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THE NATURE OF VISUAL SENSORY PERCEPTION DURING THE READING PROCESS

by

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CHAPTER I

INTRODUCTION

Problem

The purpose of this study was to confirm or deny the assertion that visual sensory input during reading of English prose involved the sequential visual acquisition of letters.

Significance of the Study to Education

This study was based upon cognitive reading theory which sets forth the viewpoint that human behavior was related to the perception, storage, and retrieval of sensory information.[1] The coordination of these three elements with different responses determine the scope of learning. A defect in the perception, storage, or retrieval of sense data may result in a defect in learning.

The particular theoretical model of reading used in this study

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[1] Randall A. Silverston and John W. Deichmann, "Sense Modality Research and the Acquisition of Reading Skills," Review of Educational Research 45 (Winter 1975): 162.

was a six stage model proposed by John J. Geyer.[2] Geyer's model described how sense data may be processed while reading. A major hypothesis of his model was that the input of visual images was sequentially ordered during the fixational pause. The purpose of this study was to support or reject this assertion.

This research had little to do with the teaching of reading. Eventually, the viewpoint of cognitive theory, and the results of this study, may contribute to finding some answers to problems encountered during the processes of learning to read and of teaching others to read. An application was noted by Geyer.[3] If the input of words were sequential, and if input may be either from left-to-right or from right-to-left, then the reversal of some words by beginning readers would be easy to understand. It may be possible by training beginning readers in the habit of left-to-right scanning to reduce the tendency to reverse words.

This study was concerned with establishing that the ability to acquire words sequentially existed. If that ability were shown to exist, then relationships to learning behaviors may be sought.

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2 John J. Geyer, "Models of Perceptual Processes in Reading," in Theoretical Models and Processes of Reading, ed. Harry Singer and Robert B. Ruddell (Newark, Delaware: International Reading Association, 1970), pp. 75-79 (hereafter cited as Geyer, "Models of Reading").

3. John J. Geyer, "Geyer's Response," in Theoretical Models and Processes of Reading, ed. Harry Singer and Robert B. Ruddell (Newark, Delaware: International Reading Association, 1970), p. 97.

Hypotheses

In the reading process, some time must be used for activities in addition to the acquisition of the visual image. One such activity may be eye movement. An acquisition process which took as much or more time than the total reading process could not be the acquisition process actually used while reading because no time would remain for other necessary time-consuming reading activities.

Differences found by subtracting a subject's acquisition time from his reading time were inferred to be greater than zero since, by the above logic, reading time must be greater than the acquisition time used while reading. The average of these differences must be greater than zero also. Applying this reasoning to acquisition time for words and to acquisition time for letters suggested two hypotheses:

$$H_{r(1)}: \bar{d}_1 > 0$$
$$H_{r(2)}: \bar{d}_2 > 0$$

Where $\bar{d}_1$ was the average of differences found by subtracting each subject's visual acquisition time per word from his reading time per word, and $\bar{d}_2$ was the average of differences found by subtracting each subject's visual acquisition time per letter from his reading time per letter. These two averages were hypothesized to be greater than zero because an acquisition style used while reading necessarily used less time than the total reading process.

These two hypotheses were tested using the null hypotheses:

$$H_{0(1)}: \bar{d}_1 = 0$$
$$H_{0(2)}: \bar{d}_2 = 0$$

Definition of Terms

Acquisition time. Acquisition time is the time needed for visual processing of the images of words or letters. This time includes the time needed for a light pattern to stimulate the retina, the time needed to process this information into an icon and store it in iconic memory, but not the time needed to process the icon into sounds nor meanings.

Acquisition time per letter. The time needed to process the visual image of a single letter into iconic storage is the acquisition time per letter.

Acquisition time per word. The time needed to process the visual image of a single word into iconic storage is the acquisition time per word.

The icon. The icon is an essentially visual image capable of being stored for short periods of time. The icon may contain phonemic or semantic elements, but is basically visual or graphic in form. The units of the icon may combine two or more visual elements.

Iconic storage. Iconic storage is a visual short-term memory.

Parallel process. A parallel process is one in which all data elements of a unit are processed simultaneously. Parallel processing requires the same time to process one element as several elements.

Reading time per letter. A subject's reading time per letter is the average length of time the subject uses to process one letter while reading. In this study it is computed as 1000 times the number of seconds allowed for reading divided by the number of letters in the portion of the selection reported as read. The unit of measure is the millisecond per letter.

Reading time per word. A subject's reading time per word is the length of time needed to process a word while reading. In this study reading time per word is computed as 1000 times the number of seconds allowed for reading divided by the number of words reported as read. The unit of measure is the millisecond per word.

Sequential process. A sequential process is one in which data are manipulated one element at a time, with the processing of following elements delayed until the completion of previous ones.

Variables of the study. The variables of this study, d_{1i} and d_{2i}, are the differences for the ith subject between reading time and acquisition time for words and letters respectively. The difference is computed by subtracting acquisition time from the appropriate reading time.

Assumptions

It was assumed that the subjects of the study followed directions and honestly reported their responses during data collection.

It was assumed that the writing of a word was valid evidence of visual acquisition of the word by the subject. The time that a word or series of letters was projected to subjects was assumed to be a measure of the subject's acquisition time if the word was written correctly by the subject. The minimum acquisition time scored by a subject was assumed to be the best measure of visual acquisition time.

Throughout this study, it was assumed that intermittent projection would have no effect on visual acquisition and that projection times could be estimated as if the projection of images were continuous with instantaneous jumps from image to image. In fact, the projected image was interrupted by the projector's shutter while the film moved to the next frame. The duration of each interruption was about equal to the time that the image had been shown. Therefore, a projection rate of 18 milliseconds per frame described a situation where an image was presented for about 9 milliseconds and a dark screen shown for about 9 milliseconds before the next image. In estimating projection times, the full 18 milliseconds was used. It was assumed that no error was introduced into the estimation of acquisition times by this practice.

It was assumed that the movie projector used in the study ran at a constant rate with variations in rate too small to affect the data of this study. It was assumed that the stop watch used to measure projection rate and reading time was accurate and was properly used and read.

Limitations of the Study

The conclusions of this study were limited to the degree that the assumptions offered above were warranted. Particularly troublesome might be the assumption that acquisition times were measured by varying brief exposures of a word to the subjects.

The subjects of the study were students in the tenth, eleventh, and twelfth grades attending two of three high schools in the Waterford School District. The enrollment of these schools was composed almost entirely of white students living in suburban areas. Generalization of the results of this study was limited to a population of students attending similar schools.

The sample for the study was ten intact classes. The selection of individual subjects was not random. An effort was made to approach a random sample by selecting English classes whose meeting times were evenly distributed throughout the school day. Since English was required for five semesters of all students, this procedure tended to equalize the probability that any given student might be included in the sample. The composition of the sample was shown to be characteristic of the enrollments of the two high schools by grade and sex.

The results of this study were limited to the degree that randomness was approximated by the sample.

Summary

This chapter introduced the problem of whether the visual acquisition of English prose may take place by the sequential processing of individual letters. The assumptions, definitions, and limitations of the study were presented.

CHAPTER II

REVIEW OF THE LITERATURE

The viewpoint of cognitive reading theory has not been a popular one among research studies of reading. Only four of the thirty-three authors cited in the bibliography of this study were among those cited in the 364 studies referenced in the 1969 edition of the Encyclopedia of Educational Research after the article on "Reading."[4] Perhaps this was because the research of authors cited here was thought of as related to psychology more than to education.

Ralph Norman Haber commented, "Although educational psychologists have studied reading and reading disabilities extensively, they have not usually thought of reading as a process that depends on multistaged extraction of information from briefly fixated symbolic stimuli."[5] The theoretical model upon which this study was based did view reading as a multistaged data processing system.

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[4] Theodore L. Harris, "Reading," in Encyclopedia of Educational Research, ed. Robert L. Ebel (London: The Macmillan Company Collier-Macmillan Limited, 1969), pp. 1096-1104.

[5] Ralph Norman Haber, "Visual Information Storage," in Visual Search, Committee on Vision, Division of Behavioral Sciences, National Council (Washington, D.C.: National Academy of Science, 1973), p. 129.

The Theoretical Model

John J. Geyer proposed a six-stage model of perception during the reading process which involved as a part of its structure the hypothesis that both visual sensory input of data and some of the later data processing utilized information in a sequential manner.[6] Geyer's model consisted of the following stages: (1) visual input, (2) conversion to an icon, (3) iconic storage, (4) internal response, (5) verbal storage, and (6) an external response.

Visual input. Sensory input was postulated by Geyer to be a serial procedure that processed data at about one letter per 8 milliseconds during the fixational pause. Serial processing was suggested by the results of tachistoscopic experiments of George Sperling.[7]

Sperling presented a matrix of random letters to his subjects immediately followed by a patterned mask. The function of the mask was to prevent continued perception of the letter matrix from a retinal after-image after the stimulus had been terminated. The length of time that the matrix was presented was taken to be the amount of time the subjects used to acquire the visual image. Subjects reported about one letter for each 10 milliseconds of projection time. This increment of one letter per 10 milliseconds was attributed to

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[6] Geyer, "Models of Reading," pp. 75-79.

[7] George Sperling, "A Model for Visual Memory Tasks," Human Factors 5 (February 1963): 19-31.

the sequential input of visual sense data. The lower estimate of 8 milliseconds per letter was based on a study by Scharf and Lefton.[8]

Conversion to an icon. The elements of sensory data were converted into an icon for storage. The nature of this conversion was not well understood. Although little organization should occur when unconnected letters were read, Geyer assumed that some organization of information, probably phonemic, would occur before storage.[9] A. O. Dick disagreed. After a review of the literature on iconic storage, Dick concluded that the iconic image was uncoded.[10] Whether coded or not, the function of iconic conversion was to organize visual sensory experience into a form able to be stored in iconic storage for later processing.

Iconic storage. After conversion, the icon was independently stored for approximately one second in iconic storage. The temporal characteristics of iconic storage were studied by Sperling.[11] He

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[8] B. Scharf and L. Lefton, "Forward and Backward Masking as a Function of Illuminance," Paper presented at the Eastern Psychological Association, 1968, cited by Geyer, "Models of Reading," p. 71.

[9] Geyer, "Models of Reading," p. 77.

[10] A. O. Dick, "Iconic Memory and Its Relation to Perceptual Processing and Other Memory Mechanisms," Perception and Psychophysics 16 (December 1974) : 575-596.

[11] George Sperling, "The Information Available in Brief Visual Presentations," Psychological Monographs 74, No. 11, Whole No. 498 (1960): 1-29.

measured the memory span of five subjects at about four letters by exposing a matrix of letters, for example three rows of four letters each, for a brief time and asking that the subjects write as many letters of the matrix as they could. This span agreed with the results of Erdmann and Dodge reported by Huey.[12] Subjects were then asked to report only one row of a matrix. The row to be reported was identified by the sounding of a musical tone. A high pitched tone requested the top line, a low pitched tone requested the bottom line, and so forth. Sperling found that the subjects could correctly report about four letters even when the tone identifying the line to be reported sounded after the visual presentation had ended. These results implied that subjects had "read" their responses from a short-term visual memory, the iconic storage, and that the amount of data acquired and stored was at least twice that previously estimated as the memory span. Sperling estimated that at least nine letters could be stored. Much of this stored data was lost after as short a delay as 150 milliseconds. Mackworth estimated the duration of iconic storage at about one second.[13]

Although the iconic storage was believed to be able to hold about nine letters, a subject's memory span was only about four letters.

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[12] Edmund Burke Huey, The Psychology and Pedagogy of Reading (New York: Macmillan Company, 1908: reprint ed., Cambridge: The M.I.T. Press, 1969), p. 63.

[13] Jane F. Mackworth, "The Duration of the Visual Image," Canadian Journal of Psychology 17 (March 1963): 62-81.

George Wolford and Samuel Hollingworth investigated the possibility that the number of letters a subject was able to report may be limited by their short-term verbal memory.[14] Five adult subjects with normal vision were asked to report as many letters as possible of briefly seen images. The errors of these subjects were analyzed for acoustic and for visual confusions. No evidence of acoustic confusions was found. Visual confusions were abundant. Wolford and Hollingworth concluded that the reports of their subjects were not limited by a function of short-term verbal memory.

Douglas Hall studied the eye movements of five undergraduate students using a Mackworth eye camera.[15] The Mackworth camera displayed the location of a subject's eye fixation as a point of light superimposed over the stimulus image. Subjects were asked to report one of the three lines of three letters each after an exposure of 250 milliseconds. Hall observed that each subject tended to look at the place where the stimuli used to be. These results implied that the image used by these subjects was not a retinal after-image. Such images move with eye movement, which should discourage "looking at" the image as a successful recall strategy. An iconic image, however, should be independent of eye movement.

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[14] George Wolford and Samuel Hollingworth, "Evidence that Short-Term Memory is not the Limiting Factor in the Tachistoscopic Full-Report Procedure," Memory and Cognition 2 (October 1974): 796-800.

[15] Douglas C. Hall, "Eye Movements in Scanning Iconic Images," Journal of Experimental Psychology 103 (November 1974): 825-830.

Michael Posner and others showed that the iconic image was visual in content.[16] They asked their sixteen subjects to identify letter pairs as the same or different. Pairs could be identified as the same either by physical appearance or by name. Pairs matched by appearance, such as "A" and "A", were more accurately matched than pairs, such as "A" and "a", that were matched by letter name.

Dennis Holding took exception to Sperling's concept of an iconic storage.[17] In a skeptical review of the literature, he challenged the existence of a visual storage in excess of memory span, the concept of rapid decay of the visual image, and the visual nature of the icon. Holding maintained, "It remains possible to argue that what is retained after a brief exposure, however limited, is retained in the form of a trace. It is unlikely that Ss have appreciable access to visual representations which are not verbally coded."[18]

These challenges by Holding prompted a defense of the concept of iconic storage by Max Coltheart.[19]

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16 Michael I. Posner, Stephen J. Boies, William H. Eichelman, and Richard L. Taylor, "Retention of Visual and Name Codes of Single Letters," Journal of Psychology Monograph 79, No. 1, Part 2 (January 1969): 1-16.

17 Dennis H. Holding, "Sensory Storage Reconsidered," Memory and Cognition 3 (December 1974): 31-41.

18 Ibid., p. 35.

19 Max Coltheart, "Iconic Memory: A Reply to Professor Holding," Memory and Cognition 3 (December 1974): 42-48.

The purpose of the iconic storage was that of a buffer between the rapid processing of the visual input and conversion to icon and the slower processing of the internal response to follow.

Internal response. The internal response of interest in the reading process was assumed to be verbal. The function of this response was that of converting data from the iconic format to a form compatible with the verbal storage to follow. The rate of conversion from iconic to verbal format was estimated at about 250 milliseconds per unit by noting that about four units could be reported in the one second before the icon faded.

Verbal storage. Verbal storage has been the subject of several studies under the title of short-term memory. After reviewing the literature on human memory, Kumar concluded that about seven elements may be held in verbal storage.[20] Other attributes of verbal storage were debatable. It appeared that data may be available for as long as fifteen seconds from verbal storage if there were neither interference by other sounds nor rehearsal. It was uncertain whether the nature of the stored data was verbal only or if there were visual or semantic elements stored as well.[21]

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[20] V. K. Kumar, "The Structure of Human Memory and Some Educational Implications," Review of Educational Research 41 (December 1971): 284.

[21] Ibid., pp. 394-395.

The external response. The external response was the overt reaction of the reader to his reading experience. It might be eye movement or the pronouncing of a word.

Geyer's model at work. Geyer's model of reading may be viewed as three processing systems buffered by two storage systems. The function of the storage systems is that of allowing the processing of information at differing rates to progress smoothly. The first system, visual input and conversion to icon, processes data rapidly at a rate of one element every 0.08 milliseconds. The first storage, the iconic storage, holds visual elements for use by the slower internal response system that follows. Although mechanisms of recognition are not specified by Geyer, recognition may be a function of internal response. A verbal short-term memory holds the elements converted to verbal format by the internal response for the following external response. This procedure is dynamic. The flow of information from visual input to the external response through the intermediate units is continuous during reading.

Studies that Challenge Serial Acquisition

Huey presented convincing evidence that reading did not take place by separate fixations of the eye on one letter at a time.[22] Using a plaster of paris cup molded to fit the corneal surface of the eye, he was able to use the movements of the eye to operate an apparatus that recorded a greatly magnified tracing of the movement of the eye while reading. These tracings showed that the focus of the eye moved along a printed line in rapid jumps and paused briefly an average of four to seven times a line depending upon the length of the line and the individual reader.

The Geyer hypothesis was that processing of the visual image was sequential within the fixational pause. This processing did not require an eye movement for each letter.

Paul A. Kolers prepared a movie film which projected a six-letter word on a screen one letter at a time.[23] Each letter covered the same area of the screen as the preceding letter. Kolers found that skilled readers needed to view each letter for about one fourth of a second in order to be able to read the word. At that rate, his subjects would have read only about 40 words per minute. This was

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[22] Huey, pp. 24-28.

[23] Paul A. Kolers, "Three Stages of Reading," in Basic Studies in Reading, ed. Harry Levin and Joanna P. Williams (New York: Basic Books, Inc., 1970), pp. 90-118.

far below the reading rates of his subjects. Kolers concluded that ordinary reading did not take place by the sequential input of individual letters.

Kolers' presentation of each letter on the same area of the screen caused all letters after the first to mask previous letters. The effect of repeated masking could be difficult to predict. Hall's studies of the eye movements of subjects "reading" from iconic storage suggested that the icon was a mapping of the visual field which preserved the geometry of the sensory image.[24] This implied that Eriksen and Rohrbaugh were correct in describing the masking of an iconic image as the superimposition of two images.[25] Dember and Purcell found evidence that a masked image may be recovered if a second masking occured.[26]

If images were superimposed by Kolers' subjects, the recognition of even familiar words might be difficult. If the images of a letter were recovered after two or more letters were presented, Kolers' subjects may have reconstructed an image of the stimulus with some of the letters out of the original order. Kolers noted that his

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[24] Hall, p. 828.

[25] C. W. Eriksen and J. Rohrbaugh, "Visual Masking in Multi-element Displays," Journal of Experimental Psychology 83 (1970): 147-154.

[26] W. N. Dember and D. G. Purcell, "Recovery of Masked Visual Targets by Inhibition of the Masking Stimulus," Science 167 (1967): 1335-1336.

subjects did sometimes report all the stimulus letters correctly, but in a different order from presentation.[27]

Kolers' results may have been predicted by applying Geyer's model to Kolers' experimental conditions. When letters were presented to subjects more rapidly than one letter every 250 milliseconds, the masking complications described above prevented the formation of an iconic image from which an appropriate internal response could be devised. Subjects were unable to respond to each individual letter because the rate of presentation was more rapid than the rate at which the internal response was presumed to process stimuli. When the letters were presented at the rate of one letter every 250 milliseconds or slower, subjects were able to respond internally to each individual letter. This response, which Geyer estimated to occur at a rate of about 250 milliseconds per element, permitted storage of each letter in verbal storage before the stimulus was masked by following letters. Kolers' subjects would now have several seconds to recognize the word projected by reconstructing it from verbal storage.

Charles W. Eriksen and Terry Spencer presented a series of letters "T" and "U" in a circular pattern about a point where their subjects eyes were focused.[28] Letters were placed into the pattern

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[27] Kolers, p. 92.

[28] Charles W. Eriksen and Terry Spencer, "Rate of Information Processing in Visual Perception: Some Results and Methodological Considerations," Journal of Experimental Psychology Monograph 79 (February 1969): 1-16.

in random positions and each was shown for 2 milliseconds. Pauses between letters varied from 5 to 30 milliseconds between separate trials, but were constant within each trial. Subjects were asked to indicate whether the letter "A" had been shown. Eriksen and Spencer found that subjects were able to detect the target letter as well when the presentation of nine letters took 50 milliseconds as when it took 25 seconds. Eriksen and Spencer concluded that this result almost certainly ruled out serial encoding.

The subjects in Eriksen and Spencer's study were not engaged in an activity very similar to reading prose. They never knew where the next letter would be presented. Rapid serial processing of the type suggested by Geyer may not be possible without the expectation that the next letter will be located in a known position. Also, the subjects were required only to recognize one letter -- the target letter. It may not have been necessary for the subjects to process all the letters shown since they would be able to decide that the "A" was present as soon as they recognized that letter. This may explain why they were able to be as accurate at their task in brief times as in longer ones.

Jeffery R. Travers used a computer-operated oscilloscope to present strings of letters to college students.[29] Thirty subjects were asked to identify words or random letter strings shown one

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[29] Jeffery R. Travers, "The Effects of Forced Serial Processing of Identification of Words and Random Letter Strings," Cognitive Psychology 5 (September 1973): 109-137.

letter at a time. Both single position and adjacent displays were shown. The letters were shown both unmasked and with forward and backward masking. He found that unmasked letters were identified accurately within a range of 50 to 100 milliseconds exposure per letter. Words with masking were not identified as well. Words shown with an immediate following mask were identified about as well as were words shown in one place on the screen. These in turn were recognized about as well as random strings of letters. Travers concluded that these three conditions required more time than the unmasked words because his subjects were able to process unmasked words out of iconic storage in parallel.

If Geyer's model were accurate, Travers forced his subjects to process letters to the internal response stage before they were able to organize the letters into words by either showing the letters in place or by following them with a masking stimulus. The greater time needed for the internal response accounted for the additional time required by subjects to recognize these words. Random strings were processed to this stage as individual letters because there was no organization of them into fewer units by either the iconic conversion nor the internal response. There was no semantic and no verbal code to use for random letters except the letter names.

Travers also noted that the most rapid rate of presentation, 50 milliseconds per letter, was well below the reading rate of his subjects. Even so, they missed about 14 percent of the words presented as unmasked with letters adjacent. He suggested that this error rate

may have been due to being unable to process in parallel into iconic storage or due to the style of letters composed by the computer.

M. Kinsbourne and Elizabeth K. Warrington studies the question of sequential processing by presenting two and three letter strings to two subjects.[30] The exposure of the letters was followed by a random pattern mask. Both the duration of the presentation of the letters and the delay before masking was varied. Kinsbourne and Warrington found that their subjects were able to identify a single letter shown for 2.5 milliseconds if a relatively long interval elapsed before masking. As the stimulus time increased, identification could be achieved with a reduced delay before masking. Their subjects were able to identify two and three letter strings with an 8 millisecond delay before showing the random mask. If these subjects scanned letters sequentially, and if masking were effective in halting visual input, then these letters were scanned at a rate of one every 2.7 milliseconds. If masking was not effective in halting visual input, then the results of Sperling's study suggesting that visual input was sequential would also be in doubt.

Geyer suggested that these subjects, knowing the nature of the study's visual presentation, were able to use an "attending broadly"

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[30] M. Kinsbourne and Elizabeth K. Warrington, "The Effect of an After-Coming Random Pattern on the Perception of Brief Visual Stimuli," Quarterly Journal of Experimental Psychology 14, Part 4 (1962): 223-234.

strategy. Geyer maintained that reading took place by sequential visual acquisition because of the reader's expectation and long habit of reading from left-to-right.[31]

The Need for this Study

Of the studies reviewed, many deduced acquisition style from data gathered from tachistoscopes and similar devices. Only Kolers and Travers forced subjects to acquire visual images serially by presenting images sequentially.

Kolers used a 16mm movie projector to show letters in the same location on a screen. This procedure allowed subsequent letters of a word to be masked by previous ones. The 16mm projector was able to present images at a rate of about one every 42 milliseconds. This study used a Super 8mm movie projector able to present images at a rate of about one every 18 milliseconds. Serial processing of the visual image was forced by presenting words one letter at a time. Subsequent letters in each word were shown to the right of previous ones so that superimposing all the frames for one word would show the word as it would usually be printed. This procedure allowed images to be presented more than twice as rapidly as in Kolers' study and avoided the masking of some letters in a word by others.

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[31] Geyer, "Models of Reading," p. 71.

Travers used a computer-operated oscilloscope to present words one letter at a time with letters spread from left-to-right. He reported that at 50 milliseconds per letter, the most rapid rate of presentation, 14 percent of the words were incorrectly identified. Assuming an average word of five letters, 240 words per minute may be shown at the rate of 50 milliseconds per letter. Travers noted that this was below the reading rate for many of his subjects, but he did not report either the number of subjects who acquired words at this rate nor their reading rates.

This study did gather data on both the acquisition times and the reading times of subjects. Assuming an average word of five letters, a projection rate of 18 milliseconds per letter would display over 600 words per minute. This was well above the reading rates of nearly all the subjects of the study.

Several of the studies reviewed used relatively small samples. Travers reported the largest sample, thirty subjects, while the smallest reported only two subjects. Some studies provided their subjects with practice sessions so that the subjects were prepared for the data collection experience. This practice may have permitted the development of viewing strategies that were not representative of the reader in general.

This study used a fairly large sample of 194 high school students as subjects who were given no previous practice. Consequently, results of this study may be generalized with more confidence than the studies reviewed that used few subjects or whose subjects had been allowed to practice before data collection.

Summary

In this chapter the literature related to visual perception and reading was reviewed. A theoretical model by John J. Geyer was described. Some studies related to visual acquisition, both supporting and challenging Geyer's model, were reviewed.

This study added to the literature by comparing reading and acquisition times for words serially presented to a fairly large sample of unpracticed subjects.

CHAPTER III

DATA COLLECTION

Research Design

A major hypothesis of the model of reading perception offered by John J. Geyer was that visual data acquired during reading were sequentially ordered within the fixational pause. The time needed for the acquisition of a visual image was deduced to be less than total reading time because the total reading time included time consuming activities in addition to and independent of acquisition of a visual image. The hypotheses of this study were based on that deduction. They were:

$$H_{r(1)}: \bar{d}_1 > 0$$

$$H_{r(2)}: \bar{d}_2 > 0$$

The variable $\bar{d}_1$ was the average of differences that were calculated by subtracting each subject's acquisition time per word from his reading time per word. The variable $\bar{d}_2$ was the average of differences calculated by subtracting the acquisition time per letter for words shown a letter at a time from each subject's reading time per letter. Testing these hypotheses required measurement of acquisition times and reading rates of subjects.

The acquisition time for words seen as a whole was measured by presenting an entire word to subjects for varying time durations. The writing by a subject of a word presented was considered to be evidence that the subject was able to acquire the word visually in the time allowed for presentation. The minimum presentation time for which a subject could write the presented word correctly was scored as that subject's acquisition time for words shown as whole words.

Presentation of words one letter at a time for varying time durations was used to force sequential acquisition of words. The writing of a word by a subject was considered evidence that the word written had been acquired by the subject in the time allowed for presentation. The minimum presentation time per letter for which a subject could write a word correctly was scored as the acquisition time per letter for words shown sequentially.

The number of words reported as having been read in twenty seconds was taken as a measure of the subject's reading rate from which a reading time per word could be calculated. The minimum of three such times was scored as a subject's reading time per word.

The number of letters reported as having been read in twenty seconds was considered to be a measure of a subject's reading rate from which a reading time per letter could be calculated. The minimum of three such measures was scored as the subject's reading time per letter.

The difference variables used to test the research hypotheses of this study were calculated by subtracting the acquisition times described above from the corresponding reading times for each subject. The hypotheses were tested by computing a statistic appropriate to difference variables and comparing its value to the tabled value. The selection of statistics will be discussed in the following chapter.

The level of significance for testing the main hypotheses of this study was set at alpha equals 0.01. The level of significance for testing assumptions about distributions was set at alpha equals 0.05. The power required of statistical tests was set at 0.95 for an alternative to be specified. Alternatives were chosen that were within the values which would not change the decision to reject the null hypotheses.

The Pilot Study

Need for a Pilot Study. These procedures raised questions about previous assumptions for which empirical support was desirable. (1) In the event that a subject wrote a word incorrectly, was it probable that the word happened to be one which was not easily recognized outside the context of a sentence? (2) In the event that a subject wrote a word correctly, was it probable that some acquisition technique had been used that was not typical of the technique used while reading? (3) In reporting the number of words of a prose selection read, was it probable that subjects skipped parts of the selection?

Procedure. Sixty students in grades ten, eleven, and twelve were chosen from the enrollment of the pilot school using a table of random numbers. Ten male and ten female subjects were selected from each grade. These students were the subjects of a pilot study designed to find some answers to the three questions posed above.

The first two questions, concerning the validity of acquisition scores, may be addressed by allowing subjects to view words presented briefly and by including among the words some nonsense strings of random letters. Eliminating from the study any word that was not correctly written by most subjects of the pilot study would tend to assure that the words used could be read easily out of context.

If there were little difference in the ability of the subjects to write words and random letters, then perhaps similar reading techniques had been used for both. Random letters may be written by reading and recalling each letter. Words processed this way may not be acquired in a way that was characteristic of the reading process. If the subjects were able to write the words shown better than they did the random strings of letters, it would seem less probable that the words had been acquired by a process not typical of reading.

An attempt was made to determine if a subject had skipped a section of the reading selection by altering the selections and asking subjects to locate the change. Subjects were also asked to locate changes in a selection which they had not read by guessing. A marked difference in the ability to locate changes in the reading selection favoring those who had read the selection would allow this procedure,

described in detail below, to be used to assure that subjects did in fact read the part of the selection which they reported as read.

A list of 210 six-letter words was selected arbitrarily from a dictionary.[32] This was done by opening the dictionary at random near the front of the book and selecting the first six-letter word viewed on the page. If a six-letter word was not seen the next page was consulted, but when a six-letter word was noted, it was written down and an uncounted group of pages skipped. This process was continued until the dictionary had been leafed through twice. It was not claimed that these words would be representative of English words in general.

A random selection of ninety-five of these words combined with four nonsense words composed of random letters was made into a filmstrip. The pilot subjects were asked to view the filmstrip and write each word as it was shown. The words were shown on the screen for about a half second by interrupting the projection light manually. Subjects had ten seconds in which to respond.

About 200 words from the articles on "License," "Trademark," and "Water" were reproduced from the 1974 World Book Encyclopedia with the permission of the publisher, Field Enterprises Educational Corporation. Three forms of each article were prepared. The first was the same as the original. The second form was made by changing

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[32] Joseph H. Friend and David B. Guralnik (ed.), College Edition Webster's New World Dictionary of the English Language, (New York: The World Publishing Company, 1956).

one word in each line. The word to be changed was selected at random ignoring articles and conjunctions. The third form was made by replacing the selected word in each line with a blank.

Each subject was given an article to read, an exercise based upon that article, and an exercise based upon one of the two remaining articles. Subjects were not given a copy of the latter article. They were asked to guess the correct responses without having seen the original article.

The subjects of the pilot study were organized into two groups for data collection. Subjects in one group were given exercises that required the circling of a word in each line that had been altered. The subjects of the other group were given exercises that required the writing of a missing word in the blank space in each line. The assignment of pairs of exercises to subjects was random.

Results of the pilot study. Of the sixty subjects only thirty-one subjects, about 52 percent, took part in the pilot study. This group of subjects may not be considered to be representative of the school enrollment. The results of the pilot study were interpreted conservatively with consideration given to a pessimistic estimation of the responses of the missing subjects.

TABLE 1

PERCENTAGE OF SUBJECTS CORRECTLY WRITING NINETY-FIVE BRIEFLY SEEN WORDS

Total Number of Words Written Correctly	Percentage of Sample Present (n=31)	Percentage of Total Sample (N=60)
67	100	52
91	97	50
94	94	48
95	87	45

A filmstrip containing ninety-five six-letter words had been used to determine whether subjects could recognize these words outside the context of a sentence. The first column of Table 1 shows the number of words to be written correctly. The number of subjects to write these words is expressed as a percentage of the thirty-one subjects present in the second column and as a percentage of the total of sixty subjects in the third column. For example, the first line may be read as: sixty-seven words were correctly written by 100 percent of the subjects present, which was 52 percent of the total sample.

There were ninety-four words written correctly by 94 percent of the subjects present. If only two of the absent subjects were able to write these words, then over half of the total of sixty subjects would have correctly written these words. These ninety-four

words were used as a pool from which words may be selected for measurement of acquisition times for this study. The assumption that these words could be recognized outside the context of a sentence seemed justified.

Random strings of letters had been included in the filmstrip to help determine whether subjects had acquired images in a manner that may be assumed valid to the reading process. It was predicted that the viewing strategy used while reading would be more efficient than one used to acquire a random string of letters and that words would therefore be written more accurately than the random strings of letters.

The four random strings used in the filmstrip are shown in the first column of Table 2. The percentage of subjects to write each correctly is given in the second column. The last column shows the percentage of all the subjects who would have written the random strings correctly assuming that all the missing subjects were to have written each one correctly. This last assumption assured a pessimistic estimation of the responses of the missing subjects.

TABLE 2

PERCENTAGE OF SUBJECTS CORRECTLY WRITING EACH RANDOM STRING OF LETTERS

Random String	Percentage of Subjects Present (n=31)	Total (N=60)
ocnedr	55	77
wfsnuc	35	67
gdrkyc	23	60
vqlojg	19	58

Comparing Table 1 and Table 2, note that "ocnedr" was written by 55 percent of the subjects present. That was more than any other random string, but 32 percent less than the 87 percent of the subjects present who wrote all ninety-five words correctly. However, if missing subjects were assumed to have written all the random strings correctly and all the words incorrectly, "vqlojg" would have been written correctly by 58 percent of the subjects, fewer than any other random string, but more than any word, none of which would have been correctly written by more than 52 percent of the total of sixty subjects. These results force reliance upon the assumption that the writing of a briefly seen word correctly by a subject is a valid measure of the acquisition of the word.[33]

TABLE 3

AVERAGE PERCENTAGE OF CORRECT RESPONSES ON TESTS OF READING RETENTION

Type of Item	After Reading Article	Without Reading Article
Circle Changed Word	31	25
Fill in Missing Word	38	25

[33] This assumption was introduced on pages 6 and 7 of this study.

Reading retention tests had been given to the subjects of the pilot study in an effort to determine whether or not a subject had read the portion of a selection he reported as having read. Table 3 summarizes the results of these retention tests. Subjects who had read a selection did a little better on each type of item than those who had guessed answers to items without reading the selection. Two or three consecutive incorrectly marked items would not be good evidence that a subject had skimmed over that section of the reading selection. In addition, fifteen of the thirty-one subjects guessed at least as many items correctly for the selection they had not read as for the selection they had read. These two types of retention items were judged worthless for the purpose of assuring that subjects had read all of a selection reported as read. The items requiring circling a word changed in each line were used to discourage skimming by subjects while having their reading rate timed. These results forced reliance upon the assumption that subjects honestly reported their responses during data collection.[34]

The purpose of the pilot study was to find answers to three questions about the assumptions of the study. These questions and some answers are restated below.

<u>In the event that a subject wrote a word incorrectly, was it probable that the word happened to be one which was not easily recognized outside the context of a sentence?</u> An answer to this

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[34] Introduced on page 6 of this study.

question was sought by asking subjects to write six-letter words shown briefly. The results of the pilot study indicated that subjects were able to recognize most of the words shown out of context. Words that were correctly written by 94 percent of the subjects who took part in the pilot study were retained for use in the study.

In the event that a subject wrote a word correctly, was it probable that some acquisition technique had been used that was not typical of the technique used while reading? An answer to this question was sought by including strings of six random letters among the words shown the pilot subjects. The results of the pilot study did not provide an adequate answer to this question. The study was forced to rely upon the assumption that writing a word correctly was evidence that the word had been acquired in a manner similar to reading.

In reporting the number of words of a prose selection read, was it probable that subjects skipped parts of the selection? An answer to this question was sought through the use of reading retention tests. The results of the pilot study indicated that these tests were unable to substantiate a subject's claim to have read a portion of a reading selection. It was necessary to rely upon the assumption that subjects honestly reported the number of words read in the time allowed for reading.

An additional conclusion of the pilot study was that the technique used for obtaining subjects was unsatisfactory. When as many as 48 percent of the subjects were missing, implications of data may be impossible to interpret or to generalize to the target population. A sample of intact English classes, described below, was selected in an effort to reduce the number of subjects missing for data collection. The use of

English classes tended to equalize the opportunity of any given student to be selected for the study because English classes met throughout the school day and all students were required to take at least five semesters of English.

The Population of the Study

The population of this study consisted of the students attending high school in the Waterford School District in the 1974-1975 school year, and other high school students who were similar to these. Waterford residents were nearly all Caucasians at the time of the study. Family resources ranged from families receiving public assistance to those able to afford homes in the $60,000 bracket. The Waterford area contained several lakes. The developed land areas were almost entirely residential. There was little industry, but there was some commercial development along major roadways.

The Sample for the Study

The subjects for this study were taken from the students of two of three high schools in the Waterford School District. The two schools used for data collection were selected randomly. The remaining school was used for the pilot study.

Because only 52 percent of the pilot subjects took part in the pilot study, the membership of intact classes was used for the study. English classes were used because five semesters of English were

required of all students. One teacher from each school agreed to allow his students to serve as subjects. Two classes of a third teacher had to be substituted at the last minute due to conflict with an educational movie schedule. The film was available only at that time and the teacher was unwilling to have his students miss the film.

There were 205 students attending the selected classes on the dates of data collection. Of these, eleven students were eliminated because they either arrived to class after data collection had started or did not follow directions. The remaining 194 students were the subjects of this study.

The procedure outlined above was not a random selection. Not every student had an equal opportunity to be selected. An attempt was made to equalize the opportunity for selection by using English classes that met throughout the school day. A fairly large sample of 194 students took part in the study. Evidence was collected that the sample was representative by grade and sex of the enrollment of the two high schools from which the sample was taken. This was done using Chi Square goodness of fit tests. Table 4 shows the enrollment of two high schools, the sample, the expected sample, and the values of Chi Square. The expected values were those of a hypothetical sample that was proportional to the high school enrollments in each category. The values of Chi Square were within a range that would be expected by chance at the 0.05 level of significance. Therefore, it would appear that the sample was representative of the high school enrollments in the distribution of students by grade and sex in the Waterford School District.

TABLE 4

DISTRIBUTIONS OF HIGH SCHOOL ENROLLMENTS AND THE SAMPLE OF THE STUDY

Grade	Tenth		Eleventh		Twelfth					
Sex	M	F	M	F	M	F	Total	df	Chi Square	
School 1										
Enrollment	234	208	233	187	187	178	1227			
Sample	16	16	20	19	9	11	91			
Expected	17.4	15.4	17.3	13.9	13.9	13.2	(91.1)	5	4.52	n.s.
School 2										
Enrollment	223	228	206	180	178	168	1183			
Sample	20	17	21	14	21	10	103			
Expected	19.4	19.8	17.9	15.7	15.5	14.6	(102.9)	5	4.57	n.s.
Both Schools										
Enrollment	457	436	439	367	365	346	2410			
Sample	36	33	40	33	31	21	194			
Expected	36.8	35.1	35.3	29.5	29.4	27.9	(194)	5	3.20	n.s.

Table value of Chi Square for 5 degrees of freedom: 11.07 at the 0.05 level of significance.

Data Collection Instruments

A Super 8mm movie was filmed using sixty words chosen randomly from the pool of ninety-four words identified by the pilot study. Each item was composed of the following elements: an item number of about 108 frames, 18 blank frames, the selected word and about 540 blank frames.

At a projection rate of 54 frames per second, the item number was shown for two seconds, the break before the word for 0.33 seconds, and the response frames, for about ten seconds. Projection times for the word selected varied from 0.1 seconds to 1.7 seconds.

The film was made by photographing white cards upon which the word or letter to be shown had been marked using Prestype 1220-60L style transfer letters. The appearance of these letters is shown in Figure 1 below.

abc

Figure 1 - The Style of Transfer Letters Filmed

These letters were chosen because they resemble the letters commonly seen in print. Lower case letters were used because they are more common than upper case letters.

Items 1 to 30 were intended to measure acquisition time without imposing a structure upon the subject. All letters of the word were projected at once. Items varied from ninety frames per word to six frames per word. Table 5 shows the way in which these items varied.

TABLE 5

NUMBER OF FRAMES PER WORD
WORDS SHOWN AS A WHOLE

Item No.	Frames per Word
1- 2	90
3- 4	84
5- 6	78
7- 8	72
9-10	66
11-12	60
13-14	54
15-16	48
17-18	42
19-20	36
21-22	30
23-24	24
25-26	18
27-28	12
29-30	6

Items 31 to 60 were intended to measure acquisition time per letter by forcing subjects to view each word one letter at a time. This was done by projecting only one letter of a word at a time. Items varied from fifteen frames per letter to one frame per letter. Table 6 shows the way these items were organized.

TABLE 6

NUMBER OF FRAMES PER LETTER
WORDS SHOWN SEQUENTIALLY

Item No.	Number of Frames Per Letter	Per Word
31-32	15	90
33-34	14	84
35-36	13	78
37-38	12	72
39-40	11	66
41-42	10	60
43-44	9	54
45-46	8	48
47-48	7	42
49-50	6	36
51-52	5	30
53-54	4	24
55-56	3	18
57-58	2	12
59-60	1	6

Comparing Table 5 and Table 6 shows that items 1, 2, 31, and 32 all used ninety frames to show a word. Items 1 and 2 showed the whole word for ninety frames while items 31 and 32 showed each letter for fifteen frames. The last column, frames per word, was the same in both tables.

Figure 2 is an enlargement of items 30 and 60 from the film used to measure acquisition times. Frame lines have been added for clarity. Both items used six frames to show a word. Item 30 showed the entire word at once. Item 60 showed each of the six letters for one frame only.

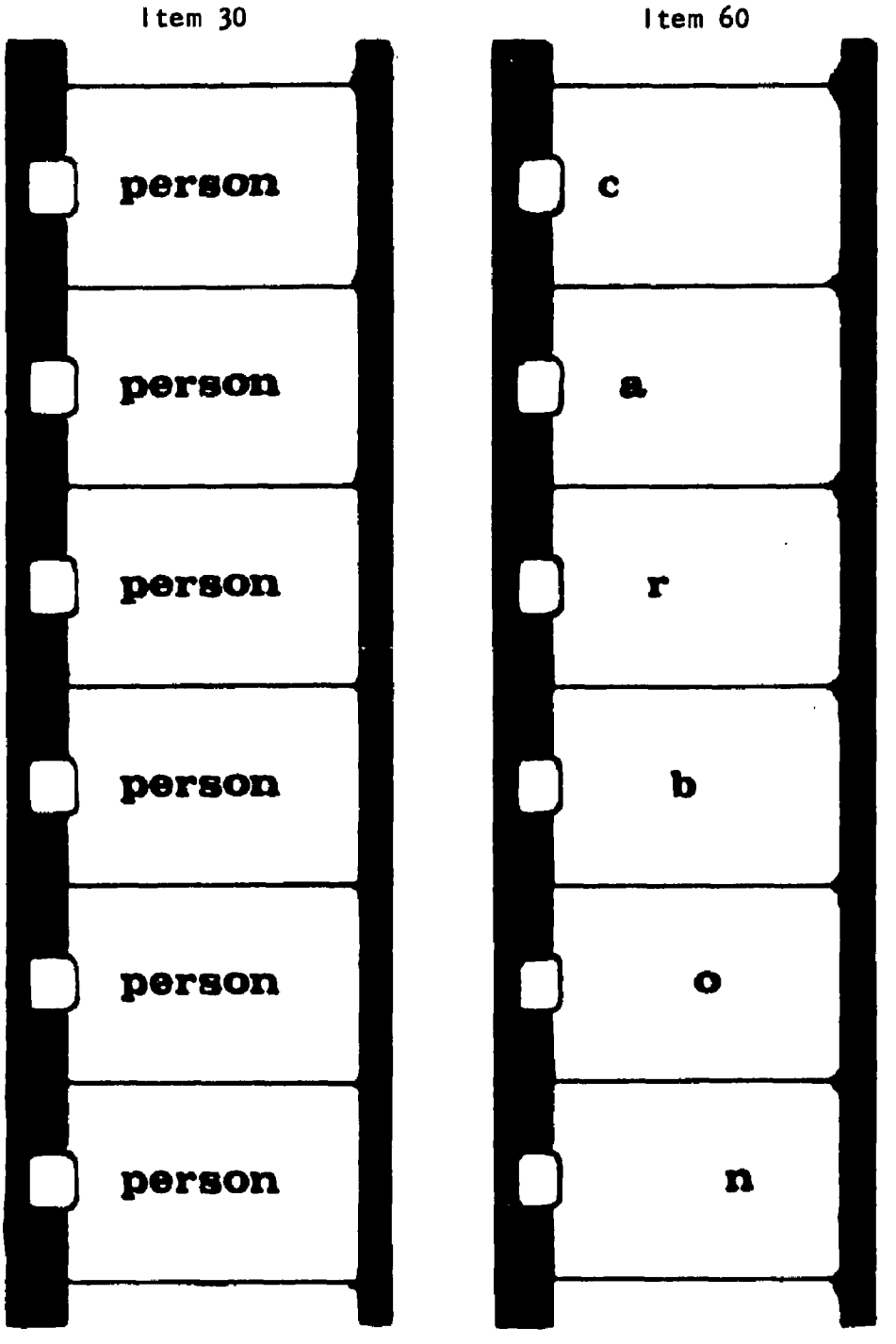

Figure 2. Enlargement of two types of film presentation. Items like item 30 were used to measure acquisition times per word. Items like item 60 were used to measure acquisition times per letter.

The same articles used in the pilot were used to measure reading rate. These consisted of about the first 200 words from the articles on "License," "Trademark," and "Water." Two forms were made of each article. One was the same as the original. The second had one word in each line altered. The second copy was included to discourage skimming while reading the article.

The amount of light reflected by the lighted and darkened movie screen upon which the words were shown was measured with a Metrastar photographic lightmeter. This was done to assure that the contrast between the projected letters and the background would be great enough to permit easy recognition of a projected image. A ratio of at least four to one between the lighted and darkened screen was desired.

The 789 frames between the second and the third items were timed with a stop watch so that the projection rate of the Super 8mm movie projector could be determined empirically.

Data Collection Procedure

At the beginning of each session the subjects were told that they were being asked to take part in a study of reading perception. Data collection booklets containing a place to write words projected and the articles to be read were passed out. Before each film was shown, subjects were told what to expect to see and asked to write

as many words as possible in the line numbered the same as the word.[35]

After the second film, the subjects were asked to read the article titled "License." The instructions were, "Read rapidly, but pay attention to every word." At the end of twenty seconds, subjects were told to stop reading and mark an "X" after the last word they had read. After the subjects had finished circling the word on the following page which they thought had been changed, the directions were repeated for the next article. When the third article had been finished, the booklets were collected.

Summary

This chapter outlined the design of the study and described a pilot study. The population of the study was identified and the selection of the study's sample was discussed. The construction and use of data collection instruments were described.

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[35] The exact directions given are Appendix B, pp. 87.

CHAPTER IV

ANALYZING THE DATA

Preparing Data for Analysis

Student booklets were corrected by hand and the results recorded on a form for punching onto computer cards. After all the booklets had been corrected, a random sample of three booklets from each class was rescored. This sample of about 15 percent was taken to locate errors made while correcting and recording data. All booklets in a class were reprocessed if an error was located in the sample. A second sample, taken in the same manner, located no errors. The data were then punched onto computer cards and verified by a skilled keypunch operator.

The variables recorded were: (1) code numbers indicating the building, grade, and sex of each subject, (2) t_1, the minimum number of milliseconds associated with the correctly written items from items 1 to 30, (3) t_2, the minimum number of milliseconds associated with the correctly written items from items 31 to 60, (4) t_3, the subject's reading time in milliseconds per word for the article on "License," (5) t_4, the subject's reading time in milliseconds per word for the article on "Trademark," (6) t_5, the subject's reading time in milliseconds per word for the article on "Water," (7) t_6, the subject's reading time in milliseconds per letter for the article on "License,"

(8) t_7, the subject's reading time in milliseconds per letter for the article on "Trademark," and (9) t_8, the subject's reading time in milliseconds per letter for the article on "Water."

The number of milliseconds associated with the times t_1 and t_2 were determined by the projection rate of the Super 8mm movie projector used in the study. The same machine was used for all data collection. The time needed to project the 789 frames between items 2 and 3 was measured with a stop watch. The average time for these frames was 14.42 seconds. The standard deviation was 0.04 seconds. Assuming that the projector ran at a steady rate, 789 frames in 14.42 seconds equaled a projection rate of 18.3 milliseconds per frame. Table 7 shows the projection times associated with each item of the film based on a projection rate of 18.3 milliseconds per frame.

Items numbered 1 to 30 showed an entire word at a time. According to Table 7, item number 27 was shown for twelve frames and was projected for a total of 219.6 milliseconds. A subject who had item 27 correct would be credited with an acquisition time for whole words of at least 219.6 milliseconds per word. A subject correctly writing item 28 would be credited with the same time. If item 27 was the last item to be written correctly among items 1 to 30, then 219.6 milliseconds per word would be scored as t_1, the minimum number of milliseconds per word associated with the correctly written items from items numbered 1 to 30 inclusive.

TABLE 7

PROJECTION TIMES ASSOCIATED WITH EACH ITEM
USED TO MEASURE ACQUISITION TIME

Item Number	Frames Per Word	Milliseconds Per Word	Item Number	Frames Per Word	Milliseconds Per Letter
1- 2	90	1647.0	31-32	15	274.5
3- 4	84	1537.2	33-34	14	256.2
5- 6	78	1427.4	35-36	13	237.9
7- 8	72	1317.6	37-38	12	219.6
9-10	66	1207.8	39-40	11	201.3
11-12	60	1098.0	41-42	10	183.0
13-14	54	988.2	43-44	9	164.7
15-16	48	878.4	45-46	8	146.4
17-18	42	768.6	47-48	7	128.1
19-20	36	658.8	49-50	6	109.8
21-22	30	549.0	51-52	5	91.5
23-24	24	439.2	53-54	4	73.2
25-26	18	329.4	55-56	3	54.9
27-28	12	219.6	57-58	2	36.6
29-30	6	109.8	59-60	1	18.3

The variables d_1 and d_2, the differences between acquisition and reading times for words and letters respectively, were calculated using a computer program written in the FORTRAN IV language. The program was verified by analyzing fictitious data previously calculated manually. The difference variables were computed for each subject using the following formulae:

$$d_1 = \text{Min } (t_3, t_4, t_5) - t_1 \qquad (1)$$

$$d_2 = \text{Min } (t_6, t_7, t_8) - t_2 \qquad (2)$$

The expression "Min" referred to taking the smallest element within the following parenthesis. Therefore, d_1 was the difference of the minimum time that a subject read one word and the minimum time the subject acquired one word projected as a whole. The variable d_2 was the difference between the minimum time a subject read one letter and the minimum time the subject acquired one letter when words were projected letter by letter.

After the data collection booklets had been scored, it was discovered that nearly every subject had been assigned the minimum values for t_1 and t_2, the two measures of acquisition time. A device which could present images more rapidly than the projector used in this study may have permitted observation of smaller values of each subject's acquisition times. According to the formulae, (1) and (2), smaller values of t_1 and t_2 would produce greater values of d_1 and d_2 if the values of the reading times were unchanged.

The hypotheses of this study state that the average values of d_1 and d_2 were greater than zero. If these hypotheses were supported by the observed data, no error would be introduced by estimating values of d_1 and d_2 using the observed values of t_1 and t_2. More accurate data collection could result only in greater values of d_1 and d_2 with correspondingly greater average values of d_1 and d_2. If the observed average values of d_1 or d_2 were greater than zero, then more accurately measured values would be greater than zero also. If the hypotheses of the study were rejected by the observed data, then more accurate observations of acquisition times might reverse the decision to reject the hypotheses.

These effects, described above, of using upper bound measures of t_1 and t_2 were considered when the hypotheses of the study were evaluated.

Selecting Statistical Tests

Data were collected from subjects who were classified in two categories by school, three categories by grade, and two categories by sex. If there were no differences between schools, grades, or sexes as measured by the variables d_1 and d_2, then it would be proper to pool all the subjects into one group to test each research hypothesis. This procedure would eliminate the risk of finding spurious significant differences by avoiding the calculation of several statistical tests. If there were differences between schools, grades,

or sexes, then it would be improper to eliminate the categories in which the differences occurred by pooling their membership. A statistical test was needed that would identify differences among schools, grades, or sexes if such differences existed in the variable of the study.

Analysis of variance is a parametric test used to test for differences among subjects classified by one or more variables. The decision to pool or not to pool subjects in different categories could be based on an F-test from an analysis of variance of the two difference variables.

The hypotheses of the study were hypotheses of differences. They stated that the means of variables d_1 and d_2 were both greater than zero. A statistical test of magnitude for the means of difference variables was needed.

The t-test is a parametric test used to test differences of magnitude. The decision to reject or not to reject the hypotheses of this study could be based on a t-test of the two difference variables.

The assumptions underlying these parametric tests were: (1) that the observations were independent, (2) that observations were drawn from normally distributed populations, and (3) that the scores of subjects were measured by at least an interval scale. In the case of analysis of variance, an additional assumption must be added: (4) that the samples in the various classifications had equal variances.

It was doubted that the differences between acquisition times

and reading times, d_1 and d_2, were normally distributed. All the acquisition scores found by showing subjects whole words were 109.8 milliseconds per word, the minimum time possible. Of the 194 subjects, 188 scored 18.3 milliseconds per letter, the minimum time, as their acquisition time measured by showing words sequentially by letters. Reading times may not be expected to be normally distributed because it seemed likely that poor readers may drop out of high school in proportionally greater numbers than good readers. For these reasons, the scores of subjects were submitted to Chi Square goodness of fit tests to a normal distribution. The degree of freedom for the tests were reduced by two because the means and standard deviations of the normal distributions used were estimated using the means and standard deviations of the sample. These tests were provided and computed by the Department of Systematic Studies of Oakland Schools.[36] Table 8 summarizes the results of these tests. Both variables d_1 and d_2 differed from normal distributions at the 0.05 level of significance.

It was doubted that the samples were drawn from groups having equal variances. Bartlett's Test for the homogeneity of variances was designed to test the assumption that sample cells in analysis of variance were of equal variances.[37]

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[36] John T. Roscoe, The Funstat Package in FORTRAN IV (New York: Holt, Rinehart and Winston, Inc., 1973), pp. 77-80.

[37] Wilfrid J. Dixon and Frank J. Massey, Jr., Introduction to Statistical Analysis (New York: McGraw-Hill Book Company, Inc., 1957), pp. 179-180.

TABLE 8

FREQUENCY DISTRIBUTION FOR GOODNESS OF FIT OF d_1 and d_2 TO A NORMAL DISTRIBUTION USING TWENTY CELLS OF EXPECTED EQUAL FREQUENCY

Cell	Expected	d_1	d_2
1	9.7	0	1
2	9.7	11	12
3	9.7	14	8
4	9.7	18	13
5	9.7	9	17
6	9.7	11	11
7	9.7	4	9
8	9.7	6	6
9	9.7	12	25
10	9.7	23	8
11	9.7	13	7
12	9.7	3	6
13	9.7	24	21
14	9.7	6	8
15	9.7	6	6
16	9.7	7	6
17	9.7	7	6
18	9.7	3	7
19	9.7	4	7
20	9.7	13	10
Mean	-	103.45	27.09
Standard Deviation	-	72.47	16.08
Chi Square	-	82.91*	62.70*
Degrees of Freedom	-	17	17

* Significant at the 0.05 level of significance.

Table 9 summarizes the sample sizes, variances, and results of Bartlett's tests for d_1 and d_2, the differences between reading time and acquisition time for words and letters respectively. Because the F-values of Bartlett's tests were larger than the tabled values for both variables, the assumption that these samples were from populations having the same variance was rejected for both variables d_1 and d_2 at the 0.05 level of significance.

When the underlying assumptions of analysis of variance are met, it is one of the most powerful statistical tests of significance. When the assumptions are not met, it is sometimes difficult to estimate the effect upon the power of the test and upon the level of significance for rejecting the null hypothesis. If the sample sizes in each cell are equal, the actual level of an F-test from an analysis of variance is very nearly the same as the tabled value, even when the variances of the sample cells are not equal.[38] Conversely, if the variances in the cells are equal, varying the sample sizes within the cells has little effect upon the level of significance of the F-test from an analysis of variance. When both the number of subjects in the sample cells and the variances of these cells differ, control over the level of significance of the F-test of an analysis of variance is lost. According to Table 9 the sample sizes for the variables of this study

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[38] Gene V. Glass, Percy D. Peckham, and James D. Sanders, "Consequences of Failure to Meet Assumptions Underlying the Analysis of Variance and Covariance," Review of Educational Research 43 (Summer 1972): 245.

TABLE 9

VARIANCES AND SAMPLE SIZES OF THE DIFFERENCES BETWEEN ACQUISITION AND READING TIMES FOR WORDS AND LETTERS, d_1 and d_2, RESPECTIVELY

Variable	School 1 Sample Size	School 1 Variance	School 2 Sample Size	School 2 Variance	Bartlett's Test Degrees of Freedom	Bartlett's Test F-Value
d_1						
Tenth Grade Males	16	11,308.45	20	1,936.53	--	--
Tenth Grade Females	16	4,126.14	17	3,303.18	--	--
Eleventh Grade Males	20	4,138.64	21	6,115.32	--	--
Eleventh Grade Females	19	2,408.95	14	2,914.21	--	--
Twelfth Grade Males	9	4,764.23	21	9,365.87	--	--
Twelfth Grade Females	11	1,996.06	10	9,716.40	--	--
Homogeneity Test	--	--	--	--	(11, 18,956)	2.92*
d_2						
Tenth Grade Males	16	545.71	20	105.47	--	--
Tenth Grade Females	16	182.49	17	160.32	--	--
Eleventh Grade Males	20	186.07	21	306.78	--	--
Eleventh Grade Females	19	114.43	14	220.42	--	--
Twelfth Grade Males	9	294.38	21	435.23	--	--
Twelfth Grade Females	11	85.55	10	432.01	--	--
Homogeneity Test	--	--	--	--	(11, 18,956)	2.68*

* Significant at the 0.05 level of significance.

vary from twenty-one subjects in the largest cell to nine subjects in the smallest cell. Bartlett's Test of the homogeneity of variances rejected the assumption that the variances among the cells of the variables d_1 and d_2 were equal. Neither the sample sizes nor the variances of the cells of these variables are equal. Therefore, an analysis of variance of the variables d_1 and d_2 should not be used.

Nonparametric tests are generally less powerful than equivalent parametric tests, but the assumptions underlying nonparametric tests are often either fewer or more easily met. The power of a statistical test refers to the probability that the test will reject a null hypothesis when it should be rejected. The more powerful of two statistical tests is the one most likely to reject correctly a false null hypothesis.

Power-efficiency is a measure of the power lost by using a nonparametric test in the place of a similar parametric test. This measure is the ratio of the number of subjects needed by the nonparametric test to the number needed by the parametric test if the power of the two tests is to be equal. This relation may be expressed by the following equation.[39]

$$P.E. = (100)\frac{N_a}{N_b}\text{ percent}$$

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[39] Sidney Siegel, Nonparametric Statistics (New York: McGraw-Hill Book Company, 1956), pp. 20-21.

In this formula, P.E. is the power-efficiency of nonparametric test B which has the same power with N_b subjects as has parametric test A with N_a subjects. To be comparable, both statistical tests A and B must fit the same research design.

The accuracy of the probability statements of nonparametric tests usually does not depend upon a particular distribution of the population sampled. This property sometimes permits wider generalization of the results of nonparametric tests than of parametric tests.

The Kruskal-Wallis one-way analysis of variance is used to test whether several independent samples are from different populations. The null hypothesis for this test is that the samples are members of the same population or were drawn from populations having equal means. The assumptions underlying the Kruskal-Wallis one-way analysis of variance are: (1) that the samples are independent, (2) that the variable tested has an underlying continuous distribution upon which rank orders may be based, and (3) that the variable be measured at least by an ordinal scale. The power-efficiency of the Kruskal-Wallis one-way analysis of variance is 95.5 percent compared to analysis of variance.[40]

The variables of this study, d_1 and d_2 met the assumptions of the Kruskal-Wallis one-way analysis of variance. Responses of one subject did not affect those of other subjects, and the inclusion of a subject in the sample did not affect the probability that another subject be included.

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[40] Ibid., pp. 184-193.

The samples were independent. The variables were differences in time. Time is generally accepted as a continuous variable. The units of measure, the millisecond per word and the millisecond per letter, are ratio-interval scales upon which rank orders may be based.

The Kruskal-Wallis one-way analysis of variance may be applied to this study to determine whether there is a difference between schools, grades, or sexes for d_1 and d_2, the differences between acquisition and reading times for words and for letters respectively. This requires six applications of the Kruskal-Wallis analysis, one for each classification of subject for each of the two variables. This repeated analysis increases the probability of locating a spurious difference among the classes of subject. This increased risk is acceptable, because the purpose of the analysis is to avoid pooling inappropriate groups of subjects. These subjects are grouped into twelve cells (two schools by three grades by two sexes). If the total number of tests, including the Kruskal-Wallis tests, for each variable is less than the twelve tests that would be needed to test each group separately, then the risk of locating spurious differences may be reduced also.

After the Kruskal-Wallis analysis, the subjects may be arranged into groups having means that do not differ at the 0.05 level of significance. The scores of these subjects meet all the assumptions of the t-test except that of being drawn from normally distributed populations. In a review of the literature, Gardner concludes that with large samples the shape of the distribution of a variable has negligible effect on

t-values.[41] The size of a "large" sample is not specified. The t-test is used in this study to test the main hypotheses for groups of more than thirty subjects.

Results

The Kruskal-Wallis one-way analysis of variance tests were computed to determine if there were differences between schools, grades, or sexes on the variables d_1 and d_2 of the study. The program used computed a Chi Square statistic corrected for the number of ties in the ranking of variables.[42] This program and the computer power to use it were provided by the Department of Systematic Studies of Oakland Schools.

The purpose of this analysis was to avoid the risk of improperly evaluating the research hypotheses by pooling groups whose means differed. A minimum power of the Kruskal-Wallis analyses of 0.95 was set to define the extent of this risk. The value of the minimum average difference, d_{min}, that would be significantly greater than zero at the 0.05 level of significance was computed for the group in each analysis having the smaller observed mean. This minimum became the alternative for that group for the computation of the power of an analysis of variance test.[43] This

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[41] Paul Leslie Gardner, "Scales and Statistics," Review of Educational Research 45 (Winter 1975): 49.

[42] Roscoe, pp. 70-74.

[43] Dixon and Massey, pp. 256-258.

power was computed assuming that the data had met the assumptions of analysis of variance. The number of subjects in the group was reduced to 0.955 of the actual number in order to convert the power of an analysis of variance to an estimate of the power of the Kruskal-Wallis one-way analysis of variance.[44] The power computed for the Kruskal-Wallis tests was above 0.95 for each test.

Tables 10, 11, and 12 summarized the results of the Kruskal-Wallis one-way analysis of variance. The critical values of Chi Square for the 0.05 level of significance and the proper degree of freedom were printed below each table. There was a difference between schools for both variables d_1 and d_2 at the 0.05 level of significance. Neither variable differed among grades at the 0.05 level of significance. There was a difference between males and females in the variable d_1 at the 0.05 level of significance. There was no difference between males and females in d_2 at the 0.05 level of significance. Therefore, when testing the hypotheses of the study for variable d_1, $H_{r(1)}$, t-tests were calculated for four groups of subjects: (1) males attending school 1, (2) females attending school 1, (3) males attending school 2, and (4) females attending school 2. When testing the hypotheses for d_2, $H_{r(2)}$, t-tests were calculated for two groups of subjects: (1) subjects attending school 1 and (2) subjects attending school 2.

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[44] Siegel, pp. 192-193.

TABLE 10

SUMMARY OF KRUSKAL-WALLIS ONE-WAY
ANALYSIS OF VARIANCE BY SCHOOLS

Variable	n	Sum of Ranks	Mean	df	Chi Square
d_1 School 1	91	9756.0	113.29		
d_1 School 2	103	9159.0	94.78	1	5.113*
d_2 School 1	91	9720.5	29.32		
d_2 School 2	103	9194.5	25.11	1	4.728*

* Significant at the 0.05 level of significance.

TABLE 11

SUMMARY OF KRUSKAL-WALLIS ONE-WAY
ANALYSIS OF VARIANCE BY GRADES

Variable	n	Sum of Ranks	Mean	df	Chi Square	
d_1 Grade 10	69	6876.0	106.78			
d_1 Grade 11	74	7310.0	100.69			
d_1 Grade 12	51	4729.0	102.98	2	0.509	n.s.
d_2 Grade 10	69	7166.5	28.73			
d_2 Grade 11	74	7061.0	25.54			
d_2 Grade 12	51	4687.5	27.11	2	1.495	n.s.

TABLE 12

SUMMARY OF KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE BY SEX

Variable	n	Sum of Ranks	Mean	df	Chi Square
d_1 Males	107	9572.5	97.63		
d_1 Females	87	9342.5	110.63	1	4.897*
d_2 Males	107	9771.0	26.25		
d_2 Females	87	9144.0	28.12	1	2.896*

* Significant at the 0.05 level of significance.

The results of these t-tests were summarized in Table 13. Every value of the t statistic was larger than the tabled value for the appropriate degree of freedom at the 0.01 level of significance.[45] Indices of skewness and of kurtosis were calculated to permit judgment of the degree of departure of each group's distribution from a normal distribution. The formulae used were:

$$\text{Index of skewness of } d_k = \frac{\sum_{i=1,n_k}(d_{ik}-\bar{d}_k)^3}{n_k s_k^3}$$

$$\text{Index of kurtosis of } d_k = \frac{\sum_{i=1,n_k}(d_{ik}-\bar{d}_k)^4}{n_k s_k^4}$$

[45] Dixon and Massey, p. 384.

TABLE 13

SUMMARY OF t-TESTS THAT MEANS OF d_1 AND d_2 WERE GREATER THAN ZERO

Variable	Group	k	n	Mean	Standard Deviation	Index of Skewness	Index of Kurtosis	df	t
d_1	School 1								
	Males	1	45	121.31	81.5499	1.26	5.05	44	9.979*
	Females	2	46	105.43	53.8224	0.24	3.02	45	13.286*
	School 2								
	Males	3	62	80.43	75.8362	1.67	6.91	61	8.351*
	Females	4	41	116.47	68.0462	1.24	5.92	40	10.959*
d_2	School 1	5	91	29.32	15.3006	1.16	5.65	90	18.282*
	School 2	6	103	25.11	16.5558	1.37	6.52	102	15.393*

* Significant at the 0.01 level of significance, one-tail test.

The variables d_k were differences for group k between acquisition times and reading times. The variable n_k was the number of subjects in the group k, and s_k was the standard deviation of d_k. The variable k was the group number as listed in Table 13. For a normal distribution these indices have values of 0.0 and 3.0 respectively.[46]

Research Decision

The research hypotheses of this study were:

$$H_{r(1)}: \bar{d}_1 > 0$$

$$H_{r(2)}: \bar{d}_2 > 0$$

In the above formulae, $\bar{d}_1$ was the average of the differences found by subtracting acquisition time for words from reading time for words, and $\bar{d}_2$ was the average of differences calculated by subtracting acquisition time for letters from reading time for letters. The variable d_1 was a measure of the difference between acquisition time and reading time when the mode of acquisition had not been structured by the format of measurement. This was accomplished by measuring acquisition time by varying the times that subjects could view whole words at once. The variable d_2 was a measure of the difference between acquisition time and reading time when subjects were forced to acquire words sequentially. This was accomplished by measuring acquisition time by varying the times that subjects could view individual letters of words shown one letter at a time.

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[46] Edwin E. Ghiselli, Theory of Psychological Measurement (New York: McGraw-Hill Book Company, 1964), pp. 58-60.

The hypothesis $H_{r(1)}$ was tested by four t-tests, the tests for groups in which k equals 1 to 4 in Table 13. All of these tests were significant at the 0.01 level of significance. These results supported the first research hypothesis. The subjects of this study were able to acquire words rapidly enough to account for their reading rates when acquisition style was not structured. If this hypothesis had not been supported by the data, then either the data collection procedure or the logic underlying the hypothesis would have been faulty. Either of these alternatives would have implied that no valid conclusions may be based upon the results of the study for $H_{r(2)}$ because the data collection procedure and logic underlying the two hypotheses were similar.

The hypothesis $H_{r(2)}$ was tested by two t-tests, the tests in which k equals 5 and 6 in Table 13. All of these tests were significant at the 0.01 level of significance. These results supported the second research hypothesis. The subjects of this study were able to acquire words rapidly enough to account for their reading rates when the sequential acquisition of words one letter at a time was forced. These results implied that subjects may acquire words sequentially during the reading process.

Seven statistical tests were used to evaluate the first research hypothesis: three Kruskal-Wallis analyses and four t-tests. Five statistical tests were used to evaluate the second research hypothesis: three Kruskal-Wallis analyses and two t-tests. A total of twelve statistical tests were used to evaluate the two research hypotheses of the study. Twenty-four tests would have been needed if the twelve

classifications of subjects were evaluated separately for each of the two research hypotheses. The procedure followed in the study probably limited the introduction of error by reducing the total number of statistical tests used to evaluate the two research hypotheses of the study.

Summary

This chapter has presented the analysis of the data of this study. The processes used to prepare data for computer analysis were described, and the times associated with each item of the film used to measure acquisition times were computed and summarized. The formulae used to calculate the variables of this study, d_1 and d_2, were given as each subject's minimum acquisition time subtracted from the subject's minimum reading time for words and letters respectively. These were the variables used to test the hypotheses of the study.

Kruskal-Wallis one-way analyses of variance were used to determine which groups of subjects could be appropriately pooled. This nonparametric test was used because the variables of the study were unable to meet the assumptions underlying analysis of variance. The Kruskal-Wallis tests allowed pooling the variable d_1 by grades only. This pooling formed four groups: (1) male subjects attending school 1, (2) female subjects attending school 1, (3) male subjects attending school 2, and (4) female subjects attending school 2. Pooling was appropriate for the variable d_2 by both grade and sex. This pooling formed two groups:

(1) subjects attending school 1 and (2) subjects attending school 2. These six groups were each tested separately by t-tests for each of the study's research hypotheses.

The t-test was selected for testing the research hypotheses because it was a powerful parametric test that was robust to violation of the assumption of normality in the variables tested. The variables of this study, d_1 and d_2, were able to meet the assumptions of the t-test other than that of normality. These t-tests found that the means of each group tested were above zero at the 0.01 level of significance. Both research hypotheses were supported by these results.

Support of $H_{r(1)}$ implied that subjects were able to acquire words seen without structure of acquisition well enough to account for their reading rates. This result was predicted by the first hypothesis of the study. Support of the hypothesis was evidence that the processes used to measure acquisition times and reading times were valid.

Support of $H_{r(2)}$ implied that subjects were able to acquire words by forced serial acquisition rapidly enough to account for their reading rates. This result was predicted by the second hypothesis of the study. Support of this hypothesis was evidence that acquisition during the reading process may be sequential.

CHAPTER V

CONCLUSIONS

Review of the Study

It was the purpose of this study to answer the question of whether the visual acquisition of words could take place by the sequential input of individual letters. This study was based upon the viewpoint of cognitive psychology which had as its central function the study of sensory input and the processes by which sensory information was stored, decoded, and used.[47] A model of reading by John J. Geyer provided the theoretical basis of the study.

Geyer's model was an information processing approach to reading that stressed the storage devices and the response systems used during reading. A major hypothesis of Geyer's theoretical model stated that the input of visual information during the fixational pause of the eye was sequential.[48]

Reading time was postulated to be greater than acquisition time because reading involved time consuming activities in addition to the visual acquisition of images. Therefore, reading time minus acquisition time would be greater than zero and the averages of these differences would be greater than zero also.

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[47] U. Neisser, Cognitive Psychology (New York: Appleton-Century-Crofts, 1967), p. 4.

[48] Geyer, "Models of Reading," p. 75.

This reasoning led to the formation of two research hypotheses:

$$H_{r(1)}: \bar{d}_1 > 0$$

$$H_{r(2)}: \bar{d}_2 > 0$$

The variable $\bar{d}_1$ was the mean of the difference scores found by subtracting acquisition time for words from reading time for words. The variable $\bar{d}_2$ was the mean of the difference scores found by subtracting the acquisition time for letters from the reading time for letters. The variable d_1 was interpreted as a measure of the difference between acquisition time and reading time when acquisition was not structured by data collection. This was done by measuring acquisition times by varying the time a subject was allowed to view a word shown as a whole. The variable d_2 was interpreted as a measure of the difference between acquisition time and reading time when sequential acquisition of words by individual letters was forced by data collection. Sequential acquisition was forced by measuring acquisition time by varying the time a subject was allowed to view one letter of a word shown one letter at a time.

Students attending Waterford's high schools and other similar students were the population for the study. The subjects of the study were students attending English classes in two of the three high schools in the Waterford School District. A total of ten intact classes were selected from the high schools in the study. An attempt was made to obtain a sample representative of the population by selecting classes that met throughout the school day. English classes were chosen because all students were required to take five semesters of English. The

sample was not a random sample. Chi Square goodness of fit tests showed that the sample was representative of the schools enrollments by grade and by sex.

Analysis of the variables d_1 and d_2 with Kruskal-Wallis one-way analysis of variance tests divided the subjects into six groups for testing the two research hypotheses of the study. The research hypotheses implied that the means of each of these six groups were greater than zero. A t-test was calculated for each group using the null hypothesis that the mean of the group was equal to zero. One-tailed tests were used. Each t-value permitted the rejection of the null hypothesis at the 0.01 level of significance. Both research hypotheses were supported by these results.

Conclusions of the Study

The first research hypothesis, $H_{r(1)}: \bar{d}_1 > 0$, was supported at the 0.01 of significance level by t-tests of the means of groups having k equal to 1 through 4 in Table 13. The means of the difference scores between acquisition time and reading time for words were significantly greater than zero. Subjects were able to acquire words more rapidly than they were able to read words when acquisition was not structured. This result was evidence that the estimation of acquisition by varying the duration of projected words was a valid procedure. When acquisition was not structured, subjects were free to use that style of acquisition used while reading which would necessarily be less than reading time because acquisition was one of several time consuming parts of reading.

The second research hypothesis, $H_{r(2)}: \bar{d}_2 > 0$, was supported at the 0.01 level of significance by t-tests of the means of groups having k equal to 5 and 6 in Table 13. The means of the difference scores between acquisition time and reading time for letters were significantly greater than zero. Subjects were able to acquire words more rapidly than they read words when sequential acquisition of words by individual letters was forced by presenting words to be acquired one letter at a time. This result was evidence that reading may proceed by the acquisition of words serially one letter at a time. For the population of this study, Geyer's hypothesis that reading did take place by serial acquisition may not be challenged by the assertion that the human perceptual system was unable to acquire words rapidly enough by serial means to be able to support commonly observed reading rates. In fact, all but one of the 194 subjects of this study were able to acquire a six-letter word, seen one letter at a time, faster than they read six letters of a prose selection.

This research resolved an apparent contradiction between the results of studies by George Sperling and Paul A. Kolers. Sperling had deduced from tachistoscopic experiments that acquisition of visual images were sequential.[49] Kolers showed that his subjects were unable to acquire words rapidly enough to account for their reading rates when words were presented letter by letter.[50] Since Kolers had displayed each letter in

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[49] Sperling, "A Model of Visual Memory Tasks," pp. 19-31.

[50] Kolers, "Three Stages in Reading," pp. 90-118.

the same location, it was suggested that letters after the first may have interfered with acquisition of following letters by masking. This study demonstrated the ability of its subjects to acquire words letter by letter when each letter shown was displaced to the right of previous letters. Acquisition was rapid enough to account for the observed reading rates of the subjects.

The results of this study were predicted if acquisition during reading were sequential. The results do not, however, prove that readers do as a matter of fact acquire visual images sequentially during reading. It was possible that the results of this study were an artifice of iconic storage. It may be argued that subjects acquired each letter as it was shown until an image of the entire word was formed in iconic storage. The processing of the image may then have continued as usual for reading without necessarily assuming that acquisition must be sequential.

The Need for Further Research

If the success of the subjects of this study in acquiring words sequentially were a function of iconic storage, subjects should be able to acquire words whose letters were shown in random order as long as the physical location of each letter in the visual field, relative to the other letters displayed, were the same as their locations in the word. Success in acquiring words shown in this way would strengthen the argument that the results of this study were functions of iconic

storage. Failure to acquire words when letters were shown randomly would strengthen the hypothesis that acquisition during reading is sequential by showing that the results of this study were probably not a function of iconic memory.

The subjects of this study were not selected at random and were taken from a narrow population. There is a need for replication of this study using a random sample from a larger population. Particularly, variance of race, cultural background, and age was slight among the sample used in this study. Replication by random sampling from a larger population would permit wider, more confident generalizations of the results of the replication than of this study.

In this study acquisition was measured using six-letter words. If serial acquisition were used in reading, then words of varying length, phrases, and sentences short enough to fit within the subject's eye span may be acquired serially. Replication of this study using words of varying length, phrases, and short sentences would be an additional test of Geyer's hypothesis.

The acquisition times measured in this study were upper bounds of the variable. Nearly every subject scored at the least time possible with the devices used. Measurement of shorter acquisition times are possible through the use of instruments able to present visual images at a more rapid rate than one image per 18 milliseconds. Rates as rapid as one image every 2 milliseconds should be sufficient to determine acquisition rates more accurately. Presentation rates near one image every 2 milliseconds may permit measurement of the variance of acquisition

times. This in turn permits estimation of the reliability of measurement.

Nearly all subjects scored the same acquisition times. This lack of variance among subjects prevents identification of subjects experiencing relative difficulty in visual acquisition, should such subjects exist. If the use of more rapid presentation of visual images reveals variance among subjects, a correlational study may disclose other reading problems associated with difficulty in visual acquisition. Should such relationships exist, it would be appropriate to study the effect of practice at visual acquisition upon the related problems. Studies of possible interaction between practice at visual acquisition and remedial treatment of the related reading problems may also be designed.

It may be interesting to determine whether the ability to acquire visual images serially is a learned skill. This may be done by testing the ability of non-readers to acquire familiar visual images sequentially.

Summary

In this chapter the methods of the study were reviewed. The results supporting the two research hypotheses were restated. It was concluded that these results were evidence that warranted Geyer's hypothesis that reading takes place by the input of sequentially ordered visual images during the fixational pause of the eye. The need for further research to increase the scope and confidence of generalization was cited. A need to determine variance in serial acquisition and to

relate such variance to reading skills was noted. The possibility that practice in serial acquisition may aid in the remediation of related reading problems was suggested as a topic for research should a relation between acquisition and reading skill be established.

APPENDIX A

Data collection booklets

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Name _____ Date _____

Circle your grade: 10 11 12

Circle your sex: Boy Girl

You will see two movies that flash words on the screen. Write each word in the space below that is numbered the same as the word. That is, write word 1 in space 1, and so forth.

1. _____	16. _____	31. _____	46. _____
2. _____	17. _____	32. _____	47. _____
3. _____	18. _____	33. _____	48. _____
4. _____	19. _____	34. _____	49. _____
5. _____	20. _____	35. _____	50. _____
6. _____	21. _____	36. _____	51. _____
7. _____	22. _____	37. _____	52. _____
8. _____	23. _____	38. _____	53. _____
9. _____	24. _____	39. _____	54. _____
10. _____	25. _____	40. _____	55. _____
11. _____	26. _____	41. _____	56. _____
12. _____	27. _____	42. _____	57. _____
13. _____	28. _____	43. _____	58. _____
14. _____	29. _____	44. _____	59. _____
15. _____	30. _____	45. _____	60. _____

Think about how you watched for the words during the movie. Check the statements that best describe how you watched.

When the whole word was shown at once:

_____ 1. I usually tried to look near the center of the word and tried to see the word as a whole.

_____ 2. I usually tried to look at the first letter first and to scan the letters from left to right.

_____ 3. I don't remember how I usually tried to see the word.

_____ 4. Other way. (Tell how) _____

_____

When the words were shown one at a time:

_____ 1. I usually tried to look near the center and see the complete word at once.

_____ 2. I usually tried to look at each letter as it appeared.

_____ 3. I don't remember how I usually tried to see the word.

_____ 4. Other way. (Tell how) _____

_____

Boating brings pleasure to millions of people every year. Many enjoy paddling a canoe across a lake or fishing from a rowboat. Others like to glide over the water in a sailboat.*

Boating brings joy to millions of people every year. Many enjoy riding a canoe across a pond or fishing from a rowboat. Others like to glide over the water in a hydrofoil.

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*Taken from "Boating" in Volume 2 of The World Book Encyclopedia. © 1974 by Field Enterprises Educational Corporation with the permission of the publisher.

LICENSE*

License means permission. The word license is most often used to mean a permit granted by a public authority. Sometimes the granting authority is the federal government. Sometimes it is a state or city government.

A license may permit a person to carry on a business or to practice a profession. It implies that the person who receives the license is capable of doing his work without injuring the public. For example, a physician must receive a state license before he may legally practice medicine. The license means that the state considers the physician qualified in his profession.

There are many other kinds of licenses. A man must have a license before he may legally go hunting or fishing. In many states and cities, it is unlawful to own a dog without a license.

Usually a person must pay a certain amount of money for a license. All states require the owner of an automobile to buy a vehicle license. This kind of license has two purposes. It brings funds into the state treasury, and it identifies the vehicle in case of an accident. Many cities also require vehicle licenses, usually in connection with a system of safety tests for automobiles.

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There are many other types of licenses. A man must have a license before he may lawfully go hunting or fishing. In many states and counties, it is unlawful to own an animal without a license.

Usually one must pay a certain amount of cash for a license. All states require the owner of an automobile to buy a vehicle permit. This kind of license has two uses. It brings funds into the government treasury, and it identifies the vehicle in case of trouble. Many cities also issue vehicle licenses, usually in connection with a system of safety tests for cars.

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*Based on "License" in Volume 12 of The World Book Encyclopedia.

WATER*

Water is the most common substance on earth. It covers more than seventy per cent of the earth's surface. It fills the oceans, rivers, and lakes, and is in the ground and in the air we breathe. Water is everywhere.

Without water, there can be no life. Every living thing - plants, animals, and man - must have water to live. In fact, every living thing consists mostly of water. Your body is about two-thirds water. A chicken is about three-fourths water, and a pineapple is about four-fifths water. Most scientists believe that life itself began in water - in the salty water of the sea. The salty taste of our blood, sweat, and tears suggests that this might be true.

Ever since the world began, water has been shaping the earth. Rain hammers at the land and washes the soil into rivers. The oceans pound against the shores, chiseling cliffs and carrying away land. Rivers knife through rock, carve steep canyons, and build up land where they empty into the sea. Glaciers plow valleys and cut down mountains.

Water helps keep the earth's climate from getting too hot or too cold. Land absorbs and releases heat from the sun quickly. But the oceans absorb and release the sun's heat slowly.

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*Taken from "Water" in Volume 21 of The World Book Encyclopedia.

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*Based on "Water" in Volume 21 of The World Book Encyclopedia.

TRADEMARK*

A trademark identifies and distinguishes the products of one business firm from those of another. It may include a word, a sentence, a name, a symbol, a picture, or any combination of these. Trademarks usually appear on the product or its container. Many trademarks contain the name of the owner of the business. But manufacturers often use some word to describe the qualities of the product, or make up a word. The spoken part of a trademark is called the brand name.

Trademarks provide a simple way for people to determine who is responsible for a particular item. They also help people identify the brands they liked in the past so they may purchase them again. Manufacturers use trademarks to promote the sale of their goods.

Service marks also identify goods and services. They do not have to be attached to a product. Companies that provide services to the public, such as transportation companies, use these marks to advertise their services. For example, a blue sign with a bell, the symbol of the American Telephone and Telegraph Company, tells every passerby that a public telephone is available for use.

Laws to protect the rights of the trademark owner were developed in the early eighteen hundreds.

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Laws to protect the interests of the trademark owner were passed in the early eighteen hundreds.

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MERCHANDISE MART PLAZA
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October 28, 1974

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Royal Oak, Michigan 48073

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Sincerely yours,

Clare Atwood

Clare Atwood
Permissions Editor

CA:ls

APPENDIX B

Directions to subjects

INSTRUCTIONS GIVEN DURING DATA COLLECTION

The words in capital letters were read out loud to the subjects.

TODAY YOU WILL BE ASKED TO TAKE PART IN A STUDY OF READING PERCEPTION. MANY EXPERTS BELIEVE THAT READERS SEE EACH WORD AS A WHOLE, BUT SOME BELIEVE THAT READERS SCAN WORDS ONE LETTER AT A TIME. YOU WILL HAVE AN OPPORTUNITY TO TRY EACH WAY OF LOOKING AT WORDS.

Pass out the test booklets.

PLEASE COUNT THE NUMBER OF PAGES IN YOUR BOOKLET. THERE SHOULD BE NINE. IF YOU DO NOT HAVE NINE PAGES, RAISE YOUR HAND AND WE WILL EXCHANGE YOUR BOOKLET FOR ANOTHER.

Allow time.

WRITE YOUR NAME AT THE TOP OF THE PAGE. (Allow time) WRITE THE DATE (give the date). CIRCLE THE NUMBER BENEATH YOUR NAME THAT IS THE SAME AS YOUR GRADE. BOYS CIRCLE "BOY," AND GIRLS CIRCLE "GIRL."

Allow time and check booklets.

YOU WILL BE SHOWN TWO FILMS THAT SHOW WORDS BRIEFLY ON THE SCREEN. WRITE EACH WORD IN THE SPACE NUMBERED THE SAME AS THE WORD. THAT IS, WRITE WORD ONE IN SPACE ONE, AND SO FORTH.

THE FIRST FILM WILL SHOW AN ENTIRE WORD AT ONE TIME. EACH WORD WILL BE SHOWN FOR A SHORTER TIME THAN THOSE BEFORE IT. YOU WILL HAVE TEN SECONDS TO WRITE EACH WORD. THAT IS ENOUGH TIME FOR YOU TO WRITE CAREFULLY. BEFORE EACH WORD IS SHOWN, I WILL SAY THE NUMBER THAT GOES WITH IT. THIS WILL HELP YOU KEEP YOUR PLACE AND WILL ALSO LET YOU KNOW

WHEN THE NEXT WORD IS ABOUT TO APPEAR. IF YOU CANNOT READ A WORD, WRITE AS MANY LETTERS AS YOU CAN. ARE THERE QUESTIONS?

Answer questions. Show reel #1. Time item 2.

Wait until the film has ended.

IN A MOMENT, YOU WILL BE SHOWN THE SECOND FILM. IT WILL SHOW WORDS ONE LETTER AT A TIME. WRITE EACH WORD AFTER IT HAS BEEN SHOWN IN THE SPACE NUMBERED THE SAME AS THE WORD. IF YOU CANNOT READ A WORD, WRITE AS MANY LETTERS AS YOU CAN. IN THIS FILM, THE FIRST LETTER WILL BE SHOWN AT THE LEFT OF THE SCREEN. THE REST OF THE LETTERS WILL BE SHOWN ONE AT A TIME EACH TO THE RIGHT OF THE PREVIOUS LETTER. ARE THERE QUESTIONS?

Answer questions. Show reel #2.

FOLD OVER THE FIRST PAGE OF YOUR BOOKLET SO THAT ONLY THE SECOND PAGE CAN BE SEEN, LIKE THIS. (Hold up booklet.) THINK ABOUT HOW YOU WATCHED FOR THE WORDS DURING THE MOVIE. CHECK THAT STATEMENT THAT BEST DESCRIBES HOW YOU WATCHED. CHECK ONE STATEMENT FOR EACH FILM. Allow time.

TURN OVER THE SECOND PAGE SO THAT ONLY THE NEXT PAGE CAN BE SEEN. ON IT ARE TWO SAMPLE PARAGRAPHS ABOUT BOATING. THE SECOND IS THE SAME AS THE FIRST EXCEPT THAT ONE WORD IN EACH LINE HAS BEEN CHANGED. READ THE PARAGRAPHS AND CIRCLE THE WORD IN EACH LINE OF THE SECOND PARAGRAPH THAT IS DIFFERENT FROM THE FIRST. Allow time.

YOU SHOULD HAVE CIRCLED, "JOY" IN THE FIRST LINE, "RIDING" IN THE SECOND LINE, AND "HYDROFOIL" IN THE LAST LINE. ARE THERE QUESTIONS? Answer questions.

FOLD OVER THE PAGE SO THAT ONLY THE NEXT PAGE MAY BE SEEN. LOOK AT THE BOTTOM OF THE PAGE. BELOW THE LINE, IT SHOULD BEGIN, "TAKEN FROM 'LICENSE' . . . " IF IT DOES, TURN YOUR BOOKLET OVER SO THAT THE BLANK SIDE IS UP. IF IT DOES NOT, RAISE YOUR HAND. Check that booklets are face down. Help those who raise hands.

When every one is ready, continue. THE EXERCISE THAT FOLLOWS IS DONE THE SAME WAY AS THE SAMPLE ON "BOATING", BUT IT IS LONGER. WHEN YOU ARE TOLD TO BEGIN, TURN YOUR BOOKLET OVER AND READ THE ARTICLE ON "LICENSE". YOU WILL HAVE 20 SECONDS AND YOU ARE NOT EXPECTED TO FINISH. WHEN THE TIME IS UP, I WILL SAY "STOP", MARK AN "X" AFTER THE LAST WORD YOU READ. ARE THERE QUESTIONS? Answer questions.

READ THE ARTICLE RAPIDLY, BUT PAY ATTENTION TO EVERY WORD. YOU MAY BEGIN.

Time 20 seconds.

STOP. MARK AN "X" AFTER THE LAST WORD YOU READ. FOLD THE PAGE OVER SO THAT ONLY THE NEXT PAGE MAY BE SEEN. YOU SHOULD FIND A SECOND ARTICLE ON "LICENSE". CIRCLE THE WORD IN EACH LINE THAT IS DIFFERENT FROM THE ARTICLE ON "LICENSE". DO NOT TURN TO THE NEXT PAGE NOR LOOK BACK AT THE PREVIOUS PAGE. Allow about 90 seconds.

FOLD THE PAGE OVER SO THAT ONLY THE NEXT PAGE MAY BE SEEN. LOOK AT THE BOTTOM OF THE PAGE. BELOW THE LINE IT SHOULD BEGIN, "TAKEN FROM 'WATER' . . . " IF IT DOES, TURN YOUR BOOKLET OVER. IF IT DOES NOT, RAISE YOUR HAND. Check.

THIS EXERCISE IS DONE THE SAME WAY AS THE LAST. WHEN YOU ARE TOLD TO BEGIN, READ THE ARTICLE RAPIDLY, BUT PAY ATTENTION TO EVERY WORD.

YOU MAY BEGIN.

Time 20 seconds.

STOP. MARK AN "X" AFTER THE LAST WORD YOU READ. FOLD OVER THIS PAGE AND CIRCLE THE WORD IN EACH LINE OF THE SECOND ARTICLE ON "WATER" THAT IS DIFFERENT FROM THE ONE YOU JUST READ. DO NOT TURN TO THE NEXT PAGE NOR LOOK BACK TO THE PREVIOUS ONE. Allow about 90 seconds.

FOLD OVER THE PAGE SO THAT ONLY THE NEXT PAGE MAY BE SEEN. BELOW THE LINE IT SHOULD BEGIN, "TAKEN FROM 'TRADEMARK' . . . " IF IT DOES, TURN YOUR BOOKLET FACE DOWN. IF IT DOES NOT, RAISE YOUR HAND. Check.

THIS EXERCISE IS DONE THE SAME WAY AS THE LAST. WHEN YOU ARE TOLD TO BEGIN, TURN YOUR BOOKLET OVER AND READ THE ARTICLE RAPIDLY, BUT PAY ATTENTION TO EVERY WORD. YOU MAY BEGIN.

Time 20 seconds.

STOP. MARK AN "X" AFTER THE LAST WORD YOU READ. FOLD OVER THIS PAGE AND CIRCLE THE WORD IN EACH LINE OF THE SECOND ARTICLE ON "TRADEMARK" THAT IS DIFFERENT FROM THE ONE YOU JUST READ. DO NOT LOOK BACK TO THE PREVIOUS PAGE. Allow about 90 seconds.

FOLD THIS PAGE OVER. YOU SHOULD HAVE RETURNED TO PAGE ONE. CHECK TO SEE THAT YOU HAVE WRITTEN THE DATE. (Repeat date.) ALSO CHECK THAT YOU CIRCLED THE CORRECT GRADE AND SEX. (Allow time.)

THANK YOU VERY MUCH.

Collect test booklets. Rewind the film.

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