8-1972

The Order of Information Processing in the Perception of Short Sentences

Maryam Abusaidi
Western Michigan University

Follow this and additional works at: https://scholarworks.wmich.edu/masters_theses
Part of the Experimental Analysis of Behavior Commons

Recommended Citation
https://scholarworks.wmich.edu/masters_theses/2742

This Masters Thesis-Open Access is brought to you for free and open access by the Graduate College at ScholarWorks at WMU. It has been accepted for inclusion in Master's Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact maira.bundza@wmich.edu.
THE ORDER OF INFORMATION PROCESSING
IN THE PERCEPTION OF SHORT SENTENCES

by

Maryam Abusaidi

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Degree of Master of Arts

Western Michigan University
Kalamazoo, Michigan
August 1972
ACKNOWLEDGEMENTS

I would like to extend my warmest thanks to Dr. Robert M. W. Travers, my advisor and committee chairman for his great interest, generous giving of time and extreme patience throughout the course of this study. His advice and supervision have broadened my training and skill in the area of information processing and reading.

I also wish to express my special thanks to Drs. Frank Fatzinger and Chris Koronakos, whose guidance and assistance have been invaluable during preparation and submission of this thesis.

My thanks also to a friend from Iran, Miss Eftekhar Miri, for her encouragement and interest in this research, and finally to the College of Education for its financial support throughout the past two years.

Maryam Abusaidi
INFORMATION TO USERS

This dissertation was produced from a microfilm copy of the original document. While the most advanced technological means to photograph and reproduce this document have been used, the quality is heavily dependent upon the quality of the original submitted.

The following explanation of techniques is provided to help you understand markings or patterns which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting thru an image and duplicating adjacent pages to insure you complete continuity.

2. When an image on the film is obliterated with a large round black mark, it is an indication that the photographer suspected that the copy may have moved during exposure and thus cause a blurred image. You will find a good image of the page in the adjacent frame.

3. When a map, drawing or chart, etc., was part of the material being photographed the photographer followed a definite method in "sectioning" the material. It is customary to begin photoing at the upper left hand corner of a large sheet and to continue photoing from left to right in equal sections with a small overlap. If necessary, sectioning is continued again – beginning below the first row and continuing on until complete.

4. The majority of users indicate that the textual content is of greatest value, however, a somewhat higher quality reproduction could be made from "photographs" if essential to the understanding of the dissertation. Silver prints of "photographs" may be ordered at additional charge by writing the Order Department, giving the catalog number, title, author and specific pages you wish reproduced.

University Microfilms
300 North Zeeb Road
Ann Arbor, Michigan 48106
A Xerox Education Company

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
ABUSAIDI, Maryam
THE ORDER OF INFORMATION PROCESSING IN THE PERCEPTION OF SHORT SENTENCES.

Western Michigan University, M.A., 1972
Psychology, experimental

University Microfilms, A XEROX Company, Ann Arbor, Michigan

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PROBLEM STATEMENT</th>
<th>THEORETICAL BACKGROUND AND REVIEW OF THE LITERATURE</th>
<th>OVERVIEW OF THE PROBLEM</th>
<th>METHODOLOGY AND DATA COLLECTION</th>
<th>EXPERIMENT I</th>
<th>EXPERIMENT II</th>
<th>EXPERIMENT III</th>
<th>GENERAL DISCUSSION AND CONCLUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Context (Meaningfulness)</td>
</tr>
<tr>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Visual information</td>
</tr>
<tr>
<td>II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Position of the words in a fixation</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>REFERENCES</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>APPENDIX A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>APPENDIX B</td>
</tr>
</tbody>
</table>

1  PROBLEM STATEMENT
2  THEORETICAL BACKGROUND AND REVIEW OF THE LITERATURE
19  OVERVIEW OF THE PROBLEM
21  METHODOLOGY AND DATA COLLECTION
25  EXPERIMENT I
26  Materials
27  Procedure
29  Results
35  EXPERIMENT II
35  Materials
36  Procedure
37  Results
42  EXPERIMENT III
43  Materials
43  Procedure
43  Results
49  GENERAL DISCUSSION AND CONCLUSION
50  Context (Meaningfulness)
52  Visual information
55  Position of the words in a fixation
58  REFERENCES
61  APPENDIX A
63  APPENDIX B

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Counter-balanced Design of the Two Sets of Sentences .......... 27</td>
</tr>
<tr>
<td>II</td>
<td>Mean Number of Trials for Recognition of Each Word in Each Position Under Each Condition, in Experiment I .......... 32</td>
</tr>
<tr>
<td>III</td>
<td>Mean Number of Trials for Recognition of Each Word in Each Position Under Each Condition, in Experiment II .......... 39</td>
</tr>
<tr>
<td>IV</td>
<td>Percentage of Words Recognized for Each Position Under Each Condition .......... 45</td>
</tr>
</tbody>
</table>

LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Harvard Tachistoscope .......... 23</td>
</tr>
<tr>
<td>2</td>
<td>Graphic Presentation of the Mean Number of Trials for Recognition of Each Word in Each Position Under Each Condition, in Experiment I .......... 33</td>
</tr>
<tr>
<td>3</td>
<td>Graphic Presentation of the Mean Number of Trials for Recognition of Each Word in Each Position Under Each Condition, in Experiment II .......... 40</td>
</tr>
<tr>
<td>4</td>
<td>Graphic Presentation of Percentage of Words Recognized for Each Position Under Each Condition .......... 46</td>
</tr>
</tbody>
</table>
PROBLEM STATEMENT

There have been many studies involving different theoretical models and processes in reading. Gibson (1962) has studied the development of grapheme-phoneme correspondences and associations, Nodine and Hardt (1970) have investigated letter position and recognizability, Samuels (1970) has studied different methods through which words are recognized, Geyer (1970) has investigated perceptual processes in reading, Stauffer (1970) has explored cognitive factors in reading, and Goodman (1970) has attempted to explore reading in terms of psycholinguistic theory.

Some of the recent research on reading has come from studies which deal mainly with information processing approaches to visual perception (Dick and Dick, 1969). Such studies include "Visual Processing and the Use of Redundant Information in Tachistoscopic Recognition" (Dick, 1970), and "Processing of Sequentially Presented Letters" (Haber and Nathanson, 1969) and others.

These studies have tried to clarify questions that are relevant to reading such as: What interacting systems are involved in reading? How is the information being processed through these systems? What variables influence perception in reading? What are the important cues in recognition of words and sentences? How does the order of information processing affect reading?
The present study has dealt primarily with the last question. It examines the order in which the information is processed through tachistoscopic presentation of short sentences.

THEORETICAL BACKGROUND AND THE REVIEW OF THE LITERATURE

Since the psychological analysis of reading has been a fairly new approach in this area, most of the studies that will be discussed are only partially related to this study.

As E. J. Gibson (1965) has pointed out, a prerequisite to good research on reading is the psychological analysis of the processes which implies complete understanding of the perceptual, cognitive, linguistic and motivational aspects of the field. Knowing this, one may consider how the skill is learned and how it could best be taught. She has suggested that there are three phases in learning reading: 1) learning to differentiate graphic symbols, 2) learning to decode letters to sounds (map the letters into sounds), 3) and using gradually (progressively) higher-order groupings of words.

Gibson has pointed out the child's acquisition of the language is a prerequisite for reading. The child is first able to discriminate graphemes by detecting their distinctive features which, in fact, is a gradual process of perceptual learning that comes with practice. When the graphemes become discriminable from one another the decoding
process becomes possible. Decoding is simply the matter of associating a grapheme with its appropriate speech sound.

Gibson emphasizes that although graphemes are processed perceptually in reading, the task is not a letter-by-letter recognition sequence. For instance, with a tachistoscopic exposure of a fraction of a second, a skilled reader can recognize four unconnected letters, within a group of letters. In the case of words, he can see a long word, and in a sentence he recognizes about four words. Therefore, in one exposure letter-by-letter sequential processing is obviously not possible (Gibson, 1965).

Finally the child, as he grows up, is capable of using a higher order of groupings of words which means he can recognize bigger "chunks" of graphic stimuli in each fixation. Gibson has also mentioned the role of the practice in perceptual learning. With practice, the errors are reduced and the perception of distinctive features of a letter or word becomes more discriminable. Therefore, sheer repetition will yield improvement. Other factors such as reinforcement, punishment, correction of errors and variation of the stimulus can have interacting effects with practice in terms of perceptual learning. She has classified practice methods into four types of tasks: detection, discrimination, recognition and identification.

Haber is one of the few psychologists who has done
several experiments on repetition and recognition of words and letters. His main concern is: Do repeated brief exposures of a word at a constant duration contribute to the growth of a percept, in terms of recognition of that word? In his experiment he chose nine groups of seven letter three syllable English words. Each group contained 56 words that were judged to be non-rare. He used five durations, "the lowest of these five durations at which subject perceived more than just an occasional word, was defined as his threshold duration (T)". (Haber, 1965, p. 41) Other durations were designated as T-5, T+5, T+10, T+15. Exposure duration and number of trials varied independently in order to investigate the growth of the perception for each word.

Each word was assigned to one of the exposure durations (T, T-5, T+5, T+10, T+15) and one of the eight numbers (1, 2, 3, 4, 5, 10, 15, 25), each indicating the number of trials for each word. For instance the first word was assigned (randomly) to a subject with the duration of T+5 and the number three (3) indicated the number of trials for that particular word. For each stimulus exposure, the subject was required to report verbally the letters that he was certain he had seen (perceived) and their position (order) in relation to the word, even if the subject was sure that he could identify the word. Therefore, all of the verbal reports were based on the identification of the letters not words. The criterion for
perceiving a word was when the subject could correctly identify all of the seven letters on any of the exposures. This criterion (using letters rather than words) increased the probability of reports based on what the subject actually saw rather than on what he thought he saw. The analysis of the data showed that with duration constant the probability of perceiving a word increased with the number of trials so that the word was quite clear and easily identified after a number of flashes, even though only a blank uniform field could be seen for the first few trials.

On the other hand, Haber notes that "despite this effect of repeated exposures, the probability of perceiving a word was always higher for a single flash at a given duration than for two or more flashes at a shorter duration summing to the same total duration". (Haber, 1965, p. 40)

Haber offers several explanations for the mechanism involved in the growth of a percept through repeated exposures. One is that when the information was received and processed on one flash, this could facilitate perception of a word on the next flash (or perhaps increase the perception toward the distinctive feature of the letters of that word) at least for the first few trials. An alternative interpretation, which yet requires more research, is what he has called short term memory explanation:

"If the image of the stimulus from which the subject is working fades rapidly at very low durations so that he cannot 'scan' all of the letters, he may not be able to perceive
them all before they fade. This interpretation is consistent with recent evidence which suggests that short term memory fades quite rapidly and allows subject only a short time, perhaps much less than a second, to process the letters in the stimulus. If processing of a seven-letter word takes a given length of time, and the duration of the flash leads to a short term memory shorter than that time, then subject will never correctly identify all of the letters." (Haber, 1965, p. 46)

He has suggested in this particular experiment, that the threshold duration for the perception of a word was probably very close to the life of the image in short term memory.

Haber and his co-workers have conducted other experiments to see the effect of different variables on the growth of perception, in terms of word recognition.

He has found out that meaning does play a role in recognition, since his subjects were able to recognize the English words faster than the Turkish ones. He states that meaning could have an "inhibitory" effect as well as "facilitatory", but perceptual growth occurs regardless of this effect (Hershenson and Haber, 1965).

In another experiment, he presented a different three-letter word on each trial, and found out that the probability of seeing a particular letter is a function of whether the previous word had an identical letter in that serial position, i.e. if the word "cat" appeared in one flash and on the next flash the word "was" appeared on the screen, then the probability of perceiving the letter
"a" was much higher for this letter than for any of the other letters in the word sequence. Therefore, it appears that the perceptual growth of the individual letter may carry over between words (Standing and DaPolito, 1968). Recognition can also occur despite the changes in the location or specific physical form of the letter even with peripheral vision (Haber, Standing and Boss, 1970).

In one of the studies entitled "Processing of Sequentially Presented Letters" (Haber and Standing, 1969), 1,250 common English words from four to eight letters were presented in such a way that the words were shown one letter at a time. Each letter acted as a visual noise field for the preceding letter. The processing time was defined as onset to onset of sequentially presented visual letters. Haber believes this would predict recognition better than either the time each item is on, or the time between the offset of an item and the onset of the next one; also shortening off time for processing of each item can be compensated by lengthening on time and vice versa.

His results showed that 1) the processing of a letter takes an amount of time that is independent of the rate of presentation, but is dependent on the length of the words. 2) Stability of the processing time per letter (holding word length constant), suggests serial (letter-by-letter) interpretation of information processing. Another assumption
he has made is that the processing time for the various letter positions (order of letters in the words) could not have been equal. No noise mask followed the last letter and preceded the first letters of any word, consequently, these letters (first and last) had more time available to be processed in relation to the time available for processing letters in other positions. He concluded, this could have been the main reason for finding more correct responses for the first and last letters than for the middle positions. He writes:

"The average letter should, therefore, have a greater probability of being correctly reported in a short word than in a long word, a fact that would explain the increased processing time for letters of long words. In addition, memory span may be exceeded more often by long than by short words. Thus, the subject may process the letters of long words at a high rate, but forget some of them before he can make his report."

(Haber and Standing, 1969, p. 361)

In one experiment on "Visual Perception of Rapidly Presented Word Sequences of Varying Complexity", Foster (1970) says that in a short sentence consisting of six words, meaningful or nonsense, the longer words are reported more often than shorter ones. He explains, this could be due to the fact that usually long words are more often surrounded by words of shorter length, then, the beginnings and ends of the longer words are more likely to be free of interference from surrounding words.

In Foster's experiment, for instance, the probability of detection was .59 if the preceding word was shorter in
length, but only .49 if the preceding word was longer. Similarly if the word following was shorter the probability of detection was .58 as opposed to .51 if the word following was longer. In this study since the first and last words were detected more frequently, Foster explains this phenomenon in terms of visual noise (or masking). Furthermore, when there is no word prior to the first one and following the last, then the first and last words will be processed or perhaps presented more effectively. That is, no forward and backward masking effect will occur for the first and last words. Thus, he believes on the purely sensory grounds, the first and last words should be better reported than others. However, this is not so for the comparison between the third and the fifth words in the sequence. Finally he writes that complexity of the sentence structure only affects perception when the time available for sentence analysis (processing of information) is severely limited.

<table>
<thead>
<tr>
<th>Probability of Correct Report of Words of Varying Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length in Letters</td>
</tr>
<tr>
<td>Probability of Correct Report</td>
</tr>
</tbody>
</table>

K. I. Foster, 1970
Comparing the results of Haber's study with Foster's study, one might conclude that it will make a great difference if the word is presented alone or in the context in the sentence. In other words, according to Haber, presentation of a single short word would require less time for processing than a longer word since he believes the processing is sequential (letter-by-letter). But in the sentence, Foster believes the longer words are recognized more efficiently in relation to the shorter surrounding words.

Smith (1971) has brought up an interesting aspect of reading and that is the "reduction of uncertainty." He writes, if we consider reading like any other process for acquiring information or perhaps reducing uncertainty, then identification of letters, words, or phrases becomes more clear. In each of the three processes of reading (letter identification, word identification or phrase comprehension) information is acquired visually. This information reduces the number of alternative possibilities. The exact number of possibilities can be cited for letters (26) for words (perhaps 50,000), but the number of alternatives for comprehension is very much related to the 1) passage being read and 2) the person who reads it. However, it is not necessary to know the exact amount of uncertainty i.e. number of reducible alternatives, since often the knowledge the reader has of the world and his knowledge of language reduces the amount of visual information he
must extract from the printed page.

Although in the case of letters it is assumed that letters have equal probable alternatives, in English the letters do not occur in the language with equal frequency. For instance, some of the letters such as e, t, a, o, i, n, and s occur much more often than others. In fact, "e" occurs about 40 times more often than the least frequent letter "z". (Smith, 1971)

Because of this inequality in the frequency of occurrence of letters, the average uncertainty of letters is less than what has been estimated (4.0 bits as compared with 4.7 bits). This also applies to words, since in the English language there are some words that are used more often than others.

In terms of choosing an alternative from a category of letters or words, the inequality of frequency would perhaps make the elimination of possibilities easier.

Another aspect of reading that Smith has mentioned in his book is "redundancy". He writes, redundancy exists whenever information is duplicated by more than one source, in other words, the same information is repeated, though perhaps in a different form, in more than one place.

One can say there is redundancy whenever some of the alternatives can be eliminated perhaps in different ways. For instance, in a word with an initial letter "t", the alternatives for the second letter of that word is most likely to
be H or U rather than M, N or P. Or even if one eliminates every third or fourth word in a passage, it is still possible to comprehend the main idea of that passage.

The concept of redundancy is especially applicable to reading where the context is quite large such as in books, articles and newspapers. Thus, the larger the context the greater is the redundancy, and the more redundancy there is, the less visual information a skilled reader requires. Furthermore, if the reader requires much visual information, he will usually be unable to get it fast enough to overcome memory limitations. In terms of setting a criterion for letter or word identification, it has been suggested that it depends on how much information the reader demands. He might establish a relatively low criterion for identifying a word that is common in his past experience, but he might require more information or set a higher criterion if the word is the one that appears infrequently. A great deal of perception is the result of the fact that available information from our past experiences leads to a decision at the time when new information is received.

According to Smith, every aspect of reading can be seen as a process of categorization.

"The identification of letters involves allocating the incoming of visual information (from the marks on the page) into a set of 26 pre-established categories, each associated with the name of a letter of the alphabet. The identification of the words involves allocating the visual information to a much larger set of categories, each of which has
the sound of the word as a name and also a
number of related semantic connections or
associations. Reading for comprehension
(identification of meaning) involves the
allocation of visual information to category
structures that represents meaning to the
reader. In every case the same visual in-
formation is utilized, but it is allocated
cognitively in a different way." (F. Smith,
1971, p. 77)

The intake of visual information is supplemented by
some additional information (redundancy) that the reader
has already stored as a result of his past experience and
his mastery of language. Smith has proposed that, this is
the basis for the phenomena of the identification of visual
items on minimal information and the allocation of the same
visual information to different categories on different
occasions. The storage of preacquired knowledge takes
place in the memory system. A skillful reader, or even a
good perceiver, is the one who can be sure that the informa-
tion lost in the perceptual processing is the least important.
This can only happen if the reader's past experience has
brought him up to a level of competence so that he can predict just what the nature and relevance of incoming
information could be.

During reading, there is a characteristic form of eye
movement which is jumpy, irregular, spasmodic, but a very
accurate sort of leaping from one fixation point to another.
This movement (jump) is called a saccade. Guided by information
received from the periphery of the visual field, the eye
can move very rapidly from one side of the visual field
to the other, from left to right or up and down. The jumps are quite rapid and one can see very little during the saccadic movements. Actually the leaping eye (saccade) is practically blind. Information is only picked up between saccades when the eye is relatively still and resting.

Reading takes place during fixations. Most of these fixations center the fovea on or close to the printed line, but unless one is reading quite slowly it is not possible to predict or control where the eyes will fixate. The fixations are very short in duration and each does not last more than one-quarter of a second on the average. Usually these fixations progress from left to right on the first line then back to the beginning of the next line and so on. The view is commonly held that three to four words are perceived during each fixation. Also one is more likely to recognize the words that are in the immediate area of fixation or which are closer to the center of the fovea than the ones that fall on the periphery (Carrol, 1970). Words outside the fovea of the eyes may be less recognizable, but the past experience and previous fixations provide enough cues so that the meaning can be apprehended—at least that is contemporary theory.

All readers, good and poor, have another kind of saccadic movement, which is called regression. Regression is simply a saccade that goes in the opposite direction of the printed line (i.e. in English from right to left,
or from one line to the previous one). A skilled reader uses as little regression as possible, but for him sometimes regression can be as productive as regular fixation in forward reading. Therefore, for a non-English speaking reader who has read most of his life perhaps from right to left, such as Arabic, Hebrew or Urdu, left to right English reading habits (which might be equal to regression in his past experience of reading his native language) can be a handicap.

Carroll states that, as one reads there might be momentary pauses of attention "which can be due to lack of interest, distraction, or even stimulation from the content itself" or lapses in comprehension "which can be due to the difficulty of the material, poor writing, or other conditions." The process of comprehension can affect the movements of the eyes to a great extent. For instance, when the reader does not comprehend a passage, his eyes move back (regress) to fixate on the portion of material which he has scanned before but from which he did not grasp the main idea. (Carroll, 1970, p. 295)

Another aspect of reading that has been mentioned by Crosland (1931) is "left to right mindedness." In his experiment, he showed random letters in series ranging from one to nine for exposure of 100 milliseconds. His results showed that most letters reported were from left field and that the curve of correct reports, in terms of
letter positions, declined rapidly from left to right. The sharpest curve came between the fourth and fifth positions. But since his findings were contrary to the concept that "perception of all elements was simultaneous and that visions were clearer in the center and less clear on periphery", he explained his results as "left to right mindedness." (Geyer, 1970, p. 56)

The experiment was extended (Crosland, 1939) by repeating the same procedure with bi-lingual Jewish children. The findings showed that in reading English the results were the same as previous ones--from left to right--but in reading Hebrew, the results were reversed showing a right to left reading habit. I. H. Anderson (1933), in a similar experiment found that more English words were recognized to the left of the focus and more Hebrew to the right.

Viewing some of the differences, in terms of presentation of words and letters on the center of vision and those to either side, W. Heron (1957) has suggested some points:

1) If English letters are presented simultaneously on both sides of fixation points, those on the left side of the fixation points are reported (recognized) the best. But if the letters are exposed in the visual field one at a time (successive rather than simultaneous presentation), more letters are recognized to the right side of the
Heron has explained his results in terms of the "tendencies of the eye movements" and "post-exposural processes" under conditions of successive and simultaneous presentation. He writes:

"The fluent English reader presumably has two tendencies established; faced with a line of print there is one tendency to fixate near the beginning of the line and another to move the eyes along it from left to right. When alphabetical material is exposed in the right field alone, the two tendencies would be acting together. When, however, it is exposed in the left field alone, the tendency to move the eyes to the beginning of the line (presumably the dominant one) would be in conflict with the tendency to move the eyes from left to right. Under conditions of successive presentation we should therefore expect that more letters would be recognized in the right field. When exposure occurs simultaneously in both fields, on the other hand, the dominant tendency to move the eyes to the beginning of the line would result in more letters being recognized in the left field." (Heron, 1970, p. 47)

2) When the subject knew where the letters would appear on the tachistoscope, this knowledge made no difference, in terms of recognition, in the right field. But if the presentation was to the left side of visual field (fixation point), this prior knowledge improved the report of the left field.

3) When four letters arranged in a square pattern were presented either to the left or right side of the visual field, the subjects tended to report, first upper left, next upper right, then lower left and finally the one in the lower right.
4) In a series of letters, subjects recognized more accurately the beginning of the series than the endings.

5) When letters are double spaced the superiority of the left field is greater than if they are presented single spaced.

Harcum and others (1962, 1963) have shown that the reader of English usually "exhibit superior tachistoscopic perception for elements at the left", when these elements are presented across the center of fixation. But when the subjects were taught to respond from right to left they showed a strong right to left superiority. He wrote about his American and Israeli subjects:

"The basic difference between these groups is that the American 'instructs' himself to perceive and respond from left to right, whereas, the Israeli 'instructs' himself to perceive and respond from right to left. If the American is instructed by the experimenter to respond from right to left, he shows right-superiority to the same degree that the Israeli shows without instructions from the experimenter." (In, Geyer, 1970, p. 60)

He concluded that the perceptual process involves a spatial-temporal sequence, its direction is influenced by factors, which are acquired through experience in reading.
OVERVIEW OF THE PROBLEM

Although there has been a great deal of research and findings in the past 75 years on reading processes, there are many questions that have not been answered with precision and certainty. The actual process by which we recognize words has not been very clearly identified.

J. B. Carroll (1970) has mentioned one of the several reasons for not being able to answer many questions related to reading. He says that the whole process of "pattern perception is still one of the mysterious problems in psychology", i.e. how do we recognize a pencil or a house for what it is? How does a person develop ability of word recognition? What cues are the most important ones in recognition? Do children and adults have the same pattern of recognition? What are the differences between a skilled reader and a poor reader, in terms of word recognition? Do they process unfamiliar words in the same way? What are the actual psychological processes behind reading and comprehension of a sentence? What are the major differences between the eye movements of a skilled reader and an unskilled one? (Carroll, 1970, p. 293)

The present study was designed to investigate the perception of short sentences which are about as long as the material covered in a single fixation. The approach followed will be initially that which has been used in perceptual studies of the recognition of single words and
uses repeated short exposures. In a later study the exposure time will be a quarter of a second which is comparable to that involved in a single reading fixation. Under such conditions, and with the eyes not moving, it is hypothesized that only part of the sentence, perhaps half of the words in a four word sentence will be recognized.

The first study in the series hypothesized that semantic structure would influence the sequence in which the components of a sentence would be perceived.

It must be stated at this point that the problem turned out to be a much more difficult problem to investigate than had been initially anticipated. The three studies described in chapter two represent some steps in unravelling the difficulties involved.
METHODOLOGY AND DATA COLLECTION

The present study investigates information processing when a subject is presented with a group of four words. The interest in this problem derives from the fact that the typical fixation of the adult reader covers a span of about four words, and virtually nothing is known about information processing during a reading fixation. The procedure used is that which has been successful in slowing up perceptual processes and involves presenting the subject with a group of four words for a series of brief exposures. One would expect that on the initial exposure the subject would obtain little information except, perhaps, the position of the words, but after a number of exposures particular words would become recognized and, ultimately, a clear percept of the entire group of words would emerge.

Two main conditions would appear to influence the order in which information is processed when the stimulus material consists of four-word sentences. The first is the nature of short sentences in the English language, and this was assumed to be a crucial factor. Short sentences in English consist typically of a noun phrase followed by a verb phrase (McNeill, 1970), a fact which is typically represented in psycholinguistics as NP + VP. One might expect, perhaps, that the information would be processed with the noun phrase first, and the crucial word in the noun phrase is likely to be the second word, since
the first word is typically the article. Hence, the second word might be processed first.

A second factor that might be expected to influence information processing is the position of the information with respect to the fovea. Foveal vision is superior to peripheral vision for picking up fine cues and, hence, words near the center of the fovea might be picked up first.

Experiment I was designed to study the effects of semantic structure on the order in which the elements of a sentence are recognized.

Experiment II was designed to examine the order and amount of recognition during a very short fixation period, about 20 milliseconds. It also was designed to investigate whether there is any relationship between the location of the words being recognized in terms of the fovea of the eyes.

Experiment III was almost a replication of the second experiment, to confirm the obtained results with a longer exposure duration of a quarter-of-a-second (250 milliseconds) which is similar to regular fixation in reading.

Apparatus

The apparatus used in this experiment was the Harvard Tachistoscope (Figure 1), which consisted of three main components, namely, an exposure cabinet, a power switch, and a 3-channel electronic timer.
The exposure cabinet provided two fields. Two B4, 4-watt, florescent lamps are used to illuminate each field. The lamps are placed on wooden flaps or doors, one below and one above the material to be viewed. The circuit into which the lamps were wired was such that they could be turned on and off within a millisecond. The illumination of the apparatus was calibrated 1.26 Candle/m².

Holders d and h were used for exposing materials. Each holder could be attached to either end of the cabinet. Holder d which was placed in field two was used for exposing cards that had short sentences printed on them. In Experiments II and III a pre-exposure fixation point was shown on the center of a white card in field one. But for Experiment I a plain white card was shown through field one.

The electronic timer was divided into three sections. Channel number one controlled field one, channel number two controlled the delay between exposing the two fields, and channel number three controlled field two. The timer could be adjusted to control the exposure of each field in milliseconds or through a multiplier it could be adjusted to provide longer intervals.

In order to watch subject's eye movements during Experiments II and III, a small hole, about 0.7 centimeters (less than half-an-inch), was made through the holder d. But, because of the darkness one could not follow these
movements, therefore, a small light bulb was placed above the window of the tachistoscope, where the subjects viewed the sentences, to illuminate the eyes. To reduce light coming in through the hole in the back, a large piece of black cardboard paper was mounted on a stand behind the opening. The black background prevented the subjects from being distracted by looking at the hole or the image that would have otherwise come through it.

Subjects

The sample used in the experiment was obtained from a population of college students attending Western Michigan University. Their age range was between 18 and 25 years old. In each experiment 12 subjects participated, six males and six females.

EXPERIMENT I

Experiment I was designed to investigate the influence of semantic structure on the components of a sentence in terms of its recognition. The crucial structure was assumed to be that of a noun phrase followed by a verb phrase.

The sentences consisted of four words, and no pre-exposure fixation point was provided for the subjects, in other words, the location of fixations was arbitrarily chosen by each subject.
Materials

Materials used in this experiment were two sets of six by four inch white index cards. Each set contained twelve cards, and on each card a short sentence was typewritten in upper-case elite type. Both sets had twelve sentences, six meaningful and six nonsense. The length of each sentence was about 4.5 centimeters. The meaningful sentences were made from words included in the first 1,000 most common English words, chosen from Thorndike and Lorge (1944). The nonsense sentences were made of four groups of letter combinations which were meaningless. All sentences, meaningful and nonsense, consisted of four words.

There were two conditions for each set which depended upon where the sentence appeared in the field of view. Sentences were presented either centered in the field of view or off-centered to the left. The off-centered sentences were located in such a position that the end of the sentence was in the center of the field.

Thus, in each set there were twelve sentences, six meaningful and six nonsense which were typed either centered or off-centered. The meaningful sentences each had a letter in the back of the card, and the nonsense sentences had a number on the back to identify them. The sentences were as follows:
Table I shows how the sentences were grouped in a counter-balanced design. All of the subjects were randomly assigned to one of the sets.

**TABLE I**

COUNTER-BALANCED DESIGN OF THE TWO SETS OF SENTENCES

<table>
<thead>
<tr>
<th>SET I</th>
<th>SET II</th>
</tr>
</thead>
<tbody>
<tr>
<td>M N</td>
<td>M N</td>
</tr>
<tr>
<td>Centered</td>
<td>Off-Centered</td>
</tr>
<tr>
<td>a 1</td>
<td>d 4</td>
</tr>
<tr>
<td>b 2</td>
<td>e 5</td>
</tr>
<tr>
<td>c 3</td>
<td>f 6</td>
</tr>
<tr>
<td>Off-Centered</td>
<td>Centered</td>
</tr>
<tr>
<td>d 4</td>
<td>a 1</td>
</tr>
<tr>
<td>e 5</td>
<td>b 2</td>
</tr>
<tr>
<td>f 6</td>
<td>c 3</td>
</tr>
</tbody>
</table>

Procedure

Each one of the twelve subjects was randomly presented with 12 cards—meaningful, nonsense, centered, and off-centered. The cards were presented through field two of the tachistoscope, and a white card was placed in field one.
The distance between the eyes and the card was approximately 50 centimeters (20 inches). During the presentation there was no fixation point in the background (field one), so the subject could freely fixate on any arbitrary spot prior to the exposure of the sentence.

The duration of each presentation for all twelve subjects was constant, 20 milliseconds for meaningful sentences and 40 for nonsense sentences. This duration was derived from a preliminary study, and permitted the subjects to interpret the meaningful sentences in less than 15 trials. Thus a subject might have to work with $15 \times 12$ exposures in going through the entire series.

At the start of the experiment, the participants were given a brief description of the purpose of the experiment and the procedure involved. But they were not told about the limitation of the number of trials since this could have an indirect effect on the subject's performance. They might have felt they were under pressure since the number of trials was limited.

The subject was instructed to look through the window of the tachistoscope and press the microswitch in order to see the sentence which was going to be flashed on the screen of the tachistoscope. Prior to the presentation of the cards, two practice sentences were given to the subjects so they could become familiar with the experimental situation.
The report of the subjects, for each trial, was recorded on the response sheet (Appendix A and B). Prior to the start of the experiment the subject was told that he must pause after each trial to report what he had seen (perceived) during each exposure trial, even if he had seen only a letter of a word. If the subject recognized a word correctly, he was informed of his correct response. This also was done for nonsense sentences in which the subject was usually uncertain if he had seen all the letters in a word correctly.

The main dependent variable was the number of trials required for the correct recognition of a word. Thus through such recognition measures, the order in which words were recognized could be obtained. If the subject did not recognize the word in 15 trials then the recognizability of that word was arbitrarily set at 15.

The main independent variable was the presentation of sentences—under four conditions—meaningful centered, nonsense centered, meaningful off-centered, and nonsense off-centered.

Results

The mean recognition score was obtained for each word under four conditions. For the meaningful centered sentences the recognizability of the first word was highest (1.38) as compared to other words in the sentence as shown in Table II. The discrepancy between the recognizability of the second and third word was very small .20, and the last
word had the highest mean, therefore it was least recognizable.

The trend of recognition shown in Figure 2 implies a very slight, but almost certainly insignificant, left to right recognition trend.

When the subjects were questioned "where do you direct your gaze?," the typical response was that his fixation was on the specific part of a word that was not recognized on the previous trial. Subjects behaved in this way when they had not fully recognized a word on a previous trial, but if they had already identified a word then the fixation was directed to the next word. In other words, after the first few trials the subject would attend to only those components of a word or a sentence that needed to be scrutinized.

Under the second condition, where the sentences were meaningful off-centered, the pattern of recognition was to some extent similar to the previous condition in the sense that there was a .20 discrepancy between the second and third words. The curve (Figure 2) indicates, that there has been a slight tendency of pre-exposure fixation toward the center of the card, since the last word had a relatively higher rate of recognition as compared to other words in the sentence. It seems that the overall pattern of recognition becomes random and the subject attends to any arbitrarily selected word in the sentence.
Under the third condition, where the sentences were nonsense centered, the pattern of recognition is very much similar to the above (condition II), in the sense that the pre-exposure fixations were prominently on the center of the card, since the second word was more easily identified ($\bar{x} = 5.08$, Table II). From then on, the recognition is random.

Under condition IV, where the sentences were nonsense off-centered, contrary to what was expected the last and first words had the same level of recognition, both 7.50 (Table II). The second word had the least mean (7.13) as compared to other words in the sentence. This implies that the pre-exposure fixation, even on the first few trials, has been toward the left side of the visual field, perhaps the center of the sentence.

Considering the data obtained under four conditions, one can infer that under condition III and IV the recognition of the words in the sentence is mainly random, although in the third condition there is a slight tendency of pre-exposure fixation toward the center of the card to result in the recognition of the last word first. In the first condition (meaningful centered), despite the fact that the discrepancy between the means were very small, the tendency of recognition toward the first word is higher. In the second condition (meaningful off-centered), although the differences among the four means are small,
TABLE II

MEAN NUMBER OF TRIALS FOR RECOGNITION OF EACH WORD IN EACH POSITION UNDER EACH CONDITION IN EXPERIMENT I

<table>
<thead>
<tr>
<th>Number of Words in the Sentence</th>
<th>Condition I M-C*</th>
<th>Condition II M-OC</th>
<th>Condition III N-C</th>
<th>Condition IV N-OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Word</td>
<td>1.38</td>
<td>2.41</td>
<td>6.22</td>
<td>7.50</td>
</tr>
<tr>
<td>Second Word</td>
<td>2.47</td>
<td>2.77</td>
<td>5.08</td>
<td>7.13</td>
</tr>
<tr>
<td>Third Word</td>
<td>2.27</td>
<td>2.75</td>
<td>6.61</td>
<td>7.66</td>
</tr>
<tr>
<td>Fourth Word</td>
<td>2.91</td>
<td>1.25</td>
<td>8.13</td>
<td>7.50</td>
</tr>
</tbody>
</table>

* M-C  Meaningful Centered
M-OC  Meaningful Off-Centered
N-C   Nonsense Centered
N-OC  Nonsense Off-Centered
FIGURE 2

GRAPHIC PRESENTATION OF THE MEAN NUMBER OF TRIALS FOR RECOGNITION OF EACH WORD IN EACH POSITION UNDER EACH CONDITION, IN EXPERIMENT I

Recognizability for Each Word in Terms of Number of Trials

Number of Words in Each Sentence

First Word  Second Word  Third Word  Fourth Word

I (M-C)

II (M-OC)

III (N-C)

IV (N-OC)
the first word was identified after the last word.

In this experiment it was not possible to conclude whether or not any one of the four words, in a group of sentences and under four conditions, were more crucial than others in terms of recognition. However, looking at the graphs (Figure 2), one can see the considerable mean difference between the recognizability of the meaningful as compared to nonsense sentences, in terms of number of trials.

There was a very slight tendency for the first word to be better recognized under condition I and II (after the last word). This could have been due to the fact that all of these sentences began with the same article (THE). Therefore, the repetition of the same word could have facilitated its recognition. Another interpretation is that, perhaps, the subject has simply expected an article at the beginning of the sentence.

A second experiment was conducted to answer some of the problems encountered in the Experiment I, mainly to find out: 1) if the pattern of recognition is NP + VP, what components of this sequence is more crucial? 2) if there is any relationship between the recognizability of words and their position in relation to the fovea. Finally, in order to have a better control over the eye movements a pre-exposure fixation point was provided, to simulate a reading fixation.
EXPERIMENT II

Experiment II was designed to overcome some of the limitations encountered in the Experiment I. The purpose was to investigate the order and amount of recognition during a short fixation (20 milliseconds) with better control over the eye fixation point.

In reading, the image of the fixation point falls directly in the center of the fovea (Yarbus, 1967), and in one fixation a person is said to be capable of processing an optimum of four to five words (Smith, 1970); the present study intended to discover the specific word or words (among four words) that are being processed in relation to the paracentral and peripheral vision, and the order in which words are processed. Finally it was hoped to find out whether or not the processing of a sentence, under the controlled condition of the experiment, is in terms of its NP + VP components.

Materials

Materials used in this experiment were similar to those used in the previous study. The difference was that in the meaningful sentences the article "THE", at the beginning of each sentence was replaced by an adjective or pronoun. The sentences were as follows:
This was done to control the problem of repetition of the first word throughout the sentences. The rest of the materials were exactly the same as in Experiment I.

Procedure

The main difference between the procedure in Experiments I and II was that, the subjects participating in Experiment II were provided with a small central fixation point in field 1, and were instructed to fixate on that point.

A white card with a central dot was presented through the field 1 of the tachistoscope, and the sentences were exposed through field 2. The fixation point was located in such a way that it would fall in the middle of the centered sentences, and almost at the end of the off-centered sentences. The subjects were instructed to focus their attention on the dot and not to change their fixation point before and during presentation of the sentences.
To make sure that subjects were looking at the central dot and were not changing their fixation point, the observer watched their eyes through a small opening which was made in the holder d. If there were any changes in the fixation of the subject it was recorded on the data sheet.

Some of the subjects reported that it was very hard for them to focus on one spot, knowing the location where the sentence would appear. In fact the data of four students who moved their fixation point in the case of off-centered sentences were not included in the analysis. They were replaced by data from new subjects.

Results

As in the previous experiment, mean recognition was obtained for each word under four conditions—meaningful centered, meaningful off-centered, nonsense centered, and nonsense off-centered.

Under the first condition (meaningful centered), the recognizability of the second word was considerably higher ($\bar{x} = 1.80$), in relation to other words in the sentence. After the second word, the third word was identified with relatively higher mean, 3.16 as compared to 1.80 (Table III). Then the first word with the mean of 4.60, and finally the last word ($\bar{x} = 5.88$) were recognized. The mean difference between the first and the last word was comparatively smaller than either second and first or second and last words. This indicates that first and last words had almost
the same level of recognition with better recognizability toward the left side of fixation point. More than half of the subjects were able to recognize the first and last words (8 out of 12), in later trials.

Under the second condition (meaningful off-centered), the last word was identified first, next in the sequence was the third word, then the second word, and finally the first word was identified. The curve describing this relationship is shown in Figure 3. It declines sharply from the first to the last word, indicating the high rate of recognizability in the last and third words as compared with the first and second words in the sentences. Less than half of the subjects were able to recognize the first two words (about 4 out of 12), in later trials.

For the nonsense sentences, both centered and off-centered, the pattern of recognition was quite similar to that of meaningful sentences, but with a greater mean range of values (Figure 3). Under condition III (nonsense centered) only two or three subjects were able to recognize first or last words, similarly in condition IV (nonsense off-centered), only two out of 12 subjects identified the letters in the first two words.

The data presented in Figure 3, clearly indicates the superiority of the recognition of the last word, in the off-centered sentences, and the second word in the centered sentences. Furthermore, it has been shown that in a single
### TABLE III

**MEAN NUMBER OF TRIALS FOR RECOGNITION OF EACH WORD IN EACH POSITION UNDER EACH CONDITION IN EXPERIMENT II**

<table>
<thead>
<tr>
<th>Number of Words in the Sentence</th>
<th>Condition I M-C*</th>
<th>Condition II M-OC</th>
<th>Condition III N-C</th>
<th>Condition IV N-OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Word</td>
<td>4.66</td>
<td>10.13</td>
<td>12.00</td>
<td>12.36</td>
</tr>
<tr>
<td>Second Word</td>
<td>1.80</td>
<td>8.77</td>
<td>3.63</td>
<td>11.88</td>
</tr>
<tr>
<td>Third Word</td>
<td>3.16</td>
<td>2.88</td>
<td>7.22</td>
<td>7.58</td>
</tr>
<tr>
<td>Fourth Word</td>
<td>5.88</td>
<td>1.36</td>
<td>11.13</td>
<td>3.38</td>
</tr>
</tbody>
</table>

* M-C Meaningful Centered
M-OC Meaningful Off-Centered
N-C Nonsense Centered
N-OC Nonsense Off-Centered
FIGURE 3

GRAPHIC PRESENTATION OF THE MEAN NUMBER OF TRIALS FOR RECOGNITION OF EACH WORD IN EACH POSITION UNDER EACH CONDITION, IN EXPERIMENT III

Number of Words in Each Sentence

Recognizability for Each Word in Terms of Number of Trials

I (M-C)

II (M-OC)

III (N-C)

IV (N-OC)
fixation those components of a sentence that are located near the fovea are being processed at a higher degree than the ones near peripheral vision. Also looking at Figure 3, one can infer that the order of recognition is not based on identification of either the first two words or the last two words. Consequently, recognition is not in terms of NP + VP components of a sentence.

The report of the subjects, mainly with off-centered and with the nonsense sentences, indicated that they could not identify words (except the ones on the immediate area of fixation point) unless they changed their fixation point prior to each exposure. In other words, the recognizable elements of a sentence are the ones which provide an image that falls near the center of the fovea.

It was only under condition I that a few subjects reported the whole sentence at once. According to their report, usually the second word "stood out" or "was more clear". This indicated that perhaps, paracentral vision is superior to peripheral. Another reason for arriving at this conclusion was that, under the second condition (meaningful off-centered) only one (out of 12) could report a whole sentence. Again this could be due to the fact that peripheral vision is not as acute as paracentral.

According to Smith (1971), only a duration of at least 50 milliseconds is equal to that of a reading fixation. The data from the present experiment suggested that in a
reading fixation, covering four words, only the two words located near the center of the fovea would be well recognized and the two peripheral words would remain difficult to identify. This finding is contrary to the statements of most of those who have described what happens during a reading fixation. The latter writers generally imply that a reading fixation, covering about four words, permits the reader to read all four words. The data of the present experiment are contrary to this assertion, and they suggest that rapid reading probably involves the identification of perhaps only 50 per cent of the words covered by each reading fixation. Since this finding could be a result of the short duration of the exposures used in this experiment, a third experiment was conducted to check on the number of words that are recognized on a single exposure that corresponds roughly to that of a single reading fixation.

EXPERIMENT III

Experiment III was designed to explore the possibility of assessing the amount of information processed during a single fixation of 250 milliseconds. This is the length of a typical reading fixation for a college student. A second purpose was to find out, if there are any similarities between the pattern of recognition in this experiment to that of Experiment II, when a short sentence is presented in a repeated brief exposure (duration X trials, 20 x 15 in Experiment II), as compared to that of a longer exposure
(duration X trials, 250 x 1, in Experiment III), in terms of amount and order of recognition.

Materials

The materials used in this experiment were exactly the same as what were used in Experiment II.

Procedure

The main difference between the two experiments lies in the procedure. For one thing, the duration of the presentation was changed to 250 milliseconds, and the number of trials were reduced to one single presentation (trial) for each sentence. In other words, each stimulus was presented for one exposure of 250 milliseconds.

As in the previous experiment the subjects had a central fixation point. The report of each subject, for a single exposure, was recorded on a data sheet. Unlike Experiment II a score of zero was given to any word (or words) that the subject could not identify; in the previous experiment the subject would receive a score of 15 for not recognizing a word after 15 trials.

The rest of the procedure was the same as in Experiment II.

Results

The mean frequency of recognition and percentage of words recognized in each position for each condition is shown in Table IV.
Under the centered condition (I and III), the percentage of words recognized was highest for the second word, then, after second word the third word had relatively high percentage of recognition as compared to other words in the sentence. For the nonsense sentences, in fact, the only recognizable items were second and third words in the sentence (Table IV).

Under the off-centered condition, as in the previous study, the last words had the highest rate of recognition, in fact, in condition IV (nonsense off-centered) the last word was the only word that had been identified by subjects.

The overall trend of recognition is very similar to that in Experiment II, indicating the higher rate of recognition for words near the center of the fovea as compared to those near periphery (Figure 4).

In terms of amount of recognition, these data presented an implication which is contrary to what has been said about the amount of recognition during one single fixation. According to these data, the actual recognition is much less than four or five words per fixation. In this experiment it was only under condition I (meaningful centered), that four subjects (out of 12) were able to recognize a particular sentence at once, identifying all of the words in that sentence. In three such cases, the sentence was "SUMMER SKY IS BLUE". This could have been due to the arrangement and size of the words involved, since according
TABLE IV

PERCENTAGE OF WORDS RECOGNIZED FOR EACH POSITION UNDER EACH CONDITION

<table>
<thead>
<tr>
<th>Number of Words in the Sentence</th>
<th>Condition I M-C*</th>
<th>Condition II M-OC</th>
<th>Condition III N-C</th>
<th>Condition IV N-OC</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Word</td>
<td>9.00%</td>
<td>1.33%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Second Word</td>
<td>22.16%</td>
<td>2.75%</td>
<td>6.91%</td>
<td>0</td>
</tr>
<tr>
<td>Third Word</td>
<td>12.50%</td>
<td>12.50%</td>
<td>5.50%</td>
<td>0</td>
</tr>
<tr>
<td>Fourth Word</td>
<td>8.33%</td>
<td>23.58%</td>
<td>0</td>
<td>10.41%</td>
</tr>
</tbody>
</table>

* M-C  Meaningful Centered
M-OC Meaningful Off-Centered
N-C  Nonsense Centered
N-OC Nonsense Off-Centered
FIGURE 4

GRAPHIC PRESENTATION OF PERCENTAGE OF WORDS RECOGNIZED FOR EACH POSITION UNDER EACH CONDITION

Percentage of Recognizability in One Fixation

I (M-C)

II (M-OC)

III (N-C)

IV (N-OC)

First Second Third Fourth

Word Word Word Word

Number of Words in the Sentence
to Foster (1970), usually when a longer word is followed by the words of shorter length, the recognizability of the longer word is higher than if it had been surrounded by words of almost the same length.

In both Experiments II and III in the case of the centered sentences the fixation point was located at the center of the sentence, yet the tendency was for recognition to be better for the second word (left side of fixation point) than for the third word (right side of fixation point). One interpretation of this phenomenon is that in the English language, there is a strong tendency to interpret information from the left side to the right side of the fixation point. These results are also consistent with Harcum's findings (1963), which indicated that English speaking subjects show a better recognition to the left side than to the right side of the visual field.

These data seemed to support the view that in one experimentally controlled fixation, perhaps only 50 percent of words are perceived. Yet in a larger context it is possible for the reader to comprehend the main idea without having to perceive every word during fixations. The amount of information perceived during regular reading, where the context is large, can be much more in a single fixation than was found in this study. For one thing, the reader is able to predict what is coming next, and therefore, his attention is mostly
focused on the important cues. In other words, the reader requires less visual information if the context is large and he is familiar with it, than if it had been a short unfamiliar sentence. Hence, he is able to process, perhaps, bigger "chunks" of information during a normal reading.

There are three important factors that seem to contribute to processing of words in a sentence; first, the context itself (meaning); secondly, cues that a person is familiar with, and has experienced in the past, such as the knowledge of how letters are arranged into words. In the present experiment, in many cases when the words were located far from central fixation, the subject could still identify the word by recognizing only two or three visual cues. For instance, for the word "pretty" the main visual cues used for its recognition was "P" and "tty"; and finally, position of the words in a sentence is an essential factor.
GENERAL DISCUSSION AND CONCLUSION

Three separate experiments were conducted to investigate the order and amount of recognition in short sentences consisting of four words. The sentences were selected to be about as long as material covered in a single fixation.

The data from Experiment I only indicated that the meaning of a sentence is important in terms of its recognition. This was shown through the use of meaningful and nonsense sentences (Figure 2).

The data from Experiment II presented the order and amount of recognition during repeated brief exposures of 20 milliseconds, and with the eyes not moving (simulation of a fixation). The findings supported the hypothesis that in a fixation it is only about 50 per cent of the words that are actually recognized under the conditions of the experiment (Figures 3 and 4). In an actual reading situation, in which the words are recognized in context, all of the words may, possibly, be identified. In terms of the order of recognition, these data indicated a high degree of visual processing for the words near the center of the fovea, as opposed to the words located at the periphery of the fovea; also the hypothesis that, the order of recognition is in terms of NP + VP components, was rejected.

The data from Experiment III confirmed the findings from Experiment II, using a single fixation of 250 milliseconds,
which is about the length of a typical reading fixation for a college student.

Manipulation of exposure duration in Experiments II and III, were to show whether there were any differences in amount and order of recognition when the sentences are presented in brief repeated exposures of 20 milliseconds to that of a single exposure of 250 milliseconds. In terms of amount of recognition, the repeated brief exposures yielded an overall increase in amount of recognition toward the words located near peripheral vision. However, during a single exposure of 250 milliseconds the subject could recognize the maximum of two words which were located near paracentral vision, while this was not true for single fixations of 20 milliseconds (in most cases subjects could hardly recognize a word). In terms of the pattern of recognition, as presented in Figures 3 and 4 the trend of recognition is similar for both Experiments II (20 x 15) and III (250 x 1).

These experiments (mainly II and III), indicated that there are actually three factors interacting in a reading fixation, namely; meaningfulness (context); visual cues; and finally the position of the words in a sentence.

Context (meaningfulness)

In all three experiments, an obvious superiority was observed in the meaningful sentences, as opposed to the nonsense ones irrespective of the centered and off-centered condition.
There is some evidence related to eye-voice span studies (Levin and Turner, 1966), indicating that a skilled reader's eyes usually runs four or five words ahead of his voice, when he is reading aloud. The common view held for this phenomenon is that meanings are processed before identification of individual words take place. In the present study, in some cases, the subject would construct the meaning of a sentence by only perceiving two words in that sentence. For instance, BAD WEATHER IS COLD would change to "The winter is cold", or SALT FISH TASTES BAD, would change to "The fish tastes good."

The amount of expectancy and prediction are two essential components in extracting the meaning of a passage. Consequently, if the reader has a good idea in advance of what it is that he is reading, he will have a higher probability of extracting the meaning from a minimal perception of the material. Thus, for a fluent reader and in a larger context, the meaning of a sentence is not the sum total of the meanings of the individual words that exist in the sentence. Hence, the reader is able to predict and process larger units of "meaning" during his fixations. This is what Smith (1971) has called "reduction of uncertainty." The more certain (informed) the reader is about the topic he is reading, the larger will be the area that he can apprehend in a single fixation (or glance). On the contrary, when the passage is difficult or when a person is reading in a foreign
language, because of the lower amount of comprehension, the number of fixations and regressions increases until he is able to grasp the meaning of the text.

Despite the fact that short term memory is limited in terms of the transmission of visual information to the comprehension processes of the brain—it is known that short term memory can hold only four or five items at a time. This information is lost in a few seconds, yet it is possible for the reader to replace the smaller items such as letters and words with the larger units of meaning. To overcome the short term memory limitations, the reader should rely less on the visual information perceived from the page and try to process larger units of meaning.

A skilled reader is the one who has reduced his need for visual information from the printed page, by using his prior knowledge to predict the unread materials. This concept has been referred to as semantic redundancy (Smith, 1971). It results in the reduction of the number of visual features needed to identify the words in a passage.

Visual information

The reader's past experience, such as the knowledge of how letters are grouped into words, and specific visual cues are important factors in a reading fixation.

In the previous experiments, under meaningful condition, according to the report of the subjects, double letters such as "tt" in the word pretty were used as a cue to identify
the word. In contrast, in the nonsense sentences, double letters did not contribute to the recognition of the nonsense word. In fact, in many cases one of the double letters was usually replaced with a familiar combination of letters. For instance, one of the T's in the word DRTT was eliminated or replaced by letters such as, "Drit" or "Dirt", which is a more familiar arrangement of letters. Also the word VLLN was usually perceived as "Vln", indicating that the "Vi" combination is more common to the subjects past experience rather than "vl" combination.

It has been pointed out (Smith, 1971), that the typical confusions take place between clusters of letters such as, (a, e, o, u); (t, f, i) ; and (h, m, n). The report of the subjects clearly indicated the confusions, especially between the letters "m" and "n". For instance, the word SUMMER was perceived as "Sunny". Most often, when a nonsense word had the same featural cues as a meaningful word, the identical meaningful word was used in the place of the nonsense word, i. e. HONT was seen as "Hurt" or TKAP was perceived as "Trap" and ADAB as "Arab". The illustration of confusions between meaningful and nonsense words, clearly indicated the expectancy and familiarity of the subjects with certain pre-learned groupings of letters in a word. Similarly, when the word WEATHER, in the sentence BAD WEATHER IS COLD, was perceived as "Winter" this showed the subject's tendency toward the identification of meaning,
in other words, by recognizing only two or three letters (visual cues), the reader assumed that in that specific context the word should be "Winter."

According to Smith (1971), there are two sources of information available for the identification of words, one is featural (the visual information available to the eyes) and the other is sequential (the knowledge of how the words are constructed). When both of these sources overlap in a passage, the reader can easily predict and expect what he is to read next.

Usually a skilled reader does not depend on the featural information to identify a word. His recognition is based on the sequential information. In the present study, one reason that the nonsense sentences had a much lower rate of recognition than meaningful sentences was that the subject had to depend a great deal on the featural information. In fact, there was no sequential information available to the subject. A second reason could be, again, the limitation of the visual information processing and short term memory system, in which only a limited amount of visual information could be processed, and, in the nonsense sentences, the subject had to depend on his visual information to a great extent. Processing of visual information is not instantaneous. It takes a certain amount of time during which losses can occur. In reading, the image of perceived visual information (which is about five to six letters or four to five meaningful words) is lost very quickly, if it is not condensed into a meaningful form. As was mentioned previously, the less the reader
depends on featural information the faster he can read, and this is possible only through the use of other available sources such as sequential information and semantic redundancy of a passage.

Position of the words in a fixation

An interesting portion of the data obtained from Experiments II and III, was that showing the relationship between the order of recognition and the location of the information with respect to the fovea of the eyes. In past studies, this aspect of reading (processing of words in relation to the fovea) has not been investigated, and thus, the matter perhaps requires further investigation.

Yarbus (1965) estimates that the diameter of the fovea centralis is about 0.4 millimeter, or 1.3 degrees. In the present study the width of the object falling within the fovea was measured from a distance of 50.8 centimeters, where the sentences had appeared. This width would be approximately 3.0 centimeters, many believe that this is an excessively conservative estimate. The width of each sentence was about 4.5 centimeters. In the meaningful centered sentences, where the recognition was highest, only the information within about half of this width, 2.3 centimeters, was recognized and the recognized words were the ones which were located near the fixation point.

One of the problems encountered in this type of study is that of determining whether the eyes fixated steadily.
in one place or whether they moved. In order to do this, the eyes of the subject were observed directly through a small hole. According to the report of the subjects, it was difficult for them to fixate on a dot, knowing where the sentence was going to appear in the next exposure (Experiment II), and it was difficult to maintain the fixation during exposures (Experiment III). Although in the Experiments II and III, a total number of eight subjects (out of 24) were replaced because of eye movements, in a few cases one could not be sure whether eye movements did occur because of either thick or tinted glasses. In future studies it seems almost necessary to have a careful selection of the subjects, and an initial training session to provide prior experience, to prevent the subjects from changing their fixation point.

The research that has just been described is important in a number of ways for understanding processes involving a reading fixation. Because fixations are the basis of reading, related studies can be useful for understanding how children and adults read and learn to read. Understanding the processes involved in a fixation, such as those described in this research (context, visual cues and position of the words), can eventually be useful in developing procedures for teaching reading to children or to adults who have problems in this area.
It is hoped that the knowledge of how to use certain visual cues, or how to expand one's attention to a larger unit of "meaning" may contribute to some of the speed reading programs.
REFERENCES


Crosland, H. R. Letter-position effects, in the range of attention experiment, as affected by the number of letters in each exposure. Journal of experimental psychology, 1931, 14, 477-507.


Gibson, E. J. Learning to read: Experimental psychologists examine the process by which a fundamental intellectual skill is acquired. Science, 1965, 146, 1066-1072.

Gibson, E. J., Gibson, J. J., Pick, A. D., and Osser, H.  


Heron, W., Perception as a function of retinal focus and attention. American journal of psychology, 1957, 70, 38-48.


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
<table>
<thead>
<tr>
<th>CENTERED</th>
<th>OFF-CENTERED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meaningful</strong></td>
<td><strong>Nonsense</strong></td>
</tr>
<tr>
<td>a b c 1 2 3</td>
<td>d e f 4 5 6</td>
</tr>
<tr>
<td>CENTERED</td>
<td>OFF-CENTERED</td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
</tr>
<tr>
<td>Meaningful</td>
<td>Nonsense</td>
</tr>
<tr>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX B

<table>
<thead>
<tr>
<th>Off-Centered</th>
<th>Centered</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meaningful</strong></td>
<td><strong>Nonsense</strong></td>
</tr>
<tr>
<td>a b c 1 2 3</td>
<td>d e f 4 5 6</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.