typed on IBM pica, single spaced on 3½" x 5" cards and presented with the Biometrics Reading Eye II, an eye movement camera distributed by Educational Development Laboratory (EDL). With this instrument, the head is held stationary by a chin cup and forehead bars. A photo-electric beam is reflected off the cornea of each eye onto heat sensitive graph paper. While the stimulus card is being read, eye movements are recorded as a line on the graph paper. Each square on the graph paper is equal to 1/10 of a second.

Figure 1 shows a typical pattern of movements made while reading a single line of text. There are six principal components of interest in such a record: the number of forward fixations, the number of regressions, the number of total movements, the duration of forward fixations, the duration of regressions, and the duration of gaze. In this particular example, there are nine forward fixations and one regression, resulting in 10 total movements. The average duration for forward fixations is .189 seconds. The single regression had a duration of .150 seconds, and the duration of gaze was 2.85 seconds. All of these measures are typical for a competent adult reading a passage of medium difficulty.

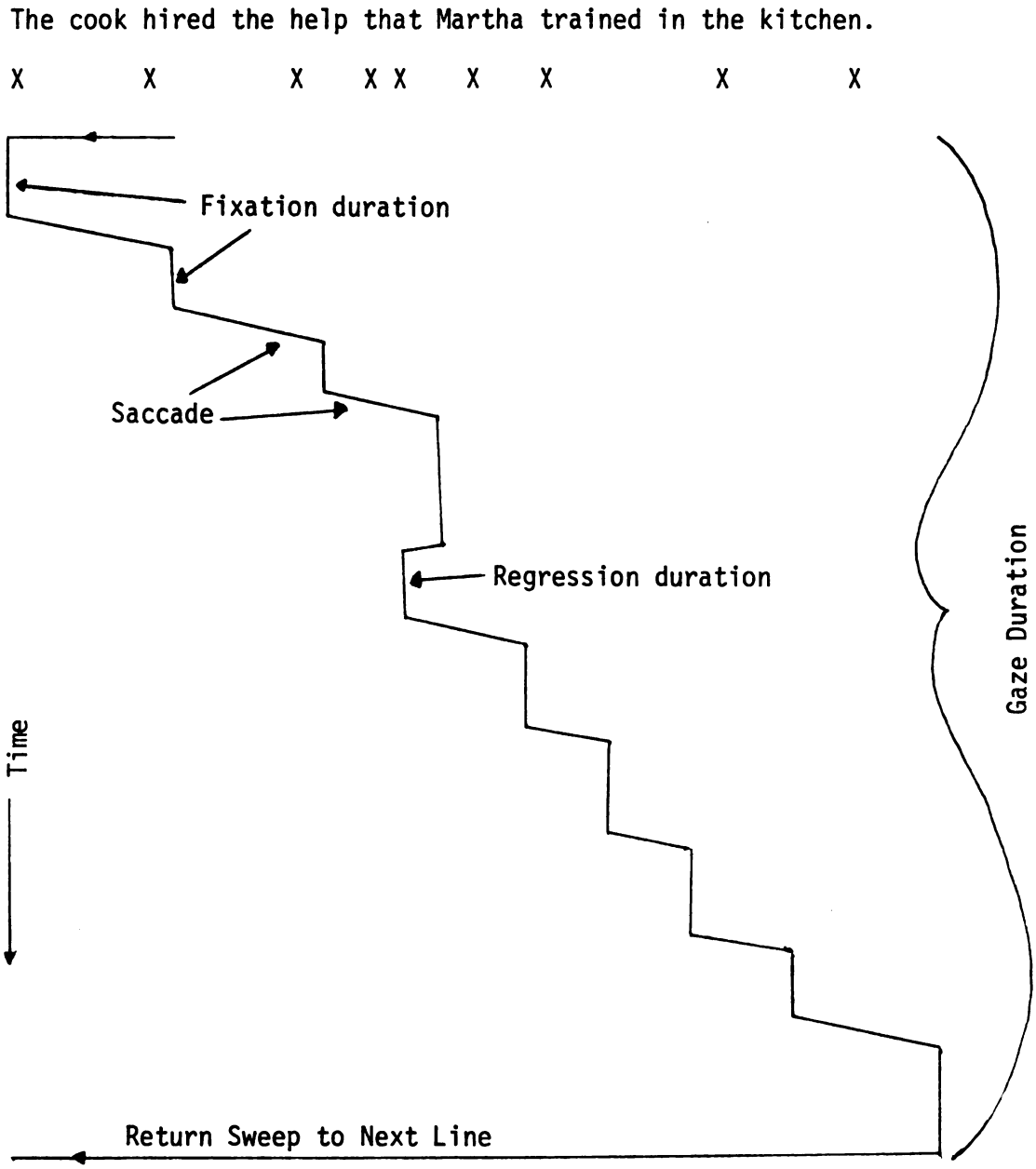

Figure 1. A hypothetical recording of eye movements by the Reading Eye II made while reading a sample sentence. Horizontal position of the line indicates position of the center of the fovea over the text and the vertical line position indicates time. The sentence being read is indicated at the top, with the position of each fixation indicated by the X. The values for the fixation duration and regression duration associated with each pause are indicated on the right. Fixation and regression durations are shown on the next page.

Fixation and regression durations for pattern of movements shown in Figure 1:

Fixation Duration	Regression Duration
.150	----
.150	----
.100	----
.300	----
----	.150
.200	----
.175	----
.175	----
.175	----
.275	----
1.700	.150

Procedure

The subjects were tested individually. The subjects were read a prepared set of instructions informing them of the operational procedures of the Reading Eye II (see Appendix C). They were told that they would be asked to silently read several different paragraphs during the recording process. They were also instructed to read naturally and to pay attention to the material on the card so that they might be able to recall it afterwards.

After the subjects' eyes were properly aligned to the Reading Eye II, they were instructed to close their eyes between selections and to maintain a motionless posture while reading the cards. The experiment included three reading selections: an EDL paragraph, a left-embedded paragraph, and a right-embedded paragraph. The subjects

initially read an EDL paragraph so as to accustom their eyes to the apparatus and allow the experimenter to make final recording adjustments. At the conclusion of the experiment, subjects were asked if they encountered any reading difficulties or if they reread any portion of the three selections. Their responses were recorded.

Following the reading selections, the subjects were presented with eight recall displays and an answer sheet. They were instructed to mark "yes" if they could remember a sentence from the selections and "no" if they could not. Each recall display was available to the subjects for the time it would take to read a sentence at the rate of 200 words per minute. The subjects were not told whether, in fact, any of the recall items had actually been in the reading selections and were not allowed to view a recall display a second time.

Design

The basic design of the study was threefold. First, the subject's visual processing behaviors on the sentence succeeding a left-embedding were contrasted with their visual processing behaviors on the sentence succeeding a right-embedding. Within the reading condition, subjects were assigned on a rotating basis one of two paragraphs containing a left-embedding and one of two paragraphs containing a right-embedding. Subjects were also randomly assigned to varying paragraph orders. No subject received left- and right-embedding sentences in paragraphs from the same word source.

Second, the subject's ability to recall selected syntactic structures was examined. The recall structures were presented to the subjects in random order and were analyzed for the following factors: the

number of left-embedded sentences recalled, the number of right-embedded sentences recalled, the number of sentences succeeding a left-embedded structure recalled, and the number of sentences succeeding a right-embedded structure recalled.

Third, the relationship between the visual processing behaviors of the subject on the sentence succeeding an embedded structure and their recall of selected syntactic structures was investigated. Each recall performance was evaluated by the investigator to determine whether that subject should be classified as a good or poor reader. The sole criterion for classification was the overall score obtained on the recall test. One point was awarded for each correct identification of either a target structure or a foil. No points were given to incorrect selections. Therefore, it was possible for an overall score to range from zero (no correct answers) to eight points (all correct answers). A good reader was defined as someone falling in the six to eight point range, while a poor reader fell in the zero to five point area. Both of the groups (good and poor readers) were then studied for significant differences in visual processing during the reading of selected syntactic structures in connected discourse.

Hypotheses

The following hypotheses were constructed from the research questions presented in Chapter I.

1. There is a relationship between the visual processing behaviors of competent adult readers on the sentence succeeding a left- and right-embedded structure.

    1.1 There is no difference in the numbers of total fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure.

1.2 There is no difference in the number of forward fixations for competent adult readers on the sentences succeeding a left- and right-embedded structure.

1.3 There is no difference in the numbers of regressions for competent adult readers on the sentence succeeding a left- and right-embedded structure.

1.4 There is no difference in the duration of forward fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure.

1.5 There is no difference in the duration of regressions for competent adult readers on the sentence succeeding a left- and right-embedded structure.

1.6 There is no difference in the duration of gaze for competent adult readers on the sentence succeeding a left- and right-embedded structure.

2. There is a relationship between the recall of selected syntactic structures by competent adult readers.

2.1 There is no difference in the recall of left- and right-embedded structures by competent adult readers.

2.2 There is no difference in the recall of the sentence succeeding a left- and right-embedded structure by competent adult readers.

3. There is a relationship between the visual processing behaviors of competent adult readers and their recall of selected syntactic structures.

3.1 There is no difference in the number of total fixations on selected syntactic structures for those adults with good recall and those with poor recall.

3.2 There is no difference in the number of forward fixations on selected syntactic structures for those adults with good recall and those with poor recall.

3.3 There is no difference in the number of regressions on selected syntactic structures for those adults with good recall and those with poor recall.

3.4 There is no difference in the duration of forward fixations on selected syntactic structures for those adults with good recall and those with poor recall.

3.5 There is no difference in the duration of regressions selected syntactic structures for those adults with good recall and those with poor recall.

3.6 There is no difference in the duration of gaze on selected syntactic structures for those adults with good recall and those with poor recall.

Data Analysis

The information tabulated on the eye movements of the subjects and the recall tests was keypunched on IBM computer cards. The data were analyzed for statistical significance by a matched pairs t-test, a t-test of means, and analysis of variance, subprogram MANOVA of SPSS (Statistical Package for the Social Sciences).

A matched pairs t-test was used to investigate the difference in visual processing behaviors of competent adult readers on the sentence succeeding a left-embedded structure and the sentence succeeding a right-embedded structure. The independent variables are the sentence following each of the embeddings, and 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, and gaze duration.

A t-test of means was used to investigate the difference in the recall of the left- and right-embedded structures and the recall of the sentence succeeding the left- and right-embedded structures. The independent variables are the selected syntactic structures, and the dependent variables are the recall performances of the competent adult readers.

Analysis of variance was used to investigate the relationship between the visual processing behaviors of competent adult readers and their recall of selected syntactic structures. The independent variables are the visual processing behaviors: total number of fixations, number of forward fixations, number of regressions, duration of forward fixations, duration of regressions, and gaze duration. The dependent variables are the recall performances of the adults when classified into good and poor recall categories.

Summary

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

The sample population consisted of 34 university graduate students considered to be competent adult readers. Eye movements were recorded while the subjects silently read paragraphs containing a left- and right-embedded sentence. The subjects were then given a recognition recall test to assess their memory for the embedded structure and the sentence succeeding the embedding.

The data were analyzed with regard to the visual processing behavior of the subjects on the sentence succeeding the embedded structure, the recall performance of the subjects for the embedded structure and the succeeding sentence, and the visual processing behavior of the subjects on the sentence succeeding the embedded structure for those with good recall and for those with poor recall.

The eye movements were photographed with the EDL/Biometrics Reading Eye II, and the materials used in the machine were four paragraphs. Each paragraph was typed on IBM pica type on a 3½ x 5" card. The

recall displays were typed on IBM pica type and presented on an overhead transparency.

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

CHAPTER IV

PRESENTATION AND ANALYSIS OF THE DATA

Introduction

The purpose of the study was to obtain and analyze data concerning the information-processing behaviors of competent adult readers when presented with selected syntactic structures during the reading of connected discourse.

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 hypothesis constructed for the study.

Hypotheses and Statistical Tests

The data concerning the visual processing behaviors of competent adult readers were analyzed using a matched pairs t-test. The data regarding the recall of the left- and right-embedded structures, and the sentences succeeding a left- and right-embedded structure were analyzed using a t-test of means. Analysis of variance was used to analyze the data on the visual processing behaviors of competent adult readers and their recall of selected syntactic structures.

The five percent level (.05) was chosen as the level for rejection of the null hypothesis being tested. It was selected as being sufficiently precise for the conditions of this study. Therefore, if the chance probability were five times in one hundred or less, then the

reflected difference was presumed not to be able to happen by chance, and the null hypothesis was rejected; but if the reflected difference might happen more than five times in one hundred (.05) through the influence of chance, the null hypothesis was not rejected. This reflects a 95% surety in preventing mistaken interpretations.

The hypotheses were presented in Chapter III in null form to make appropriate statistical hypotheses. Hypothesis 1 was, in turn, divided into six sub-hypotheses. Hypothesis 2 was divided into two sub-hypotheses, and Hypothesis 3 was divided into six sub-hypotheses. These will be restated with the findings for each one.

Hypothesis 1

1: There is a relationship between the visual processing behaviors of competent adult readers on the sentence succeeding a left- and right-embedded structure.

Ho 1.1: There is no difference in the number of total fixations of competent adult readers on the sentence succeeding a left- and right-embedded structure.

For the variable, number of total fixations, a t-test comparing the sentence succeeding a left-embedded structure with the sentence succeeding a right-embedded structure was performed (see Table 1). There were no significant differences in the number of total fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure. Hypothesis 1.1 was accepted.

Ho 1.2: There is no difference in the number of forward fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure.

The hypothesis was tested with a matched pair t-test (see Table 1). There were no significant differences in the number of forward

Table 1. T-test: Visual Processing of Competent Adult Readers on the Sentence Succeeding a Left- and Right-Embedded Structure.

Variables	Mean	SD	t	p
LE, P and RE, P				
Total Movements (L & R)	8.94	4.31	1.27	.211
Forward Fixations	7.10	2.73	1.07	.294
Regressions	1.84	2.09	1.23	.227
Duration of Forward Fixations	1.34	0.66	1.20	.238
Duration of Regressions	0.39	0.44	1.15	.259
Duration of Gaze	1.73	0.98	1.33	.194

*p < .05

KEY: LE - left-embedding
RE - right-embedding
P - paragraph (connected discourse)

fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure. Hypothesis 1.2 was accepted.

Ho 1.3: There is no difference in the number of re-regressions for competent adult readers on the sentence succeeding a left- and right-embedded structure.

The hypothesis was tested with a matched pairs t-test (see Table 1). There were no significant differences in the number of regressions for competent adult readers on the sentence succeeding a left- and right-embedded structure.

Ho 1.4: There is no difference in the duration of forward fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure.

The hypothesis was tested with a matched pairs t-test (see Table 1). There were no significant differences in the duration of forward fixations for competent adult readers on the sentence succeeding a left- and right-embedded structure. Hypothesis 1.4 was accepted.

Ho 1.5: There is no difference in the duration of regressions for competent adult readers on the sentence succeeding a left- and right-embedded structure.

The hypothesis was tested with a matched pairs t-test (see Table 1). There were no significant differences in the duration of regressions for competent adult readers on the sentence succeeding a left- and right-embedded structure. Hypothesis 1.5 was accepted.

Ho 1.6: There is no difference in the duration of gaze for competent adult readers on the structure succeeding a left- and right-embedded structure.

The hypothesis was tested with a matched pairs t-test (see Table 1). There were no significant differences in the duration of gaze for competent adult readers on the sentence succeeding a left- and right-embedded structure. Hypothesis 1.6 was accepted.

Hypothesis 2

2: There is a relationship between the recall of selected syntactic structures by competent adult readers.

Ho 2.1: There is no difference in the recall of left- and right-embedded structures by competent adult readers.

The hypothesis was tested with a t-test of means (see Table 2).

The data indicated that there were significant differences in the recall of left- and right-embedded structure by competent adult readers. Therefore, Hypothesis 2.1 was rejected.

Table 2. T-test: Recall of Selected Syntactic Structures by Competent Adult Readers.

Variables	Mean	SD	t	p
Left and Right				
-embedded structure	0.71	0.65	-2.10*	.044
-succeeding structure	0.68	0.69	-1.00	.325

*p < .05

Ho 2.2: There is no difference in the recall of the sentence succeeding left- and right-embedded structures by competent adult readers.

The hypothesis was tested with a t-test of means (see Table 2). There were no significant differences in the recall of the sentence succeeding left- and right-embedded structures by competent adult readers. Hypothesis 2.2 was accepted.

Hypothesis 3

3: There is a relationship between the visual processing behaviors of competent adult readers and their recall of selected syntactic structures.

Ho 3.1: There is no difference in the number of total fixations on selected syntactic structures for those adults with good recall and those with poor recall.

The hypothesis was tested with analysis of variance (see Table 3.1). There were no significant differences in the number of total fixations on selected syntactic structures for those adults with good recall and those with poor recall. Hypothesis 3.1 was accepted.

Ho 3.2: There is no difference in the number of forward fixations on selected syntactic

Table 3.1. Analysis of Variance: Number of Total Fixations and Recall by Competent Adult Readers.

Source	df	ss	Ms	F
Treatment	1	30.9413	30.9413	1.6511
Error	31	580.9375	18.7399	
Total	32	611.8788		

$p > .05$

structures for those adults with good recall and those with poor recall.

The hypothesis was tested with analysis of variance (see Table 3.2). There were no significant differences in the number of forward fixations on selected syntactic structures for those adults with good recall and those with poor recall. Hypothesis 3.2 was accepted.

Table 3.2. Analysis of Variance: Number of Forward Fixations and Recall by Competent Adult Readers.

Source	df	ss	Ms	F
Treatment	1	9.2406	9.2406	1.2193
Error	31	234.9412	7.5787	
Total	32	244.1818		

$p > .05$

Ho 3.3: There is no difference in the number of regressions on selected syntactic structures for those adults with good recall and those with poor recall.

The hypothesis was tested with analysis of variance (see Table 3.3). There were no significant differences in the number of regressions on selected syntactic structures for those adults with good recall and those with poor recall. Hypothesis 3.3 was accepted.

Table 3.3. Analysis of Variance: Number of Regressions and Recall by Competent Adult Readers.

Source	df	ss	Ms	F
Treatment	1	6.3638	6.3638	1.4519
Error	31	135.8787	4.3832	
Total	32	142.2425		

$p > .05$

Ho 3.4: There is no difference in the duration of forward fixations on selected syntactic structures for those adults with good recall and those with poor recall.

The hypothesis was tested with analysis of variance (see Table 3.4). There were no significant differences in the duration of forward fixations on selected syntactic structures for those adults with good recall and those with poor recall. Hypothesis 3.4 was accepted.

Ho 3.5: There is no difference in the duration of regressions on selected syntactic structures for those adults with good recall and those with poor recall.

The hypothesis was tested with analysis of variance (see Table 3.5). There were no significant differences in the duration of regressions on selected syntactic structures for those adults with good recall and those with poor recall. Hypothesis 3.5 was accepted.

Table 3.4. Analysis of Variance: Duration of Forward Fixations and Recall by Competent Adult Readers.

Source	df	ss	Ms	F
Treatment	1	.7175	.7175	1.6330
Error	31	13.6201	.4394	
Total	32	14.3376		

$p > .05$

Table 3.5. Analysis of Variance: Duration of Regressions and Recall by Competent Adult Readers.

Source	df	ss	Ms	F
Treatment	1	.5087	.5087	2.6643
Error	31	5.9193	.1909	
Total	32	6.4280		

$p > .05$

Ho 3.6: There is no difference in the duration of gaze on selected syntactic structures for those adults with good recall and those with poor recall.

The hypothesis was tested with analysis of variance (see Table 3.6). There were no significant differences in the duration of gaze on selected syntactic structures for those adults with good recall and those with poor recall. Hypothesis 3.6 was accepted.

Table 3.6. Analysis of Variance: Duration of Gaze and Recall by Competent Adult Readers.

Source	df	ss	Ms	F
Treatment	1	11.9541	11.9541	1.8262
Error	31	202.9230	6.5459	
Total	32	214.8771		

$p > .05$

Summary

Hypotheses 1 and 2 were tested with a matched pairs t-test and a t-test of means. The results were:

Hypothesis 1.1 - accepted

Hypothesis 1.2 - accepted

Hypothesis 1.3 - accepted

Hypothesis 1.4 - accepted

Hypothesis 1.5 - accepted

Hypothesis 1.6 - accepted

Hypothesis 2.1 - rejected

Hypothesis 2.2 - accepted

No significant differences were found in the visual processing behaviors of competent adult readers on the sentence succeeding a left- and right-embedded structure. A significant difference was found in the recall of left- and right-embedded structures by competent adult readers, while no significant difference was found in the recall of the sentences succeeding left- and right-embedded structures by competent adult readers.

Hypothesis 3 was tested with analysis of variance. The results were:

Hypothesis 3.1 - accepted

Hypothesis 3.2 - accepted

Hypothesis 3.3 - accepted

Hypothesis 3.4 - accepted

Hypothesis 3.5 - accepted

Hypothesis 3.6 - accepted

No significant differences were found in the visual processing behaviors of competent adult readers and their recall of selected syntactic structures.

CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Summary

The purpose of the study was to obtain and analyze data concerning the information-processing behaviors of competent adult readers when presented with selected syntactic structures during the reading of connected discourse. The study focused on the visual processing patterns of competent adult readers which occur in the structure immediately following left- and right-embedded sentences, the reader's ability to recall both the left- and right-embeddings and the succeeding structure, and the relationship between the reader's ability to recall selected syntactic structures and his/her visual processing behaviors. The behaviors measured were number of total movements, number of forward fixations, number of regressions, duration of forward fixations, duration of regressions, and duration of gaze.

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

1. The relationship between reading comprehension and syntactic structures.
2. The relationship between visual processing behavior and reading comprehension.
3. The relationship between visual processing behavior and syntactic structures.

4. The effect of syntactic structures on recall of information.

The eye movements of 34 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 related discourse, and a right-embedded structure in related discourse. Immediately following the reading selections, the subjects were presented with eight recall displays to evaluate their ability to recognize the syntactic structure in connected discourse.

Data concerning the visual processing behaviors of the competent adult readers were tested with a matched pairs t-test. No statistically significant differences were found for the adult readers when processing the sentence succeeding a left- and right-embedded structure in connected discourse.

A t-test of means examined the relationship between the recall of selected syntactic structures by competent adult readers. A statistically significant difference was found for the recall of left- and right-embedded structures, while no statitically significant difference was found for the recall of the sentence succeeding left- and right-embedded structures.

Data concerning the visual processing behaviors of the competent adult readers and their recall of selected syntactic structures were tested with analysis of variance. No statistically significant differences were found among the two recall conditions for each of the six visual processing behaviors.

The rationale of this study in examining visual processing behaviors and recall performance for competent adult readers was to

determine whether a pattern existed in the information-processing behaviors of the reader. Although no statistically significant differences existed on the sentence succeeding a left- and right-embedding for each of the six visual behaviors, an examination of the means for the areas of visual behaviors and recall performance seemed to be appropriate in order to learn whether there appeared to be a direction or pattern to the information-processing of competent adult readers. In all instances the sentence succeeding a left-embedding required a greater number of movements and longer duration pauses. When these differences were analyzed in relation to the adults with good and poor recall performance, the resulting mean scores and confidence intervals suggested a pattern in the information-processing behaviors of the reader. Consequently, the mean scores and confidence intervals for each of the visual processing behaviors for those adults with good and poor recall are presented in Figure 2.

Discussion

Analysis of the data indicated that competent adult readers made no statistically significant behavioral adjustments in their reading to accommodate the syntactic structure of the sentences being read. One interpretation of the data is that the proficient reading ability of the adults allowed them to immediately override any processing difficulties encountered with the left- and right-embedded structures. Bader, Pearce, and Thompson (1980) found that left-embedded sentences in connected discourse were significantly more difficult to process than were right-embedded sentences. The results of this study seem to suggest that the increased processing demands of the left-embedded

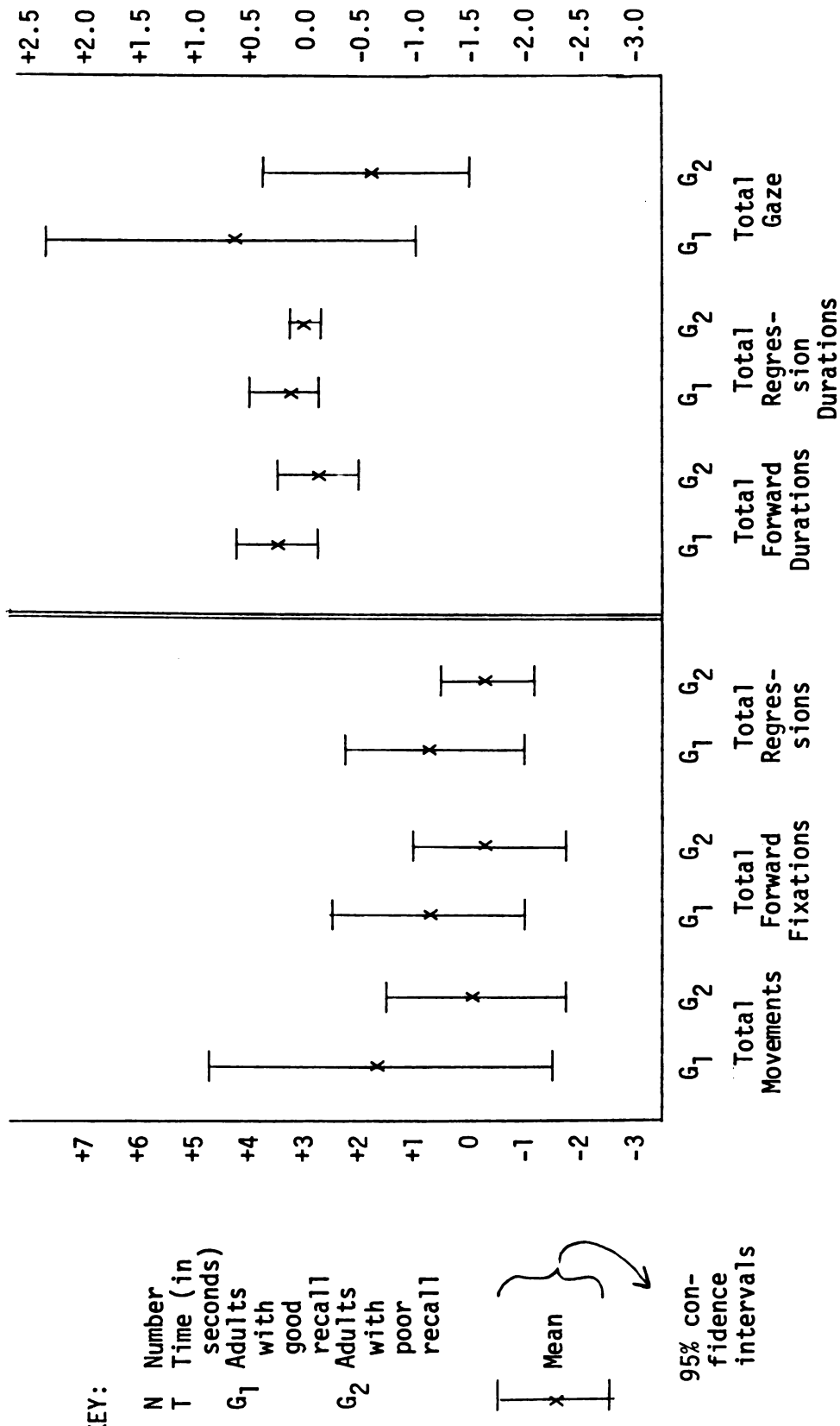

Figure 2. Means and 95% confidence intervals for visual processing behaviors and recall.

structure do not carry beyond its immediate boundaries for competent adult readers.

Another interpretation is that the passage used in the study placed only moderate processing demands upon the adults due to their sixth grade readability levels. The seemingly rapid readjustment succeeding the embedding might, therefore, be a function of the passage construction as well as the competency of the reader.

Although the results could not be allotted any statistical legitimacy, an examination of the means for the areas of visual behavior within the syntactic conditions seemed to be appropriate in order to learn whether there was a directional pattern to the visual processing of competent adult readers (see Table 4). An examination of the means indicated that the sentence succeeding a left-embedded syntactic structure required greater processing attention of the competent adult readers. Thus, the adult readers appeared to be moving toward the established syntactic discrimination patterns of the competent adult readers in the Bader et al., study (1980). However, the behavior appeared only as a tendency and cannot be interpreted as evidence of the role selected syntactic structures play in the information-processing abilities of the competent adult reader.

Analysis of the data comparing the recall performances of competent adult readers on the left- and right-embedded structures and the succeeding structures yielded a statistically significant difference for the embedded structures and no statistically signficant difference for the succeeding structures.

Table 4. Means for Visual Processing Behaviors.

Visual Behavior	Sentence Succeeding a Left-Embedding	Sentence Succeeding a Right-Embedding
Total Number of Movements	9.41	8.47
Total Number of Forward Fixations	7.35	6.85
Total Number of Regressions	2.06	1.62
Duration of Forward Fixations (in seconds)	1.41	1.27
Duration of Regressions (in seconds)	0.43	0.34
Duration of Gaze (in seconds)	1.84	1.61

While there have been a paucity of studies on the recall of selected syntactic structures in connected discourse, these results support the information-processing view concerning the central processing abilities of the skilled reader. When the reader encounters difficult material, processing alterations occur which are reflected in eye movement patterns (Judd and Buswell, 1922; Walker, 1933; Goltz, 1975; Carpenter and Just, 1977). Moreover, left-embedded syntactic structures frequently result in an increase in the number and duration of regressions and the total processing time for the reader (Wanat, 1971; Bader, Pearce, and Thompson, 1980). The recall performances of the competent adult readers in this study suggest that for left-embedded structures, an adjustment in eye movement patterns may in itself not result in comprehension. The increased demands on memory and memory search reflected in the visual processing adjustments may, for certain individuals, inhibit their apprehension of the sentence's message.

The difficulty in recalling the left-embedded structure is also in agreement with previous findings concerning the identification of syntactic structures encountered during the reading act (Sachs, 1967, 1974; Anderson, 1974). Since the original syntactic form of a sentence is not retained in memory for more then a few moments, the reader must grasp the meaning of the sentence in order to correctly identify it in a recall test. The competent adults in this study made noticeably less accurate recall judgments on the left-embedded structure. In fact, two-thirds of their responses on the recall test indicated that the left-embedded sentence foil had been in the origianl paragraph. Thus, it would appear that the meaning of the left-embedded structure was not completely internalized for many of the adults in the current study.

The fact that no statistically significant differences in recall performance were found for the structure succeeding a left- and right-embedding also supports the information-processing position on the central processing abilities of the skilled reader. When the syntactic pattern poses little or no problem for the reader, visual processing behaviors are more stable, and the reader's potential to understand the meaning of the sentence is enhanced. The previous data on the visual processing behaviors for the sentence succeeding a left- and right-embedded structure indicated no statistically significant differences in eye movement patterns for competent adult readers. Accordingly, one would anticipate that a recognition recall test of the succeeding structure would yield similar results. The data are supportive of this position and in agreement with theoretical views on cognitive processing behavior.

Analysis of the data comparing the visual processing behaviors of competent adult readers and their recall of selected syntactic structures yielded no statistically significant differences for those adults with good and poor recall. One interpretation of the data is that a Type II error occurred in the statistical analysis. The sample of adults with good recall included 16 subjects, while there were 17 subjects in the poor recall sample. In addition, differences did exist among the means scores and confidence intervals for each of the six visual processing behaviors and the two recall groups (see Figure 2). Therefore, one recommendation for future research is to increase the number of subjects and replicate these findings. The purpose of such an effort would be to determine whether the directional patterns can be replicated and statistical significance established.

Although the differences in mean scores and confidence intervals did not reach statistical significance, the directional patterns reveal that those adults with good recall made adjustments in their eye movements to accommodate the structural demands of the left-embeddings and the succeeding sentence. All six visual processing behaviors showed an increase in number of movements and length of duration during the reading of the left-embedded paragraph. On the other hand, the adults with poor recall exhibited no flexibility in eye movements and appeared to process all the syntactic structures in a similar manner.

Judd and Buswell (1922), Walker (1933), Tinker (1958), and Goltz (1975) reported that the skilled reader differs from his/her less skilled peer in almost all measures of eye movements. Moreover, skilled readers are more adaptive to the nature of the material. Difficult passages result in more and longer fixations to allow for a

processing of the structural properties and an understanding of the meaning. A greater number of regressions also occur with difficult material and seem to be partially due to the reader's effort to successfully integrate the linguistic elements of the material (Bayle, 1942; Carpenter and Just, 1977). Regressive movements can also serve as an information retrieval device or as an additional opportunity to reread previous information (Stern, 1978).

The competent adults with good recall ability exhibited the same pattern of eye movement behaviors attributed to the skilled reader who is responsive to the demands of the material being read. The fact that the competent adults with poor recall performance did not adjust their eye movements to accommodate the more difficult left-embedded structure and the succeeding sentence suggests that information-processing strategies may vary among competent adult readers. Moreover, specific visual behaviors may be characteristic of the mature reader during the successful extraction of meaning from difficult text.

In an ad hoc analysis of the Bader, Pearce, and Thompson (1980) study, Thomas (1980) found similar differences through a comparison of the visual processing behaviors of competent and less-competent adult readers. However, recall performance was not included in either the Bader et al., study or the Thomas analysis.

The visual processing behaviors exhibited by the adults with poor recall were also similar to those of the middle school readers in the Bader, Zynda, Thompson, and Pearce (1981) study. The younger readers in their study made minimal visual processing adjustments during the reading of the left-embedded sentences in connected discourse. The authors attributed this result to the developmental characteristics of

the reader and noted that the middle school readers appeared to be attending more to the semantic elements of the sentence while neglecting the syntactic features. The similarities in visual processing beahviors between the competent adults and the competent middle school students, although lacking in statistical legitimacy, raise viable questions about the developmental growth of comprehension strategies and the potential for identification of successful and unsuccessful approaches to gaining meaning from written material.

Implications of the Study

This study has contributed to our knowledge of information-processing analysis and psycholinguistics, specifically the interaction between syntactic structures and processing strategies in sentence comprehension during the reading act. This study has established that while competent adult readers may not make statistically significant behavioral adjustments to syntactic conditions, their recall of left- and right-embedded structures can be affected. The study has found that recall of the sentence succeeding a left-embedded structure may not be affected. The study has established that while there were no statistically significant differences in the visual processing behaviors of competent adult readers and their recall of selected syntactic structures, a directional pattern suggested varying reading behaviors for adults with good and poor recall performances.

This study has investigated the comprehension process during reading and has contributed to basic knowledge on sentence structure and processing strategies by competent adult readers. Furthermore, through one examination of reading behavior within conditions of cohesive paragraphs, this study has advanced our basic understanding of the reading

act in its normal setting. Future research should be conducted on individuals who are engaged in reading text to properly understand the way people gain meaning from print.

Portions of the data from this study also provide supportive evidence that the cognitive processes which underlie reading can successfully be analyzed during the reading act and that eye movements reflect these complex acts. Information of this nature can significantly advance our knowledge of the relationship between properties of the text and successful processing strategies of the reader.

Recommendations for Future Research

The findings of this study justify further investigation into the effects of selected syntactic structures on paragraph 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 for the visual processing behaviors of the competent adults could be replicated. This research would also determine whether any statistically significant differences existed between the directional tendencies noted for the visual processing behaviors and recall performances for the competent adult readers.

2. Research should be conducted to replicate the findings of this study using cohesive discourse of a more difficult reading level. The purpose of this research would be to determine whether the directional tendencies noted in mean scores for the visual processing behaviors of the competent adults could be replicated. This research would also determine whether any statistically significant differences existed between the directional tendencies noted for the visual procesing behaviors and recall performances for the competent adult readers.
3. Research should be conducted into the relationship between visual processing beahviors and recall performance on left- and right-embedded structures with competent adult readers.
4. Research should be conducted into whether or not a developmental sequence of visual processing behaviors and recall performance exists between childhood and adulthood.

APPENDIX A

SAMPLES OF LEFT- AND RIGHT-EMBEDDED STRUCTURES IN CONNECTED DISCOURSE

Samples of Left- and Right-Embedded Structures in Connected Discourse

Left-Embedded Syntactic Structure in Connected Discourse

Howard and Mike wanted jobs at the summer resort club. They read that the club's restaurant needed part-time employees. Consequently, they went to see Martha, the restaurant manager and employee trainer. She was interested in helping them find a job. Later that day, Martha sent Howard and Mike to see the cook. In the kitchen the cook that Martha trained hired the help. Howard and Mike were made evening chefs for the bar and grill. Howard handled orders and prepared drinks for the customers. Mike cooked meals. Within a few weeks, they were given promotions and made full-time employees.

Right-Embedded Suntactic Structure in Connected Discourse

Mary was shopping at an exclusive women's store. She noticed that the sales clerk ignored the prospective customers. Consequently, Mary telephoned the manager's office and registered a complaint. The manager, while processing the complaint, remembered a previous incident. The manager fired the clerk that Mary observed in the store. The clerk was given an explanation for this decision. However, she did not accept it as valid and contacted a union representative. An investigation cleared the clerk and preserved her job.

APPENDIX B

SAMPLES OF RECALL DISPLAYS USED TO EVALUATE SUBJECTS' ABILITY TO RECOGNIZE THE STRUCTURES CONTAINED IN THE PARAGRAPHS

Samples of Recall Displays Used to Evaluate Subjects' Ability to Recognize the Structures Contained in the Paragraphs

Left-Embedded Syntacic Structure

In the kitchen the cook that Martha trained hired the help.

Foil for Left-Embedded Syntactic Structure

The cook hired the help that Martha trained in the kitchen.

Structure Succeeding a Left-Embedding

Howard and Mike were hired as chefs for the bar and grill.

Foil for Structure Succeeding a Left-Embedding

Howard and Mike were made chefs and taught to cook the meals.

Right-Embedded Syntactic Structure

The manager fired the clerk that Mary observed in the store.

Foil for Right-Embedded Syntactic Structure

In the store the manager that Mary observed fired the clerk.

Structure Succeeding a Right-Embedding

The clerk was given an explanation for this decision.

Foil for Structure
Succeeding a Right-Embedding

The clerk was required to explain her actions.

APPENDIX C

DIRECTIONS READ TO SUBJECTS

BEFORE THE EXPERIMENT

Directions Read to Subjects Before the Experiment

You are going to be asked to read several different cards, one at a time, while your eye movements are being recorded by this machine. The machine is called a Reading Eye II, and it makes a record of your eye movements on the graph paper.

Please read naturally and pay attention to the material on the card. You may be asked questions about a particular selection afterwards, so it is important to concentrate on reading and to ignore the machine.

Before we can begin, your eyes must be aligned with the machine so that a photoelectric record of their movements will appear on the graph paper.

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