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A Developmental Study of the Visual Processing of Syntactic Structures in Unrelated and Related Discourse: A Comparison of Competent Middle School Readers and Competent Adult Readers

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A DEVELOPMENTAL STUDY OF THE VISUAL PROCESSING OF SYNTACTIC STRUCTURES IN UNRELATED AND RELATED DISCOURSE: A COMPARISON OF COMPETENT MIDDLE SCHOOL READERS AND COMPETENT ADULT READERS

By

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ABSTRACT

A DEVELOPMENTAL STUDY OF THE VISUAL PROCESSING OF SYNTACTIC STRUCTURES IN UNRELATED AND RELATED DISCOURSE: A COMPARISON OF COMPETENT MIDDLE SCHOOL READERS AND 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 of syntactic structures in unrelated and related discourse by competent middle school readers and to compare their performance to that of adult able readers. The study focused on the effects of types of discourse in processing syntactic structures and the effects of left- and right-embedded structures and cognitive processing performance. The behaviors measured were duration of gaze, duration of forward fixation, duration of regression, number of forward fixations, number of regressions, and number of total movements.

Materials

Materials consisted of unrelated and related discourse using active voice and employing no dependent clauses with the exception of the target embedding. The left-embedded structure was a relative clause that followed and

modified the subject. The right-embedded structure was a relative clause that followed and modified the sentence object.

The conditions were presented with the EDL/Biometrics Reading Eye II, an electronic instrument that employs a photoelectric method to record eye movements on heat-sensitive graph paper.

Population and Procedures

Thirty sixth grade students were randomly selected from a group of competent readers chosen on the basis of teacher judgment, test scores, and parental consent. Thirty university graduate students were selected from a group of volunteers. They were presumed to be competent readers because of their educational status. All participants were native English speakers.

The subjects read five selections silently: an EDL paragraph, a left-embedded structure in unrelated discourse, a right-embedded structure in unrelated discourse, a left-embedded structure in related discourse, and a right-embedded structure in related discourse. Their eye movements were recorded with the EDL/Biometrics Reading Eye II.

Major Findings

The statistical tests supported the following findings:

1. There were no significant differences in the visual processing behaviors of competent middle school

readers of left- and right-embedded structures either in the unrelated or the related discourse condition.

2. There were no significant differences between competent middle school readers and competent adult readers in the visual processing of left-embedded structures within the comparison between the unrelated and the related discourse condition.

3. There were significant differences in the visual processing of competent middle school readers and competent adult readers in areas of behavior within particular syntactic/contextual conditions. These were:

Duration of gaze

LE, SS and RE, SS

LE, π and RE, π

RE, SS and RE, π

Duration of forward fixation

LE, π and RE, π

RE, SS and RE, π

Duration of regression

LE, SS and RE, SS

LE, π and RE, π

Regressions

LE, SS and RE, SS

Implications of the Study

The results of the study indicated the following:

1. Competent middle school readers did not

significantly differentiate their reading to accommodate either the syntactic or the contextual demands of the material.

2. Competent middle school readers were more like competent adult readers in their fixation behaviors and less like competent adult readers in their duration behaviors.

3. A developmental sequence in psycholinguistic processing seems to be evolving.

4. The function and development of short-term memory regarding visual processing efficiency needs to be investigated.

5. Efficient psycholinguistic processing behaviors cannot be assumed simply because a student scores well on a standardized test.

To Michael, Susinn, and Anne,

My Family

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Gibson and Levin (1975) have stated that readers, even though they may not have a specific purpose guiding their reading, retain a general set for understanding, an urge to "make sense." Certain linguistic structures used in written materials may not always facilitate the reader's need to understand. Studies have demonstrated that readers attend longer to those linguistic structures which seem to deter comprehension. These studies have attempted to examine the relationship between linguistic structures and visual processing as they affect reading efficiency.

Many of these studies have used eye movement analysis to determine that relationship. We know that the eyes move continuously and that regressions occur. This knowledge leads us to believe as Kolers (Huey, 1968) states, that "what the reader understands from what he has read is the result of a construction he makes and not the result of a simple transmission of the graphic symbols to his mind" (p. xvii). A reader's eye movements are a picture of his unique behavior in processing printed material.

However, little has been done to study the developmental aspects of cognitive processing involving the relationship between linguistic structures and visual processing.

Cohen (1978) has stated a need for investigating both the possibility of a hierarchy of information-processing stages and how that hierarchy applies developmentally to different stages of reading maturity. This study will attempt to extend our knowledge of the developmental nature of cognitive processing.

Purpose

The purpose of this study is to examine the cognitive processing performance of competent middle school readers and to compare their performance to that of adult able readers. Specifically, the areas of examination are the effect of types of discourse in processing syntactic structures and the effect of left-and right-embeddings on cognitive processing performance.

Background

Psycholinguistic Theory

Psycholinguists attempt to describe the mental processes involved in the production, comprehension, and acquisition of language. Syntax, the way words combine to form sentences, is one of the components of language comprehension. Clark and Clark (1977) offer the following outline to describe the individual's strategy for processing syntax in order to arrive at meaning:

1. Take in raw speech sounds and retain in "working memory."
2. Organize the speech sounds into constituents.

3. Organize the constituents into propositions.

4. Retain the propositions in working memory and purge the memory of the original raw speech. In so doing, exact wording is forgotten while overall meaning is retained.

Clark and Clark maintain that these steps probably occur simultaneously and regard this description of linguistic processing as more of a global process rather than a consciously sequential strategy.

Psycholinguists also tell us that certain syntactic structures are more difficult to understand than others because of processing restraints which inhibit comprehension and impede memory. Kimball (1973) proposed the "principle of fixed structure," in which the individual is erroneously committed to a particular "set" for parsing a sentence. The principle attempts to explain why the following sentence is so difficult to process:

The horse raced past the barn fell.

He also formulated the "principle of two sentences" which demonstrates the difficulty in processing a sentence which is really more than one sentence and places a tremendous load on memory capacity:

That that John departed bothered Mary surprised Max.

In discussing processing impediments, psycholinguists have theorized that given information should precede new information in a sentence. As given information, the order

of preference seems to be: subject, objects, indirect objects, and noun phrases. Foss and Lynch (1969) demonstrated that left-embedded sentences make more demands on processing capacity than right-embedded sentences.

Visual Processing and Syntactic Structures

Researchers have used several procedures to demonstrate visual processing behaviors. Eye movement research has been a universally accepted procedure used to describe the visual processing of syntactic structures. Huey (1908) credits Javal with making initial discoveries in the field of eye movements. Tinker made significant contributions in this field by describing visual processing in terms of such visual activities as regressions, pause durations, and flexibility.

Tinker (1965) reported that eye movement behavior stabilizes by fourth grade with only small changes occurring up to the high school level when only a few minor improvements may be noted. An earlier study by Gilbert (1953) had reached similar, if not such specific, conclusions.

The eye-voice span, first reported by Quantz in 1897, is another procedure used to measure visual processing. Studies using both eye-voice span and eye movements have substantiated the psycholinguists' claim that certain syntactic structures are more difficult to process than others. Levin and Kaplan (1970) and Levin, Grossman,

Kaplan, and Yang (1970) used eye-voice span techniques to show the relationship between visual processing and textual demands. Buswell (1920) noted that the eye-voice span was affected positively by age and reading ability and negatively by the difficulty of the reading material.

Tinker (1965) found that eye movement behavior is considerably affected by the content and requirements of the prose. Bader, Pearce, and Thompson (1980) noted differences in eye movement processing in related and unrelated discourse.

Developmental Aspects of Visual Processing of Syntactic Structures

Most of the research concerning the visual processing of syntactic structures has been done using adult subjects, thus ignoring, for the most part, developmental implications in this field of study. However, there are several researchers who have added a developmental component to their investigations. Levin and Turner (1968) involved subjects from second, fourth, sixth, eighth, and tenth grades and college undergraduates in order to demonstrate the effect of grammatical structure on eye-voice span.

Tatham (1970) compared the performance of second and fourth grade children when reading sentences written on two levels of syntactic complexity. Using third, fourth, and fifth graders, Rode (1974) indicated that the type of syntactic unit (noun or verb phrase) influenced the eye-voice span of younger readers. Barnitz (1980) sought to

determine the effect of pronoun-referent structures on the reading comprehension of children in grades two, four, and six. Comprehensive examination of research concerning visual processing of syntactic structures seems to indicate that fourth grade is a key maturation point at which time readers become able to take advantage of grammatical structures.

Research Questions

The following research questions were formulated to guide the investigation:

1. Is there a difference in the visual processing of left- and right-embedded structures in unrelated discourse by competent middle school readers?
2. Is there a difference in the visual processing of left- and right-embedded structures in related discourse by competent middle school readers?
3. Is there a difference between the visual processing of left- and right-embedded structures in unrelated discourse and the visual processing of left- and right-embedded structures in related discourse by competent middle school readers?
4. Is there a difference between the visual processing behavior of competent middle school readers and the visual processing behavior of competent adult readers?

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

Definition of Terms

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

1. Competent middle school readers

   Competent middle school readers are defined as sixth-grade students selected on the basis of teacher judgment and the attainment of a score falling between the 50th and 75th percentile on the reading comprehension section of the Comprehensive Test of Basic Skills (Level 2, Form S).

2. Competent adult readers

   Competent adult readers refers to graduate students in the Elementary and Special Education Department of a large Midwestern university.

3. Syntactic Structures

   Syntactic structures refer to relative clauses following and modifying either the sentence subject or the sentence object.

4. Right-embedded sentence

   A right-embedded sentence is a sentence containing a relative clause that follows and modifies the sentence object.

   EX. The policeman stopped the car that was speeding.

5. Left-embedded sentence

   A left-embedded sentence is a sentence containing a relative clause that follows and modifies the sentence subject.

   EX. The girls who sat in front fell asleep.

6. Unrelated discourse

   Unrelated discourse refers to three sentences of differing subject matter.

7. Related discourse

   Related discourse refers to sentences cohesive with regard to semantic content.

Organization of Subsequent Chapters

Chapter II will contain a review of pertinent literature in the following areas:

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 developmental nature of syntactic processing.

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

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

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

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The review of related literature is organized under four major headings. These are:

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 developmental nature of syntactic processing.

The findings of the research in these areas serve as the basis for developing the hypotheses of this study.

The Relationship Between Reading Comprehension and Syntactic Structures

Thorndike (1917) stated in his landmark study that:

> Reading is a very elaborate procedure, involving a weighing of each of many elements in a sentence, their organization in the proper relations one to another, the selection of certain of their connotations and the rejection of others, and the cooperation of many forces to determine final response. (p. 323)

He noted the difficulty students encountered in responding to questions which tested their literal understanding of long, involved sentences. Thorndike attempted

to analyze the responses and hypothesize on the reasoning processes that produced those responses. He theorized that reading comprehension necessitated an active, involved participation on the part of the reader.

Almost fifty years later, Chomsky (1965) reinforced Thorndike's notion concerning the complicated interaction involved in language processing when he developed his theory of transformational-generative grammar. This theory posits that every sentence can be represented on a surface level and a deep structure level. A reader must not only be able to decode words and understand their individual meanings, but must also be aware of the grammatical inter-relationships in order to retrieve the underlying meaning of the sentence. Smith (1971) emphasized the importance of grammar as the link between the surface and deep structure levels of language, although, as he says, "There is no simple correspondence between surface structure of language and meaning." (p. 29)

Marcus (1971) noted that a reader may find print material ambiguous if there is a discrepancy in the relationship involving decoding words, knowing the meanings of the words as dictated by context, and understanding the mechanics of grammatical structures. He attempted to discover the relationship between syntactic complexity and comprehension facility by developing a diagnostic tool to measure comprehension of syntactic structures for intermediate grade students. He reported

that prepositional phrase modifiers and sentences which contained relative clauses in the subject-verb-object pattern of independent clauses were among the most difficult to comprehend.

A hierarchy of difficulty was established concerning specific prepositions and semantic groups of prepositions by Foust (1973). Those prepositions denoting temporal and abstract relationships were identified as the most difficult, followed by those prepositions denoting directional and positional relationships.

Adding to the information concerning levels of syntactic difficulty, Fagan (1971) investigated the effect that the number and types of transformations had on reading comprehension. He found that appositives, participles, gerunds, and genitive embeddings were the most difficult. He also reported that complex transformations rather than numerous transformations adversely affected reading comprehension. More supportive data were obtained by Stoodt (1970), who found significant correlations between reading comprehension and comprehension of various connectives.

Richek (1974) studied children's comprehension of three anaphoric forms (noun, pronoun, and null) and the effects of contextual variations on these forms. She found significant differences among the three forms with comprehension dropping to 60% in the null form. Consistent with Fagan's conclusions was the suggestion that the complexity of a sentence affects comprehension of the structures in that

sentence, but Richek added that efficient methods of measuring complexity had not yet been defined. However, Fodor, Garrett, and Bever (1968) identified the main verb as a determiner of complexity in a sentence, since verbs limit the syntactic choices with which they can occur.

Kolers (1970) and Miller and Coleman (1967) reported on the relationship between grammar and context. Kolers found that readers make fewer errors over the final three-fifths of sentences, and Miller and Coleman found more correct answers at the ends of sentences using a cloze procedure. They concluded in each case that the greater amount of syntactic data facilitated the readers' quest for understanding.

Using a technique that presented a sentence blurred in varying degrees, Sawyer (1971) reported that readers were able to recognize the existence of right-embeddings under poorer blur conditions than left-embeddings. Also found easier to recognize under more blurred conditions were "by + agent" phrases in passive sentences compared to similar prepositional phrases in active sentences. "By" phrases introducing locatives were more easily recognized than "by" phrases introducing agents in simple passive sentences.

Difficulties with reading comprehension can be attributed to the inability to organize textual material into meaningful units. In order to study this phenomenon, Cromer (1970) chose two groups of junior college readers

who were poor in reading comprehension, either because of vocabulary deficits or because of word-by-word reading. These groups with a group of good readers were presented stories in four different modes: sentences, single words, phrases, and fragmented groupings. The word-by-word readers comprehended better in the phrase mode than they did in any other mode, performing just as well as the good readers in that mode. Remediation based on chunking information into constituents may prove to benefit the reading comprehension of word-by-word readers.

In summary, the reader must integrate the phonological, lexical and syntactic information in the efficient pursuit of comprehending the deep structure of print material. However, certain syntactic structures appear to be more difficult to process than others. Therefore, it seems reasonable to continue to investigate syntactic structures and their specific effect on language processing in order to facilitate the reader's role as comprehender.

The Relationship Between Visual Processing Behavior and Reading Comprehension

In his book, Huey (1908) cites Javal's studies as providing the critical discoveries that undergird eye movement research. Javal noted that eye movements were discontinuous, and that reading, or the specific seeing of words and letters, occurred during the pauses of the eye movements. He also concluded that there was a pause every ten letters and that this was about the amount of input

that could be seen clearly in one fixation. He observed that the upper half of the line was more important and concluded that the fixation point of the eye moves along between the middle and top of the small letters.

More recently, Tinker (1958) completed a comprehensive review of the literature on eye movements, as well as conducting research in the field. In one study, Tinker (1965) compared prose of varying levels of difficulty and reported that pause duration in eye movements was directly related to difficulty of the text; that is, both the content and the requirements of the prose. Difficulty of the text, attributed to the readers' particular vocabulary deficiencies and comprehension difficulties, affected the number of fixations as reported by Buswell, 1920; Judd and Buswell, 1922; and Woodworth, 1938.

Purpose for reading can also affect visual processing. A developmental study by Levin and Cohn (1968) used students from second, fourth, ninth, and eleventh grades to determine if the eye-voice span changed according to each of three stated conditions--normal reading for pleasure, careful reading in preparation for questioning, and fast reading to search into the main idea. As has been proven to be the case in other studies, the older children had longer eye-voice spans. The eye-voice span was shortest for careful reading, and longest for quick skimming, with normal reading falling in between the two. The study demonstrates that students as early as second grade can

understand that there are different purposes for reading and can make accommodations according to those purposes.

Again measuring the eye-voice span, Levin and Kaplan (1970) concluded that the eye-voice span was affected by the structure and contextual predictability of written material by showing that the eye-voice span is longer for a sentence than for a random string of words.

The performance of good readers tends to demonstrate an adaptability to the nature of the material. Walker (1938) noted that good readers differed from less-skilled readers in being more flexible in their response to the nature of the material. The pattern of the skilled readers regarding fixations and pauses reflected the comprehension demands of the material read. In contrast, poor readers tended to use the same eye movements regardless of the textual demands.

Heiner and Henderson (1974) reported similar findings in a study which examined the eye movement behavior of skilled and less skilled seventh grade readers using material containing cloze deletions and non-treated materials. The good readers increased their fixations and regressions on the cloze materials, while the poor readers made fewer fixations and regressions on the cloze materials. The researchers speculated that the poor readers did not adjust their visual processing strategies to accommodate the demands of the cloze material, but merely intensified their efforts by extending the duration of their fixations.

Different findings were reported by Goltz (1975) using skilled and less-skilled readers at the college level. He indicated that the two groups adjusted their reading to accommodate different purposes, but that the nature of the accommodation was different. Skilled readers appeared to be more efficient in that their "regular reading" produced shorter eye fixations and larger right-going saccades. Their slower reading indicated longer duration of fixations rather than increased fixations. Skilled readers used regression to augment what they had read at a slower speed, while less-skilled readers used regression to compensate for what they had missed at an accelerated pace.

Mackworth (1972) also compared poor and skilled readers in an experiment called the "missing word task." The children, from second, fourth, and sixth grades, were asked to choose a word from a list of nouns and a list of verbs to fill in the blank in a sentence. The eye movements of the subjects were recorded, and the duration of time spent looking at the wrong list was computed. Good readers spent half as much time looking at the wrong category as the poor readers. Both groups made significant improvement between second and fourth grade, and while the good readers continued to improve, the poor readers made very little change between fourth and sixth grades.

Hochberg, Levin, and Frail, in an unpublished manuscript cited in Gibson and Levin (1975), probed the effect of peripheral vision on reader performance when interword

spaces in the reading text were filled with letterlike, meaningless symbols. Fifth graders were slowed in their reading more than second graders. This was interpreted to mean that younger children were reading word-by-word, while the older children were accustomed to using interword spaces, picked up peripherally, to move their eyes across units larger than words. This study indirectly tested Hochberg's (1970) earlier findings that peripheral vision is an important aid in deciding where fixations will occur.

Rayner (1974) investigated the areas of the periphery that provide the reader with different kinds of useful information. His ingenious computer technique monitored the fixation patterns of adult readers in situations in which a critical word was manipulated in the text. Rayner's data indicated that information about word shapes and about initial and terminal letters is picked up beginning about seven to twelve character spaces in the periphery, but that recognizing the meaning of a word begins only about one to six character spaces to the right of the fixation point.

Rayner's research, plus previous research by McConkie and Rayner (1973), demonstrated the complex processing that occurs during eye movements. Other findings gleaned from McConkie and Rayner's research were that word length affects reading farther into the periphery than does word shape or specific letter identification, and that blank spaces and beginnings of sentences are rarely fixated. On the basis

of their research, one can conclude that what is "seen" includes both the foveal region and the periphery working together to provide the reader with input to decide on the location of the next fixation.

In the area of regressive eye movements, Stern (1978) reported that a fixation occurring just before a regression is shorter than normal. He reasoned that as the reader becomes aware that he is not making sense out of the material, he quickly stops processing at that point.

In summary, eye movement research indicates that skilled readers' eye movements are flexible and adaptive, accommodating to the nature of the material and to the nature of the task. Peripheral vision also seems to be a factor in efficient reading, although more needs to be known about its specific function.

The Relationship Between Visual Processing Behavior and Syntactic Structures

Kolers (1970) and Weber (1970), working with mature readers and beginning readers, respectively, have observed that the reader makes predictions about what will follow as he reads. These predictions are based on what the reader has internalized about how his language is structured. Are there linguistic structures that are more predictable and thus easier to comprehend and to process than others?

Levin, Grossman, Kaplan, and Yang (1972) found that the left-embedded sentence type significantly limited the amount of information the reader could process as measured

by the eye-voice span. Wanat (1971) substantiated this finding in his study of the eye movement patterns of mature readers when reading isolated sentences containing left- and right-embeddings. Although the number of forward fixations were the same for both types of sentences, left-embedded forms required more total time to process.

Bader, Pearce, and Thompson (1980) reported similar findings concerning forward fixations in the unrelated sentence condition. However, their study also compared left- and right-embeddings in both unrelated sentences and connected discourse. While they found that sentences were processed more slowly than paragraphs, the left-embedded structure was processed more slowly than the right-embedded structure in both contextual conditions. They did not find a significant difference in forward fixations in the unrelated sentence condition, but they reported a difference in number and duration of regressions in the unrelated left-embedded sentence condition and the left-embedded, connected discourse condition.

Carpenter and Just (1977) examined pronoun referents to determine if regressive eye movements are selective and indicative of integrative processing. Sentences were constructed to provide the reader with strong linguistic cueing to the pronoun referrant; other sentences did not. Results indicated that this linguistic cueing facilitated identification of the pronoun referrant as evidenced by

regressive eye fixations. The researchers also posited that regressive movements may not necessarily indicate inefficient reading habits, but may reflect interpretive processing behavior.

Taylor (1960) observed similar eye movement behavior in mature readers, concluding that these readers engage in an active search for understanding when they are puzzled by different or obscure syntax and vocabulary. This search is characterized by regressive eye movements and subsequent sweeps.

Mehler, Bever, and Carey (1967) observed the visual processing behavior of college students using three kinds of ambiguous statements. They formulated the rule that the reader fixates on the first half of each constituent. However, serious criticism concerning the validity of the study was raised, although some researchers have credited the study with pointing out the need for more investigation in the area of ambiguity.

Wanat and Levin (1968) were also concerned with structures that may result in ambiguous processing. They measured the eye-voice span of undergraduate students to study their processing behavior of passive sentences which contained either an agent-present relationship or an agent-deleted relationship. The eye-voice span was longer for the agent-included sentences. It was hypothesized that the agent-included sentence was easier to process because there was a direct relationship between the surface structure

and the deep structure, thus eliminating ambiguous interpretation.

In summary, studies have analyzed the effects of different syntactic structures on the cognitive processing of written materials as measured by eye-movement behavior. While more studies of this type are needed, certain factors should be considered in conducting this kind of research. It is interesting that one of Wanat's (1970) criticisms of the previously mentioned Mehler, Bever, and Carey study (1967) concerned their use of ambiguous sentences, arguing that these forms are atypical of a normal reading situation. This position could be carried a step further, arguing that reading unrelated sentences is also atypical. However, few studies in this area of linguistic structures examine reading behavior using connected discourse. There appears to be a need for studies to approximate natural reading behavior by using connected discourse as the vehicle for probing cognitive processing of syntactic structures.

The Developmental Nature of Syntactic Processing

Huey (1908) agrees that, depending on our reading purpose, we all at some time or another read by letters, word, or phrases, using whatever method will facilitate the extraction of meaning. However, in order not to mislead us, he adds that, "we see, too, that the reader's acquirement of ease and power in reading comes through increasing ability to read in larger units." (p. 116)

Just what do we know about how the reader acquires the ability to process larger units of syntactic structure more efficiently?

Chomsky's study (1969) revealed that children were still engaged in active syntactic acquisition up to age 9 and perhaps even beyond. It was also noted that while children vary in their rate of acquisiton, they do not vary in the order of acquisition. Developmental studies done by Levin and Turner (1966) indicated that effective use of syntactic structures increases with age and skill, which is interpreted to mean that the skilled reader is sensitive to the syntactic regularities of language and uses higher order units to acquire meaning.

Gibson and Guinet (1970) found that children read inflectional endings with fewer errors than non-inflectional endings on words of equivalent length. This tendency increased from third to fifth grade.

Levin and Turner (1968) hypothesized that the phrase was the unit of decoding and attempted to test it developmentally by measuring the eye-voice span. They asked college undergraduates and students in second, fourth, sixth, eighth, and tenth grades to read phrase-embedded sentences in both active and passive voice, as well as unstructured word lists. Findings revealed that the eye-voice span increased with age and was significantly longer for sentences than for the unstructured word lists for all ages and sentence types. An important finding of the study

was that all of the age groups, except second graders, ended their eye-voice span at phrase boundaries. Readers as early as fourth grade chunked their oral reading into phrase units, but this tendency did not appear to grow stronger between fourth grade and adulthood. However, Resnick (1970) found this tendency to be stronger in adults, although also present in children. Levin and Turner's (1968) findings are consistent with Tinker's (1965) research which described eye movement patterns in reading as becoming adultlike at the fourth grade level.

Steiner, Weiner, and Cromer (1971) further corroborated the previous developmental findings when they examined the effect of a type of comprehension training on good and poor readers in fifth grade. When given a word-by-word presentation of a story, good readers made anticipation errors that were syntactically and semantically sound and often identified whole phrases rather than single words. This would suggest that the fifth graders were capable of structuring their reading into phrase units. This study supports a body of evidence demonstrating that the phrase is the major decoding unit for skilled readers.

Rode (1974) studied the effects of different syntactic structures on the eye-voice span, using subjects in the third, fourth, and fifth grades. Consistent with other studies, the eye-voice span increased with age. The data also indicated that the type of phrase, noun, or verb, had a powerful effect on the eye-voice span of the subjects at

all age levels with the span expanding in noun phrases and constricting in verb phrases. The eye-voice span was also found to terminate at verb phrases significantly more often than at noun phrases. The last finding raises the possibility that the clause is the syntactic unit that readers use for decoding rather than the phrase. Rode also speculated that short-term memory development may be a determining factor in explaining why the third graders in her study were able to chunk words into phrase units but not clause units. The fourth grade subjects began to chunk clause units together, and Rode hypothesized that an increase in short-term memory enabled them to make more efficient use of language ability.

Siler (1973) compared the effects of syntactic and semantic violations on the oral reading performance of second and fourth graders. His findings, similar for both grade levels, indicated that the category of syntactic violations and the category of combined syntactic and semantic violations were more disruptive than the category of semantic violations, but no more disruptive than each separately. Syntax appeared to have a greater disruptive effect than semantics in oral reading performance.

On the other hand, syntactic complexity seems to be an aid to comprehension and recall, rather than a hindrance, according to a study done by Pearson (1974) using third and fourth grade readers. Students preferred cohesive, more heavily embedded forms to less cohesive, less heavily embedded forms. The finding of the aided recall section

of the experiment led to the conclusion that a causal relation cannot help but be stored in a unified, subordinated chunk. Children appeared to store causal relations in long-term memory in a cued form and retrieve it in that form (which may have been more natural and familiar to them), regardless if the initial input was cued or uncued.

It may be proposed that the children in Pearson's study responded as they did because the forms they chose were more familiar to them. Hypothesizing that comprehension is aided by familiar syntactic structures, Tatham (1970) prepared sentences on two levels of syntactic complexity and had second and fourth graders read them. Comprehension was better on those selections which coincided syntactically with frequent patterns of oral language. However, as the reader matures, comprehension must expand to include written styles that are decidedly different from spoken patterns.

Barnitz (1980) used children in grades two, four, and six to determine the development in comprehension of selected pronoun-referent structures. Three linguistic comparisons were made along the dimensions of referent type, referent order, and referent distance. Analysis of the data demonstrated that: (1) noun phrase pronomials were easier to comprehend than sentential pronomials; (2) structures with forward reference were easier to comprehend than structures with backward reference; and

(3) there was no difference between intra-sentential and inter-sentential structures. A hierarchy of difficulty for each grade was also constructed based on these findings. Barnitz concluded that except for a few esoteric structures, pronoun-referent structures are generally comprehensible by the time children reach sixth grade.

Sheldon (1974) studied the developmental aspects of language processing when she compared the strategies used by adults with those used by four-and five-year-olds when processing relative clauses. The clauses were inserted either after the subject or after the object, and related either to the subject or to the object of the sentence. She found that children and adults use the same processing strategies, but differ in the emphasis placed on the particular strategies, which explained the particular types of sentences on which both groups made the most errors.

Adults seemed to over-rely on the Adjacency Strategy, which caused them to make more errors in those sentences in which the relative clause directly followed the subject, and in those sentences in which the relative clause followed the object making the object of the sentence the object of the clause.

Children, however, relied on the Parallel Function Strategy, and so made more errors in those sentences in which the noun phrases and the relative clauses did not have similar functions. The children also over-relied on

the Extraposition Strategy when attempting to find the antecedent to the relative pronoun in object relatives.

In summary, readers as early as third grade have demonstrated an ability to use syntactic structures to process reading material effectively. This processing ability increases with age and skill to include more demanding syntactic understanding. Reading material is processed into meaningful constituents, evidence having been presented for both the phrase and the clause as the main unit of decoding. Younger readers also seem to respond better to familiar syntactic structures in the early stages of reading. We also have a large body of information concerning the processing of anaphoric forms.

However, comparatively little can be said concerning significant developmental stages in processing syntactic structures. There have been relatively few studies that have attempted such an investigation. More studies need to consider adding a developmental component to the design. As it is, it is difficult to synthesize these individual studies, each dealing with a particular aspect of syntactic processing and a particular age group, and to weave a coherent developmental thread through them.

CHAPTER III.

METHODOLOGY OF THE STUDY

Introduction

The chapter describes the methodology employed in conducting the study. The data collection procedures were similar to those used in the Bader, Pearce, and Thompson (1980) study concerning the effect of related and unrelated discourse on the processing of syntactic structures. Their results, obtained with adult competent readers, will be compared to the results obtained with competent middle school readers.

Population

The population was composed of thirty middle school students in the sixth grade who were randomly selected from a group of competent readers. The competent readers were identified on the basis of teacher judgment, the attainment of a score falling between the 50th and 75th percentile on the reading comprehension section of the comprehensive Test of Basic Skills, Level 2, Form S, and parental consent. The test scores were based on results obtained during spring of the 1978-79 school year. All participants were native English speakers.

Materials

Materials developed by Bader, Pearce, and Thompson (1980) were used. These consisted of sentences using active voice and employing no dependent clauses with the exception of the target embedding. These were either left-embedded sentences that contained a relative clause that followed and modified the subject or right-embedded sentences that contained a relative clause that followed and modified the sentence object. The unrelated sentence condition consisted of three sentences of equal length (11 words) dealing with differing subject matter, while the related sentence condition consisted of paragraphs extending over seven lines that were cohesive with regard to semantic content. The target sentence in the unrelated discourse condition was the second sentence, while the target sentence in the related discourse condition appeared on the sixth line.

Apparatus

The conditions were typed on IBM pica, single spaced on 3½" x 5" cards and presented with the EDL/Biometrics Reading Eye II, an electronic instrument that employs a photoelectric method to record eye movements on heat-sensitive graph paper.

Data Collection

The subjects were tested individually during the school day in a small room designated for this purpose.

Initially students were to be tested after school, but because of the short time (approximately five to ten minutes) needed to complete the procedure, a change was made. The principal agreed to allow the subjects to be tested during the school day, provided that they were taken from class during times that were not crucial, such as study periods or free reading times.

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

After the subjects' eyes were aligned properly, they were instructed to close their eyes between selections and to keep their heads motionless throughout the experiment. The experiment included five reading selections: an EDL paragraph, a left-embedded sentence in isolation, a right-embedded sentence in isolation, a left-embedded sentence in related discourse and a right-embedded sentence in related discourse. At the conclusion of the experiment, subjects were asked if they encountered any reading difficulties or if they reread any portion of the five selections. Their responses were recorded.

Design

A 2 x 2 (context & structure) design was used to test the effect of left and right embeddings in conditions of unrelated sentences and connected discourse. Within each of the context conditions, subjects were assigned on a rotating basis two of eight constructions containing left-embeddings and two of eight constructions containing right-embeddings. No subject received left-embedded and right-embedded sentences from the same pair.

Hypotheses

1. There will be no difference in the visual processing of left- and right-embedded structures in unrelated discourse by competent middle school readers.

2. There will be no difference in the visual processing of left- and right-embedded structures in related discourse by competent middle school readers.

3. There will be no difference in the visual processing of left-embedded structures in unrelated discourse and related discourse by competent middle school readers.

4. There will be no difference in the visual processing of right-embedded structures in unrelated discourse and related discourse by competent middle school readers.

5. There will be no difference in the visual processing of left- and right-embedded structures between competent middle school readers and competent adult readers within the unrelated discourse condition.

6. There will be no difference in the visual processing of left- and right-embedded structures between competent middle school readers and competent adult readers within the related discourse condition.

7. There will be no difference in the visual processing of left-embedded structures between competent middle school readers and competent adult readers within the comparison between the unrelated and the related discourse condition.

8. There will be no difference in the visual processing of right-embedded structures between competent middle school readers and competent adult readers within the comparison between the unrelated and the related discourse condition.

Data Analysis

A matched pairs t-test was used to investigate the interaction between the visual processing of syntactic structures in unrelated and related discourse. A t-test for independent variables was used to compare the visual processing behaviors of competent middle school readers and competent adult readers.

The independent variables are the unrelated and related discourse conditions, the left-embedded and right-embedded syntactic structures, and the maturity levels of the subjects. The dependent variables are the visual processing behaviors which include: gaze duration, forward fixation duration, regression durations, number of forward fixations, number of regressions and total eye movements.

Summary

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

The eye movements of competent sixth-grade readers, who were good comprehenders, were recorded, while the subjects read sentences with left- and right-embeddings in unrelated and related sentence conditions. Their performance was to be compared to that of adult competent readers.

The eye movements were photographed with the EDL/ Biometrics Reading Eye II, and the materials used in the machine were developed by Bader, Pearce, and Thompson (1979).

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

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Introduction

The purpose of the study was to obtain and analyze data concerning the visual processing of syntactic structures in related and unrelated discourse by competent middle school readers and to compare their performance to that of adult able readers. The areas of examination focus on the effect of length of discourse in processing syntactic structures and the effect of left-and right-embeddings on cognitive processing performance.

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

Hypotheses and Statistical Tests

The data concerning the visual processing behaviors of competent middle school readers were tested using a matched pairs t-test. A t-test for independent variables was used to test the data comparing the visual processing behaviors of competent middle school readers and competent adult readers.

Hypothesis 1.

Ho 1: There will be no difference in the visual processing of left- and right-embedded structures in unrelated discourse by competent middle school readers.

The hypothesis was tested with a matched pairs t-test. (See Table 4.1).

Table 4.1.--t-Test: Left- and Right-Embeddings in Unrelated Discourse

Variables	M	SD	t
LE, SS and RE, SS			
Duration of gaze	.14	1.02	.73
Duration of forward fixation	-.04	.70	-.32
Duration of regression	.07	.60	.62
Forward fixations	-.13	3.39	-.22
Regressions	.70	2.55	1.50
Total movements (R and F)	.57	4.97	.62

*$p < .05$

Key - LE Left-embedding
RE Right-embedding
SS Sentence (unrelated discourse)
⌒ Paragraph (related discourse)

There were no significant differences in the visual processing of left- and right-embedded structures in unrelated discourse by competent middle school readers.

Hypothesis 1 was accepted.

Hypothesis 2.

Ho 2: There will be no difference in the visual processing of left- and right-embedded structures in related discourse by competent middle school readers.

The hypothesis was tested with a matched pairs t-test. (See Table 4.2).

Table 4.2.--t-Test: Left- and Right-Embeddings in Related Discourse

Variables	M	SD	t
LE, π and RE π			
Duration of gaze	.28	1.12	1.38
Duration of forward fixations	.16	.52	1.59
Duration of regression	.03	.65	.23
Forward fixations	.00	2.48	.00
Regressions	-.07	3.10	-.12
Total movements (R and F)	-.13	5.00	-.15

*$p < .05$

There were no significant differences in the visual processing of left- and right-embedded structures in related discourse by competent middle school readers. Hypothesis 2 was accepted.

Hypothesis 3.

Ho 3: There will be no difference in the visual processing of left-embedded structures in unrelated discourse and related discourse by competent middle school readers.

The hypothesis was tested with a matched pairs t-test. (See Table 4.3)

Table 4.3.--t-Test: Left-Embeddings in Unrelated and Related Discourse

Variables	M	SD	t
LE, SS and LE, π			
Duration of gaze	.31	1.00	1.69
Duration of forward fixations	.01	.60	.12
Duration of regression	.07	.66	.59
Forward fixations	.50	2.83	.97
Regressions	.67	3.65	1.00
Total movements (R and F)	1.10	5.71	1.06

*$p < .05$

There were no significant differences in the visual processing of left-embedded structures in unrelated and related discourse by competent middle school readers. Hypothesis 3 was accepted.

Hypothesis 4.

Ho 4: There will be no difference in the visual processing of right-embedded structures in unrelated and related discourse by competent middle school readers.

The hypothesis was tested with a matched pairs t-test. (See Table 4.4)

Table 4.4.--t-Test: Right Embeddings in Unrelated and Related Discourse

Variables	M	SD	t
RE, SS and RE, π			
Duration of gaze	.11	.83	.73
Duration of forward fixations	.11	.67	.87
Duration of regression	.03	.58	.24
Forward fixations	-.63	2.99	-1.16
Regressions	-.03	2.43	- .08
Total movements (R and F)	-.67	4.50	- .81

*$p < .05$

There were no significant differences in the visual processing of right-embedded structures in unrelated and related discourse by competent middle school readers. Hypothesis 4 was accepted.

Hypothesis 5.

Ho 5: There will be no difference in the visual processing of left- and right-embedded structures between competent middle school readers and competent adult readers within the unrelated discourse condition.

The hypothesis was tested with a t-test for independent variables. (See Table 4.5)

Table 4.5.--t-Test: Student and Adult Processing of Left- and Right-Embeddings in Unrelated Discourse

Variables	t
LE, SS and RE, SS	
Duration of gaze	-2.01 *
Duration of forward fixations	- .77
Duration of regression	-2.10 *
Forward fixations	- .83
Regressions	-2.15 *
Total movements (R and F)	-1.66

*$p < .05$

The data indicated that there were significant differences between the middle school readers and the adult readers concerning the visual processing of left- and right-embedded structures in the unrelated discourse condition. These differences occurred in the areas of duration of gaze, $t = -2.01$, $p < .05$, duration of regressions,

$t = -2.10$, $p < .05$, and number of regressions, $t = -2.15$, $p < .05$. Therefore, Hypothesis 5 was rejected.

Hypothesis 6.

Ho 6: There will be no difference in the visual processing of left- and right-embedded structures between competent middle school readers and competent adult readers within the related discourse condition.

The hypothesis was tested with a t-test for independent variables. (See Table 4.6)

Table 4.6.--t-Test: Student and Adult Processing of Left- and Right-Embeddings in Related Discourse

Variables	t
LE, π and RE, π	
Duration of gaze	-3.36 †
Duration of forward fixations	-2.29 *
Duration of regression	-2.15 *
Forward fixations	- .86
Regressions	-1.86
Total movements (R and F)	-1.59

*$p < .05$
† $p < .01$

The data indicated that there were significant differences between competent middle school readers and competent adult readers concerning the visual processing of left- and right-embedded structures in the related discourse

condition. The differences occurred in the areas of duration of gaze, $t = -3.36$, $p < .01$, duration of forward fixations, $t = -2.29$, $p < .05$, and duration of regressions, $t = -2.15$, $p < .05$. The differences justified rejecting Hypothesis 6.

Hypothesis 7.

Ho 7: There will be no difference in the visual processing of left-embedded structures between competent middle school readers and competent adult readers within the comparison between the unrelated and related discourse condition.

The hypothesis was tested with a t-test for independent variables. (See Table 4.7)

Table 4.7.--t-Test: Student and Adult Processing of Left-Embeddings in Unrelated and Related Discourse

Variables	t
LE, SS and LE, π	
Duration of gaze	- .47
Duration of forward fixations	-1.52
Duration of regression	.48
Forward fixations	-1.08
Regressions	.22
Total movements (R and F)	- .49

*$p < .05$

There were no significant differences between competent middle school readers and competent adult readers in the visual processing of left-embedded structures in unrelated and related discourse. On the basis of the data, Hypothesis 7 was accepted.

Hypothesis 8.

Ho 8: There will be no difference in the visual processing of right-embedded structures between competent middle school readers and competent adult readers within the comparison between the unrelated and the related discourse condition.

The hypothesis was tested with a t-test for independent variables. (See Table 4.8)

Table 4.8.--t-Test: Student and Adult Processing of Right-Embeddings in Unrelated and Related Discourse

Variables	t
RE, SS and RE, π	
Duration of gaze	-2.15 *
Duration of forward fixations	-2.77 †
Duration of regression	.35
Forward fixations	- .75
Regressions	.32
Total movements (R and F)	- .34

$p < .05$ †$p < .01$

The data indicated that there were significant differences between competent middle school readers and competent adult readers concerning the visual processing of right-embedded structures in unrelated and related discourse. The differences occurred in the areas of duration of gaze $t = -2.15$, $p < .05$, and duration of forward fixations $t = -2.77$, $p < .01$. On the basis of the data, Hypothesis 8 was rejected.

Analysis of Data Pertaining to Hypotheses 5, 6, and 8

When the visual processing behaviors of competent middle school readers were compared to the visual processing behaviors of competent adults, significant differences occurred in the four areas of behavior within particular syntactic/contextual conditions. These were:

1. Duration of gaze
   - LE, SS and RE, SS
   - LE, π and RE, π
   - RE, SS and RE, π
2. Duration of forward fixation
   - LE, π and RE, π
   - RE, SS and RE, π
3. Duration of regression
   - LE, SS and RE, SS
   - LE, π and RE, π
4. Regression
   - LE, SS and RE, SS

In order to understand the nature of the differences, the results derived in the aforementioned areas and conditions in the study of competent adult readers (Bader, Pearce, and Thompson, 1980) should be noted. (See Table 4.9)

Table 4.9.--t-Test: Visual Processing of Left- and Right-Embeddings in Unrelated and Related Discourse by Competent Adults

Variables		t
Duration of gaze		
LE, SS	RE, SS	4.13 ‡
LE, π	RE, π	4.64 ‡
RE, SS	RE, π	2.55 *
Duration of forward fixation		
LE, π	RE, π	1.72
RE, SS	RE, π	3.97 ‡
Duration of regression		
LE, SS	RE, SS	5.31 ‡
LE, π	RE, π	4.15 ‡
Regressions		
LE, SS	RE, SS	3.17 †

*$p < .05$ †$p < .01$ ‡$p < .001$

Table 4.9 presents the nature of the differences in the visual processing of adults in the four areas of behavior within particular syntactic/contextual conditions. The table

reveals that the visual processing of competent adult readers was characterized by:

1. more time for total reading and forward fixations to process left-embedded structures in both the unrelated and related discourse condition when compared to right-embedded structures in those conditions.

2. more time for total reading and forward fixations to process right-embedded structures in the unrelated discourse condition when compared to those structures in the related discourse condition.

3. more regressions to process left-embedded structures in the unrelated discourse condition when compared to right-embedded structures in the same condition.

4. no significant difference in duration of forward fixations to process left- and right-embedded structures in the related discourse condition. This area was the only exception to the significant results of the comparison between the visual processing of competent middle school readers and competent adults.

Summary

Hypotheses 1, 2, 3, and 4 were tested with a matched pairs t-test. The results were:

Hypothesis 1 - accepted

Hypothesis 2 - accepted

Hypothesis 3 - accepted

Hypothesis 4 - accepted

No significant differences were found in the visual processing behavior of competent middle school readers, when reading left- and right-embedded structures in unrelated and related discourse.

Hypotheses 5, 6, 7, and 8 were tested with a t-test for independent variables. The results were:

Hypothesis 5 - rejected

Hypothesis 6 - rejected

Hypothesis 7 - accepted

Hypothesis 8 - rejected

Significant differences in the visual processing behaviors of competent middle school readers and able adult readers were found within the following conditions:

1. LE, SS and RE, SS
   - Duration of gaze
   - Duration of regression
   - Regression
2. LE, π and RE, π
   - Duration of gaze
   - Duration of forward fixation
   - Duration of regression
3. RE, SS and RE, π
   - Duration of gaze
   - Duration of forward fixation

Reference was made to the study done with competent adult readers (Bader, Pearce, and Thompson, 1980).

With one exception, significant differences in the present study occurred in the same areas and conditions in the study of adult readers.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of the study was to obtain and analyze data concerning the visual processing of syntactic structures in unrelated and related discourse by competent middle school readers and to compare their performance to that of adult able readers. The study focused on the effects of types of discourse in processing syntactic structures and the effects of left- and right-embedded structures on cognitive processing performance. The behaviors measured were duration of gaze, duration of forward fixation, duration of regression, number of forward fixations, number of regressions, and number of total movements.

A theoretical framework was established based on psycholinguistic theory and visual processing research in the areas of syntactic structures and developmental aspects. 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 developmental nature of syntactic processing.

The eye movements of thirty sixth-grade students, designated as competent readers, were recorded with the EDL/Biometrics Reading Eye II. Materials and procedures developed by Bader, Pearce, and Thompson (1980) were used. The subjects read an EDL paragraph, a left-embedded sentence in unrelated discourse, a right-embedded sentence in unrelated discourse, a left-embedded sentence in related discourse, and a right-embedded sentence in related discourse.

Data concerning the visual processing behavior of competent middle school readers were tested with a matched pairs t-test. No statistically significant differences were found for competent middle school readers when processing left- and right-embedded structures in unrelated and related discourse.

A t-test for independent variables revealed statistically significant differences in the data comparing the visual processing behavior of competent middle school readers and adult able readers.

Conclusions

The following hypotheses were developed to determine the nature of visual processing of syntactic structures in unrelated and related discourse by competent middle school readers:

H.1. There will be no difference in the visual processing of left- and right-embedded structures in unrelated discourse by competent middle school readers.

H.2. There will be no difference in the visual processing of left- and right-embedded structures in related discourse by competent middle school readers.

H.3. There will be no difference in the visual processing of left-embedded structures in unrelated and related discourse by competent middle school readers.

H.4. There will be no difference in the visual processing of right-embedded structures in unrelated and related discourse by competent middle school readers.

All of the hypotheses were accepted; the data indicated that competent middle school readers did not signficantly differentiate between left- and right-embedded structures either in the unrelated or the related discourse condition.

The following hypotheses were developed to determine the significance of the comparison between the visual processing of syntactic structures in unrelated and related discourse by competent middle school readers and by competent adult readers:

H.5. There will be no difference in the visual processing of left- and right-embedded structures between competent middle school readers and competent adult readers within the unrelated discourse condition.

H.6. There will be no difference in the visual processing of left- and right-embedded structures between

competent middle school readers and competent adult readers within the related discourse condition.

H.7. There will be no difference in the visual processing of left-embedded structures between competent middle school readers and competent adult readers within the comparison between the unrelated and the related discourse condition.

H.8. There will be no difference in the visual processing of right-embedded structures between competent middle school readers and competent adult readers within the comparison between the unrelated and the related discourse condition.

Hypothesis 7 was accepted; Hypotheses 5, 6, and 8 were rejected. The data indicated statistically significant differences in areas of behavior within particular syntactic/contextual conditions. These were:

1. Duration of gaze
   - LE, SS and RE, SS
   - LE, π and RE, π
   - RE, SS and RE, π
2. Duration of forward fixation
   - *LE, π and RE, π
   - RE, SS and RE π
3. Duration of regression
   - LE, SS and RE, SS
   - LE, π and RE, π

4. Regressions

LE, SS and RE, SS

The condition marked with an asterisk did not produce significant differences in the study of adult competent readers (Bader, Pearce, and Thompson, 1980). The other areas produced significant differences.

Theoretical Implications

Visual Processing of Competent Middle School Readers. Analysis of the data indicated that competent middle school readers made no statistically significant behavioral adjustments in their reading to accommodate either the syntactic or the contextual demands of the material. One interpretation of the data is that the middle school students satisfied their need to understand by acting on the premise that an accumulation of information would facilitate their quest to relieve ambiguity. Observations based on eight years' experience in which the investigator worked in reading with sixth-grade students tend to verify that the predominantly forward direction of the reading strategy is developmentally consistent. Sixth-grade students are not noted for a propensity to reflect and ponder.

Although the results could not be allotted any statistical legitimacy, an examination of the means for the areas of visual behavior within syntactic/contextual conditions seemed to be appropriate in order to learn whether there was a direction or pattern to the visual

processing of competent middle school readers. The examination of the means indicated that the left-embedded syntactic structure in the unrelated discourse condition required greater processing attention for the competent middle school readers. Thus, the middle school readers appeared to be moving in the direction of the established syntactic discrimination patterns of competent adult readers. However, this behavior appeared only as a tendency. Chomsky (1969) reported that children, even after age nine, were actively engaged in syntactic acquisition. One might speculate that the competent middle school readers were developing in the direction of an effective use of context and an efficient processing of right-embedded structures.

Comparison of Visual Processing of Competent Middle School Readers and Competent Adult Readers. Analysis of the data comparing the visual processing behaviors of competent middle school readers and competent adults yielded no statistically significant differences in the number of forward fixations, regressions (with one exception), and total movements in the syntactic/contextual conditions.

Eye movement fixation behaviors, especially forward fixations, appear to be more related to the reader's ability to chunk information into linguistic units (Buswell, 1920; Judd and Buswell, 1922; Stern, 1978). The lack of significant differences in these areas may

support the previous speculation that the middle school competent readers were moving toward a more adult model of information processing, at least in these areas of behavior. Tinker (1965) described eye movement patterns as becoming more adult-like by fourth grade. The findings of this study allow the statement that some adult-like processing behaviors can be attributed to competent sixth-grade readers, although they still had not attained the flexibility that Tinker (1958) regarded as the hallmark of the mature reader.

Eye-movement behaviors which yielded statistically significant differences in the comparison of the visual processing of competent middle school readers and able adult readers were found, with one exception, in the area of duration within particular syntactic/contextual conditions. These areas included duration of gaze, duration of forward fixation, and duration of regression. The one exception was in the area of regressions. Whereas the eye movement fixation behaviors related to a greater degree to linguistic chunking, eye movement duration behaviors appear to be more related to memory and memory search. This notion is related to Clark and Clark's (1977) model of language processing which employs short-term memory as one of its components.

As stated previously, the visual processing of competent middle school readers apparently is not characterized by a retreat and reflect procedure. It appears that they

do not increase their fixation duration sufficiently to conduct a memory search in the same manner as the adults. The middle school readers may be hampered by syntactic breakdown in short-term memory which may decay faster for children than for adults because of lack of experience and maturity. Rode (1974) theorized that an increase in short-term memory enabled fourth-grade students to make more efficient use of language ability than third-grade students. Sachs (1967) reported in a study with adults that short-term memory decays quickly for surface structures, and the memory then is for the information contained in the sentence. It is posited that as short-term memory increases through experience, maturity, and practice, proficiency with less-predictable syntactic structures increases.

The area of regressions, in a comparison of left- and right-embedded structures in the unrelated discourse condition, was the one area, other than duration, to yield significant differences between middle school readers and adult readers. This finding is not inconsistent to the previous interpretation, since regressions can also be indicators of memory search. Carpenter and Just (1977) posited that regressions may not necessarily be considered inefficient processing behavior, but may reflect the reader's effort to make sense out of the material.

The data seems to suggest a developmental sequence with those behaviors relating to linguistic chunking being developed ahead of those behaviors relating to short-term

memory. In seven out of twelve conditions of duration behavior, the middle school readers were significantly different from adults. However, in only one out of twelve conditions of fixation behavior did they differ significantly, and this condition was in the category of regressions.

In a post hoc analysis of the Bader, Pearce, and Thompson study (1980), Thomas (1980) found similar differences in a comparison of the processing behaviors of competent and less-competent adult readers. The children, therefore, seemed to be processing more like adults in their chunking behaviors, while their proficiency in memory processing appears to be evolving more slowly. Clark and Clark (1977) maintain that language processing behaviors occur simultaneously. The data seem to denote, within the limitations of the study, that language processing proficiency does not develop simultaneously.

Implications of the Study

This study and the study with adults (Bader, Pearce, and Thompson, 1980) have contributed to our knowledge of psycholinguistic processing and the developmental nature of that processing. The adult study established that left-embedded structures and the unrelated discourse condition were more difficult to process. The present study has established that while competent sixth-grade readers do not make statistically significant behavioral adjustments to

syntactic/contextual conditions, they do differ significantly from adults in particular areas of behavior under certain syntactic/contextual conditions. The data also seem to indicate a developmental sequence in psycholinguistic processing.

The findings of the study prescribe caution in interpreting evaluations of reading comprehension behavior. Although the subjects of the study were considered to be good readers, they did not exhibit the same processing behaviors as competent adult readers. It would be premature at this point in the research to suggest instructional procedures in an attempt to change some of the exhibited behaviors of the children to imitate those of mature readers. Piaget, as well as other cognitive developmental theorists, has warned against hastening or interfering with developmental processes. Rather, emphasis should be placed on continuing the momentum generated by this study and the adult study to broaden the base of knowledge in psycholinguistic processing.

Recommendations for Future Research

The findings of the study justify further investigation into the developmental aspects of psycholinguistic processing behavior. Particular attention should be focused on the readers between sixth grade and adulthood in order to document the development of efficient processing of syntactic/contextual conditions and to determine the nature of that processing. It is necessary to verify the

developmental sequence suggested by the findings of the present study.

The data suggest that competent middle school readers were not significantly changing their reading behavior when confronted with different contexts and syntactic structures. If these students were properly designated as competent in comparison with their peers, the question arises as to how poor readers would perform under the same conditions. A study of this kind would perhaps yield basic information regarding the nature of the visual processing behaviors of problem readers.

Short-term memory appears to play an important role in the development of effective language processing. Additional studies are necessary to probe the function and development of short-term memory.

On the basis of the implications of this study, the following specific recommendations are made:

1. Studies are warranted to investigate and verify the developmental sequence of visual processing behaviors with subjects between sixth grade and adulthood.

2. Studies are warranted to compare the visual processing behaviors of competent readers and poor readers.

3. Studies are warranted to investigate the function and development of short-term memory regarding visual processing efficiency.

APPENDICES

APPENDIX A

SAMPLES OF LEFT- AND RIGHT-EMBEDDED STRUCTURES IN UNRELATED AND RELATED DISCOURSE

APPENDIX A

Samples of Left- and Right-Embedded Structures in Unrelated and Related Discourse

Left-Embedded Structure in Unrelated Discourse:

> The quick brown fox jumped over the split-railed fence.
>
> At the college the doctor that Bob taught loved the nurse.
>
> Joan has a hobby of collecting pre-Civil War stamps.

Right-Embedded Structure in Unrelated Discourse:

> The quick brown fox jumped over the split-railed fence.
>
> The doctor loved the nurse that Bob taught at the college.
>
> Joan has a hobby of collecting pre-Civil War stamps.

Left-Embedded Syntactic Structure in Related Discourse:

> Jack was physically handicapped and wanted to earn some spending money. He went to see an acquaintance, Marta, who trained the handicapped. Marta also managed a new hotel that had an opening for an assistant cook. To Jack's dismay, the position was no longer available. In the kitchen the cook that Marta trained hired the help. He had hired a former MacDonalds' employee.

Right-Embedded Syntactic Structure in Related Discourse:

> Dan, Dave, and Judy needed money to take a vacation over Easter. They heard that the dormitory careteria was hiring part-time employees. Consequently, they went to see Marta the cafeteria manager and employee trainer. A few days later, Marta introduced them to the cook. The cook hired the help that Marta trained in the kitchen. They were given the responsibilities of dishwashing and food preparation.

APPENDIX B

TABLES CONCERNING THE VISUAL PROCESSING OF COMPETENT MIDDLE SCHOOL READERS, COMPETENT ADULT READERS, AND A COMPARISON OF COMPETENT MIDDLE SCHOOL READERS AND COMPETENT ADULT READERS

Table A-1.--t-Test: Visual Processing of Left- and Right-Embedded Structures in Unrelated and Related Discourse by Competent Middle School Readers

Variables	M	SD	t*
LE, SS and RE, SS			
Duration of gaze	.14	1.02	.73
Duration of forward fixation	.04	.70	- .32
Duration of regression	.07	.60	.62
Forward fixations	-.13	3.39	- .22
Regressions	.70	2.55	1.50
Total movements (R & F)	.57	4.97	.62
LE, $\overline{//}$ and RE, $\overline{//}$			
Duration of gaze	.28	1.12	1.38
Duration of forward fixation	.16	.56	1.59
Duration of regression	.03	.65	.23
Forward fixations	.00	2.48	.00
Regressions	-.07	3.10	- .12
Total movements	-.13	5.00	- .15
LE, SS and LE, $\overline{//}$			
Duration of gaze	.31	1.00	1.69
Duration of forward fixation	.01	.60	.12
Duration of regression	.07	.66	.59
Forward fixations	.50	2.83	.97
Regressions	.67	3.65	1.00
Total movements	1.10	5.71	1.06

Table A-1 (continued)

Variables	M	SD	t*
RE, SS and RE, π			
Duration of gaze	.11	.83	.73
Duration of forward fixation	.11	.67	.87
Duration of regression	.03	.58	.24
Forward fixations	-.63	2.99	-1.16
Regressions	-.03	2.43	- .08
Total movements (R & F)	-.67	4.50	- .81

Key - SS Three-sentence condition
π Paragraph Condition
LE Left-Embedding
RE Right-Embedding

Note - For two-tailed test: $p < .-05$

Table A-2.--t-Test: Visual Processing of Left- and Right-Embedded Structures in Unrelated and Related Discourse by Competent Adult Readers

Variables	M	SD	t*
LE, SS and RE, SS			
Duration of gaze	.60	.80	4.13 ‡
Duration of forward fixation	.07	.44	.93
Duration of regression	.33	.34	5.31 ‡
Forward fixations	.53	2.82	1.03
Regressions	1.63	2.82	3.17 †
Total movements (R & F)	2.5	3.98	3.44 †
LE, $\overline{\pi}$ and RE, $\overline{\pi}$			
Duration of gaze	.49	.50	4.64 ‡
Duration of forward fixation	.12	.39	1.72
Duration of regression	.26	.34	4.15 ‡
Forward fixations	.46	1.63	1.56
Regressions	1.33	2.09	3.49 †
Total movements (R & F)	1.8	2.84	3.46 †
LE, SS and LE, $\overline{\pi}$			
Duration of gaze	.41	.91	2.50*
Duration of forward fixation	.23	.54	2.41*
Duration of regression	.00	.29	.15
Forward fixations	1.20	2.15	3.05†
Regressions	.50	1.79	.13
Total movements (R & F)	1.7	3.39	2.74†

Table A-2 (continued)

Variables	M	SD	t*
RE, SS and RE, π			
Duration of gaze	.30	.65	2.55*
Duration of forward fixation	.28	.39	3.97‡
Duration of regression	- .06	.21	-1.65
Forward fixations	1.13	2.09	2.97†
Regressions	2.00	2.34	.47
Total movements	1.0	2.84	1.93

Key - SS Three-sentence condition
π Paragrph Condition
LE Left-Embedding
RE Right-Embedding

Note - For two-tailed test: *$p < .05$,
†$p < .01$, ‡$p < .001$.

Adapted from Bader, Pearce, and Thompson, 1980.

Table A-3.--t-Test: Comparison of Visual Processing of Left- and Right-Embedded Structures in Unrelated and Related Discourse by Competent Middle School Readers and Competent Adult Readers

Variables	t*
LE, SS and RE, SS	
Duration of gaze	-2.01*
Duration of forward fixation	- .77
Duration of regression	-2.10*
Forward fixations	- .83
Regressions	-2.15*
Total movements (R & F)	-1.66
LE, π and RE, π	
Duration of gaze	-3.36†
Duration of forward fixation	-2.29*
Duration of regression	-2.15*
Forward fixations	- .86
Regressions	-1.86
Total movements (R & F)	-1.59
LE, SS and LE, π	
Duration of gaze	- .47
Duration of forward fixation	-1.52
Duration of regression	.48
Forward fixations	-1.08
Regressions	.22
Total movements (R & F)	- .49
RE, SS and RE, π	
Duration of gaze	-2.15*
Duration of forward fixation	-2.77†
Duration of regression	.35
Forward fixations	.75
Regressions	.32
Total movements (R & F)	- .34

Key - SS Three-sentence condition
π Paragraph Condition
LE Left-Embedding
RE Right-Embedding

Note - For two-tailed test: *$p < .05$, $p < .01$

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