R E P O R T   R E S U M E S

ED 015 086   RE 000 253

PERCEPTUAL SYSTEMS IN READING--THE PREDICTION OF A TEMPORAL EYE-VOICE SPAN CONSTANT. PAPER.

BY- GEYER, JOHN JACOB
E

PUB DATE 4 MAY 67

EDRS PRICE MF-$0.25 HC-$0.72 16P.

DESCRIPTORS- VISUAL PERCEPTION, *ORAL READING, *EYE MOVEMENTS, *VISUAL MEASURES, READING HABITS, *PERCEPTUAL MOTOR COORDINATION, EYE VOICE SPAN,

A STUDY WAS CONDUCTED TO DELINEATE HOW PERCEPTION OCCURS DURING ORAL READING. FROM AN ANALYSIS OF CLASSICAL AND MODERN RESEARCH, A HEURISTIC MODEL WAS CONSTRUCTED WHICH DELINEATED THE DIRECTLY INTERACTING SYSTEMS POSTULATED AS FUNCTIONING DURING ORAL READING. THE MODEL AS OUTLINED WAS DIFFERENTIATED LOGICALLY INTO THREE MAJOR PROCESSING FUNCTIONS--SENSORY, RECOGNITIONAL, AND RESPONSE. DATA WERE DERIVED FROM 2,465 EYE-VOICE SPAN PAIRINGS FURNISHED BY EIGHT SUBJECTS READING THREE PASSAGES OF VARYING DIFFICULTY. THE SYNCHRONIZATION OF RECORDINGS USING THE GILBERT EYE-MOVEMENT CAMERA AND TAPED ORAL READING SHOWED RELATIVELY CONSTANT EYE-VOICE SPAN. CORRELATIONS BETWEEN MEASURES OF SMOOTH READING AND THE CONSTANCY OF TEMPORAL EYE-VOICE SPAN WERE HIGH. THE ESTIMATED TIME ELAPSING BETWEEN EYE AND VOICE DURING SMOOTH READING WAS VALIDATED. REESTABLISHING A STEADY STATE FOLLOWING AN INTERRUPTION WAS NOT STATISTICALLY STABLE. THE USE OF MULTIPLE FIXATIONS, REGRESSIONS, AND PROLONGED FIXATION PAUSES WAS SUBSTANTIATED, AND SIGNIFICANT RELATIONSHIPS AMONG EYE-MOVEMENT PATTERNS WERE FOUND. THE NEED TO TEMPORALLY BALANCE INPUT AND OUTPUT SYSTEMS AND THE NEED TO CORRECT EYE-FUNCTIONING IN ORDER TO REESTABLISH TEMPORAL BALANCE WERE EVIDENT. THE MODEL WAS DECLARED INCOMPLETE, AND, ALTHOUGH IT MAY ADD TO CUMULATIVE KNOWLEDGE OF READING PHENOMENA, HAS LITTLE TO OFFER THE TEACHER AT PRESENT. THIS PAPER WAS PRESENTED AT THE INTERNATIONAL READING ASSN. CONF., (SEATTLE, MAY 4-6, 1967). (MC)

ERIC

John J. Geyer
Assistant Professor
San Diego State College
San Diego, California 92115

ED015086

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

RE 000 253

PERCEPTUAL SYSTEMS IN READING: THE PREDICTION OF A TEMPORAL EYE-VOICE SPAN* CONSTANT*

~~(For presentation on May 4, 1967, during 9:00-10:30 a.m. session)~~

This paper describes in part a study (2) which attempts to arrive at an understanding of how perception in reading takes place clearer than that proposed by classical theory. Classical theory of perception in reading was a landmark of educational research and a giant step forward in our understanding of reading phenomena. But it was a step taken originally in 1885, based on assumptions known to be oversimplified today and upon interpretations of empirical data which modern control procedures have called into question.

Until recent years neurologists believed the visual system to be relatively simple. The eye was commonly compared to a camera in which the retina reacted to light in much the same way as a

RE 000 253

* The research reported herein was supported through the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare.

photographic plate. It was thought that these reactions were transmitted instantaneously to the projection areas of the brain in a point-by-point mosaic representation. Early investigators, basing their interpretations on these assumptions, believed perception to be a unitary phenomenon with all parts of the visual field being perceived instantaneously and simultaneously. Much of the experimentation involved tachistoscopically measuring the span of attention in order to isolate the "elemental perceptive act." From these experiments the concept of the visual span of perception was derived with the accompanying belief that within each span, words were recognized by "general word shape" or "total word picture." The ongoing reading process was conceived of as a series of tachistoscopic presentations flashed to the brain by the saccadic movements of the eye. Improvement in reading was seen as "depending on the instantaneous recognition of larger and larger blocks of letters" (5).

Today, through the work of neurophysiologists and electrophysiologists, the enormous complexities of the visual system are beginning to be appreciated. The retina, alone, is known to be such a dynamic and complex organ that Ragnar Granit (3), Director of the Nobel Institute of Neurophysiology, refers to it as the "little brain." Psychophysicists and other investigators interested in the field of sensory psychology have been systematically working out the details of the variables affecting tachistoscopic and related experimentation. Using instruments and control procedures unknown to the early theorists, modern investigators have found that visual perception functions in

ERIC

much more complex and dynamic ways than those suggested by classical theory. This continual search for deeper meanings is, of course, a basic part of the scientific process, and those of us interested in reading can share with D. O. Hebb (4) some of the excitement reflected in his statement:

> What I mean to emphasize here are the new possibilities of explanation that open up when one separates sensory from perceptual processes, and recognizes that identifying the two had a purely theoretical origin, and neurological to boot.

Theoretical Background

The theoretical background and stimulus for this study were derived from two sources: General Systems Theory as applied to reading in the Substrata-factor Theory of Holmes (6, 7, 8) and Information Theory as exemplified by the Filter Theory of Broadbent (1). The Substrata-factor Theory of Reading is a comprehensive view of the reading process which has been shown by Kling (9) to match the Organismic Open Systems Model of General Systems Theory at each point. While emphasizing that reading is a processing-skill, Holmes and his co-workers have engaged to date in research methods designed to statistically identify the relationship between the many organismic systems postulated as operating in reading at a hypothetical instant in time.

Using the Substrata-factor Theory with its concepts of interacting systems as a general frame of reference, it seemed equally valid to experimentally limit the complexity of the reading task in order to trace a minimum amount of information across time. This is essentially the approach taken by the Information Theorists. Contrary to the classical position that the perception of overlearned materials

takes place instantaneously, a model constructed from this theoretical viewpoint would hold that perception requires time. Such a model would attempt to identify the directly-interacting systems operating during the ongoing minimal reading process. A major concern of the model would be the prediction of the temporal relationships involved in the processing of a series of stimuli.

The Purposes

Specifically, the purposes of the study were:

1. To construct a heuristic model of perception in reading from an analysis of the published research which would better explain the apparent dynamics and account for more of the known facts in the perception and identification of visual-verbal stimuli during reading than the classical theory.

2. To synthesize certain aspects of the model with those parallel postulates of the Organismic Open Systems Model which deal with the establishment and maintenance of a steady state in order to generate experimentally testable hypotheses that delineated specific time constants, and dealt with the dynamics of the perceptual process, and

3. To experimentally test the validity of the generated hypotheses.

The Model

From an analysis of classical and modern research, a heuristic model was constructed which delineated the directly interacting systems postulated as functioning during oral reading. As much of the data

concerned with visual perception stems from tachistoscopic studies, it was necessary to minutely analyze the variables affecting tachistoscopic reports in order to understand the relationships of the findings of these studies to normal reading. A schematic outline of the model is presented in Figure 1.

The model as outlined can be differentiated logically into three major processing functions, viz., sensory, recognitional, and response. Each of these systems has a hypothesized characteristic rate of operation thought of as being based on physiological functions inherent in the organism. Interspersed between these three systems are two storage systems which make smooth information processing possible by acting as temporal buffers which allow the integration of the different rates of the processing systems. Specifically, the model postulates that between the moment in time when a stimulus is sensed and when it is reported, the following dynamic systems tend toward an over-all steady state:

1. An <u>Initial (Sensory) Scanning System</u> operating at a hypothesized rate of 8 ms. per letter-space. Although initially volitional in direction, this purely attentional input system becomes conditioned to scan reading material in the direction in which the language is written. The postulated scanning action takes place <u>within each fixational pause</u>, the saccadic movements being vital to keeping the visual apparatus in a position where the covert or attentional scanning is within the retinal area of fine discrimination.

ERIC

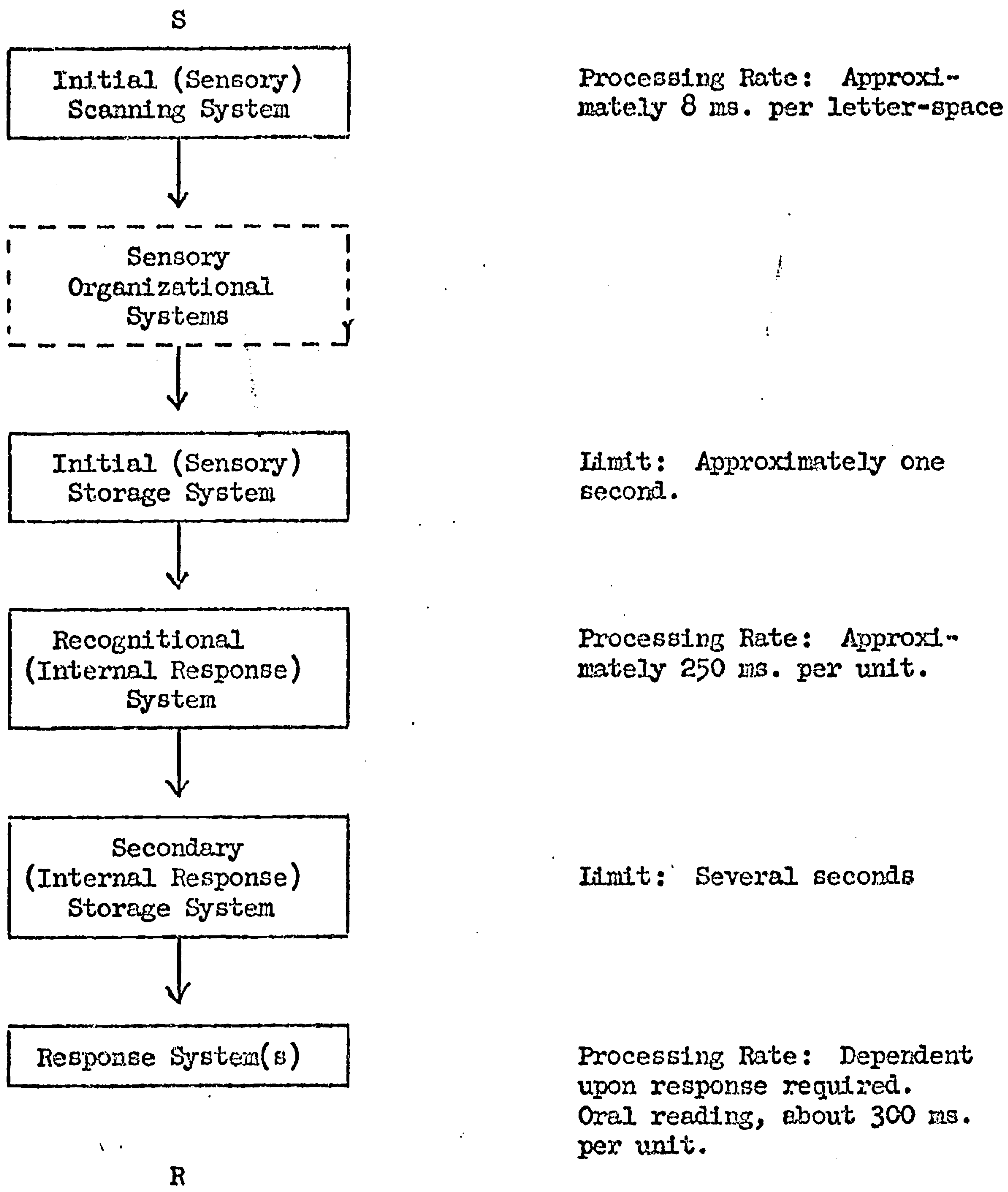

Figure 1. Block Diagram of Heuristic Model

2. A <u>Sensory Organizational System</u> whose function it is to organize and convert the scanned material into phonemic units.
3. An <u>Initial (Sensory) Storage System</u> capable of storing the phonemic stimulus units as a fading memory trace for a hypothesized period of <u>one second</u>, thus acting as a temporal buffer between the preceding and succeeding systems.
4. A <u>Recognitional (Internal Response) System</u>, thought to operate in silent reading at a rate of approximately 250 ms. per response, which converts the fading stimuli in the above storage system to a more permanent form.
5. A Secondary (<u>Internal Response) Storage System</u> capable of storing the internal response for several seconds, thus operating as a temporal buffer between the internal response and report when needed. It was assumed that this system would receive minimal use during smooth, oral reading, as the systems governing the oral response would be directly coupled to the Recognitional System.
6. An <u>Oral Response System</u> which organizes the complex musculature involved in speech.

The Dynamics

The overall function of the visual system is to allow the organism to make meaningful responses to the environment as visually perceived. In order to do this, a large number of elements in the visual field must be extracted and organized into meaningful units

which can themselves be organized into larger entities. Since the recognitional system can organize a number of sensory elements (e.g., letters) into a single response unit (e.g., a word or phrase), the sensory system must be capable of a much higher rate of operation than the recognitional system.

In the tachistoscopic situation, if 12 letters were flashed to a subject during a 100 ms. presentation, they could be covertly scanned at the hypothesized rate of 8 ms. per letter-space in approximately 96 ms. and would briefly be stored in the initial storage system. If the letters were random so that a separate response was required for each, the subject might respond to 3 or 4 letters during the storage period available, but the remainder of the letters would be lost, leaving the subject with the vague impression that he had "read" them all, but had forgotten some before he could report them. However, if the 12 letters were stored as 2 or 3 short words, this number of responses could be made within the hypothesized one-second storage capacity of the initial storage system, and the subject could respond to them all.

In continuous reading, once the subject had scanned an amount equal to his storage-response capabilities, the effective rate of further scanning would depend upon the rate of processing of the slowest systems. If input proceeded too far ahead of the response system or if recognitional or response difficulties arose, the scanned elements would be lost from storage before they could be responded to, and the subject would be required to make a regressive eye movement

in order to again scan the lost elements. In smooth reading, then, the systems would achieve a balance between the sensory and response systems. This balance would be dependent upon the time available in the initial storage system in its hypothesized role of buffer between input and output. That is, for the eye to track smoothly without regressive or refixative movements, each successive response would have to be made within the one second during which its respective stimulus was available. In order to provide for maximum buffering action, it would be advantageous to make full use of the storage time. Smooth reading, therefore, would be characterized by a relatively constant one second temporal eye-voice span regardless of the number of words or syllables being processed within that span. It is at this point that the heuristic model developed in this paper synthesizes with those postulates of General Open Systems Theory which are concerned with the establishment and maintenance of a steady state.

The Hypotheses

From the above rationale two major experimental hypotheses were generated:

H_I: During smooth oral reading, the temporal eye-voice span (a) will remain relatively constant, and (b) the period of time separating the eye and voice will approximate one second.

H_{II}: In those situations where an interruption of smooth, balanced reading occurs as evidenced by an overt error or pause in the voice, the eye will take

corrective action, following which the systems will quickly reestablish the pre-interruption balance.

Since "smooth reading" is a relative term judged from eye-movement patterns, and since an unknown amount of error variance was inevitable, Hypothesis I_a was tested by testing the following subordinate hypotheses:

(1) Between subjects, those reading more smoothly as evidenced by relatively smooth eye-movement patterns will also evidence a relatively more constant temporal eye-voice span.

(2) Between passages read by the same subject, those passages read with relatively smooth eye-movement patterns will also evidence a relatively more constant temporal eye-voice span.

(3) Within passages read by the same subject, those temporal eye-voice spans associated with smooth reading will be more constant than those associated with non-smooth reading.

The Observations

Data to test the above hypotheses were derived from 2,465 eye-voice span pairings furnished by eight subjects reading three passages of varying difficulty aloud before the Gilbert Eye-Movement Camera. During the reading, the voice was recorded by a Wollensak Stereo Tape Recorder. A specially designed modification to the camera provided simultaneous markings on film and tape at the moment of command

to begin reading and every 2/5ths of a second thereafter. All eye records were plotted on graphs of elapsed time prior to the analysis of voice records. The modification to the camera and improved methods of plotting developed during pre-experimental validation procedures exposed two hitherto unreported sources of position error thought to be common to all corneal-reflection techniques.

Voice tapes were played through a speaker and a Grass Model No. 7 Polygraph adjusted to react to varying volume. The resulting pen markings were plotted by the Polygraph on a moving graph paper which showed elapsed time. These records were then transferred to the elapsed time graphs on which the eye data had been previously recorded. The modification to the camera allowed the synchronization of the two records to be validated each 2/5ths of a second of elapsed time. The completed time graphs showed the simultaneous action of eye and voice during each 1/30th of a second for the entire passage. Measures of temporal eye-voice span were obtained from these time graphs.

The Results

Hypothesis I_a, which stated that during smooth oral reading the temporal eye-voice span would remain relatively constant, was supported by the data on each of the three subordinate hypotheses. Between subjects, rank order correlations between measures of smooth reading and constancy of the temporal eye-voice span were .83, .98, and .90 for the three passages individually and .95 for the combined

passages. Between passages read by the same subject, the relationships were apparent but not as strong. Perhaps the clearest indication of the strength of the relationship was gained by pooling all subject-passage comparisons, regardless of subject and passage differences. The resulting rank order correlation of the 24 pairs was .93. Examination of the spans associated with smooth and non-smooth reading showed that in 23 of the 24 comparisons those spans associated with smooth reading were more constant, as hypothesized.

Hypothesis I_b, which stated that the period of time separating the eye and voice in smooth reading would approximate one second, was likewise substantiated. Table 1 presents these data. The mean temporal eye-voice span for all subjects reading all passages was 1004 ms. For the three passages combined, the means for the eight subjects ranged from 904 to 1088 ms. With subjects combined on each passage, the mean temporal eye-voice spans were 909, 1033, and 1024 ms.

Hypothesis II, concerned with a reestablishment of the steady state following an interruption of it, was not statistically testable from these data. However, examination of the individual reading time graphs showed that the subjects used multiple fixations, regressions, and overly-long fixational pauses in characteristic ways at the beginning and completion of reading, at the ends of sentences, and at points of error. These graphs showed clearly that in reading under the conditions of this experiment, a significant portion of the eye-movement pattern is related to a necessity

to temporally balance input and output systems and that at points of error or at voice pauses, the eyes must take some corrective action in order to maintain or reestablish the temporal balance.

Table 1

Means and Standard Deviations of Temporal Eye-Voice Spans and Number of Fixations for Each Subject on Each Passage

Subjects	Passage 2			Passage 3			Passage 4			All passages		
	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N	$\bar{X}$	SD	N
1	953	304	80	943	357	155	953	354	178	949	345	413
2	787	133	50	927	207	99	938	258	103	904	213	252
3	777	258	58	997	295	106	988	277	111	947	280	275
4	989	182	53	1147	277	118	1061	249	120	1083	248	291
5	925	317	74	1114	416	142	1098	367	159	1070	376	375
6	882	217	53	1056	325	110	995	286	116	998	288	279
7	824	277	58	983	301	100	1049	315	108	975	301	266
8	1075	273	68	1078	347	118	1103	362	128	1088	337	314
All Subjects	909	254	494	1033	323	948	1024	315	1023	1004	305	2465

Conclusions

It was concluded that the time estimate of one second for the temporal eye-voice span was essentially correct and that the data supported at each point the aspects of Hypothesis I, relating the constancy of this span to smooth, oral reading. It was also concluded that the eye and voice interactions revealed in the reading charts supported Hypothesis II concerning the reestablishment of a temporal balance following an interruption.

The demonstration of the steady state phenomenon in the oral reading act and of the flexibility of the input and output systems in maintaining the necessary balance would seem to add verification to the application of the Organismic Open Systems Model to reading, as done in the Substrata-factor Theory by Holmes. The data, if replicable, would also seem to support those portions of the heuristic model tested, although other explanations may be possible.

Epilogue

While explaining the model presented in this paper to friends who are teachers, I am invariably asked about its relevance to the teaching-learning situation. It may be of some importance, therefore, to state specifically that as yet the model has little to offer the teacher. The model in its present form is quite tentative and incomplete. The experiment reported in this paper did not test all parts of the model and certainly not all kinds of reading. The experiment, itself, is in need of replication.

The model at present is a heuristic device. It explains classical experimental data as well as does classical theory and, in addition, explains a number of long-known phenomena which classical theory failed to explain. It is consistent with recent experimental findings which appear inconsistent with classical theory. Most importantly, it predicted and identified what, in my judgment, is probably the central and unifying measure in eye-movement analysis--a measure which had been ignored during 70 years of research because classical theory gave no indication of its importance. These considerations allow some hope that the lines of research suggested by the model may add to our cumulative knowledge of reading phenomena and, perhaps, eventually suggest new approaches to our teaching methodology. Serious speculation at this stage, however, would be premature at best.

References

1. Broadbent, D. E. Perception and Communication. New York: Pergamon Press, 1958.

2. Geyer, J. J. Perceptual Systems in Reading: A Temporal Eye-Voice Span Constant. Unpublished doctoral dissertation. Berkeley: University of California, 1966.

3. Granit, R. Receptors and Sensory Perception. New Haven: Yale University Press, 1955.

4. Hebb, D. O. "Semiautonomous Process: Its Nature and Nurture," American Journal of Psychology, 70 (1957), pp. 38-48.

5. Hebb, D. O. The Organization of Behavior. New York: John Wiley, 1961.

6. Holmes, J. A. The Substrata-Factor Theory of Reading. Berkeley: California Book Company, 1953. (Out of print.)

7. Holmes, J. A. "Basic Assumptions Underlying the Substrata-Factor Theory." Paper read at joint meeting of International Reading Association and American Educational Research Association, Philadelphia, May, 1964.

8. Holmes, J. A., and Singer, H. Speed and Power of Reading in High School. Cooperative Research Monograph No. 14, U. S. Department of Health, Education and Welfare, Office of Education, Catalog No. FS 5.230:30016. Washington, D. C.: Superintendent of Documents, U. S. Government Printing Office, 1966.

9. Kling, M. "General Open Systems Theory and the Substrata-Factor Theory of Reading," Use of Theoretical Models in Research, Highlights of the Pre-convention Institutes, International Reading Association, 1965.