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ABSTRACT

The first section of this two-part collection of articles contains six papers and their discussions read at a symposium on Theoretical Models and Processes of Reading. The papers cover the linguistic, perceptual, and cognitive components involved in reading. The models attempt to integrate the variables that influence the perception, recognition, comprehension, and utilization of printed stimuli. Affective factors influencing these variables in both acquisition and performance are included. The final paper in the symposium presents a brief review of the literature on theoretical models in reading and draws implications for teaching and research from several models selected to represent the reading development continuum from kindergarten through college. The second part of this volume represents published papers on theories and processes of reading. Included among these are: (1) "The Substrata-Factor Theory of Reading: Some Experimental Evidence"; (2) "A Developmental Model of Speed of Reading in Grades Three through Six"; (3) "A Theory of Language, Speech, and Writing"; (4) "Reading: A Psycholinguistic Guessing Game"; (5) "The Reading Competency Model"; "The Nature of the Reading Process"; and (7) "Learning to Read." (Author/WR)

THEORETICAL MODELS AND PROCESSES OF READING

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Editors

With a Foreword by James F. Kavanagh, Growth and Development Branch, Institute of Child Health and Human Development, Bethesda, Maryland

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Dedication

JACK ALROY HOLMES
1911-1967
Professor of Education
University of California at Berkeley

THEORETICAL MODELS AND PROCESSES OF READING is dedicated to Jack Alroy Holmes for his eminent contributions to the psychology of reading as a theorist, researcher, and teacher.

Born in Oakland, California, he was graduated from Oakland High School in 1931. In 1938, he earned an A.B. degree with a major in physiology and minors in physical science and English. In 1940 he received a General Secondary Credential from the University of California at Berkeley and subsequently taught chemistry and physics in high schools in Courtland and Petaluma, California. In 1942 he earned an M.A. in educational psychology and in 1943 returned to the University to work as a physicial chemist in the Manhattan Project at the U. C. Radiation Laboratory. In this position he published 10 experimental papers on uranium compounds, authored one patent and coauthored two more, all of which have been kept classified by the U.S. Army.

After the Manhattan Project, he served as director of psychological research and testing for the U.S. Army at Benecia Arsenal from 1945-1947. In 1947, while pursuing further graduate work, he became an instructor in the Reading and Study Clinic at U.C. Berkeley. In 1948, under the direction of Dr. Luther C. Gilbert, now Professor Emeritus, he completed the Ph.D in educational psychology at the University of California.

In 1947, Jack Holmes was an assistant professor of educational psychology at Oklahoma A.&M. College. In 1948, he joined the faculty at Western Reserve University as associate professor of educational psychology and director of the reading improvement services of the Personnel Research Institute. In 1950, he was called back to U.C. Berkeley as assistant professor, became associate professor in 1953, and professor of education and research psychologist in the Institute of Human Development in 1959.

Jack Holmes had a highly creative and productive career. His research interests included studies of musical ability, factors in school achievement, and, after a sabbatical year at the V. A. Hospital in Long Beach, California, with Dr. J. M. Nielsen, study of specific aphasia disabilities. However, he is best known in the field of reading for his formulation and research on the substrata-factor theory of reading. During the past fifteen years, he published or coauthored a large number of research papers and monographs, and supervised five doctoral dissertations on the psychology of reading.

Jack Holmes' pioneering work drew considerable reactions from researchers, some critical and some highly laudatory. Dr. David Clark, then Director of the Cooperative Research Branch of the U.S. Office of Education referred to the work at the high school level as "A most exciting research study representative of the best that is going on in the field of educational research."[1] Dr.

[1] Carter, Harold D., T. Bently Edwards, and Luther C. Gilbert. "Jack Alroy Holmes, 1911-1967," *In Memoriam*. Berkeley, Calif.: University of California Press, May 1968, 69-72.

Holmes also received support and encouragement from such leaders in the field as Professors Guy T. Buswell, Luther C. Gilbert, David H. Russell, Jeanne Chall, George Spache, Ruth Strang, Arthur Gates, and many others. However, he believed that his theory and research was only a first approximation and much work remained to be done to develop a comprehensive psychological, neurological, and statistically-determined model of reading. But, he felt that progress in the science of reading would best be promoted by integrating theory and research. He expressed this idea in a review of research in reading:[2]

> The present analysis reveals that, during the period from September 1960 through September 1963, at least three new and exciting trends are clearly discernible: (a) a concerted effort at theory building, (b) a greater concern for designs that are experimentally and statistically sophisticated, and (c) a host of new instruments and techniques.
>
> A field of study is generally headed for a spurt of creative productivity when theory construction and experimental research become closely interdependent and mutually directed. All signs indicate that the psychology of reading is on the threshold of just such a forward thrust and that both stimulating and disturbing days lie immediately ahead. In this new atmosphere, cherished ideas are bound to be challenged, and new ones will contend for their places when the old ones fall.

Professor Holmes was instrumental in developing this spurt of creative productivity. He will be remembered as a dedicated theorist and researcher and as a warm, generous, and kind person.

HARRY SINGER
University of California at Riverside

MARTIN KLING
Rutgers University

[2] Holmes, Jack A., and Harry Singer. "Theoretical Models and Trends Toward More Basic Research in Reading," *Review of Educational Research*, 34 (April 1964), 127-155.

The International Reading Association attempts, through its publications, to provide a forum for a wide spectrum of opinion on reading. This policy permits divergent viewpoints without assuming the endorsement of the Association.

Foreword

IN THE EARLY 1960's, with stimulation from the White House and Congress, our country saw a strong surge of interest in the health problems of children. While this national interest was first directed toward problems of early diagnosis and treatment, it soon became apparent there was also a great need for fundamental research into normal growth and development. It was reasoned that such research could help establish better base lines from which more definitive diagnosis could be made and more efficient treatment prescribed. But of even greater importance, this research could lead to the optimalization of human development through increased knowledge of man's physical and intellectual capacities.

Thus, when the National Institute of Child Health and Human Development (NICHD) was established by President John F. Kennedy in January 1963, it was assigned the broad mission of encouraging and supporting biomedical and behavioral research into the nature of human development across the life span as well as certain broad health problems affecting children and their parents. Within the framework of the National Institutes of Health, the NICHD organized its extramural grant and contract support activities in a manner which could most effectively identify critical research problem areas and then provide the stimulation, leadership, and support requisite to their ultimate solution.

During the first year as an NIH Institute, the NICHD included "human learning" as a research area requiring special attention. Later, the members of the National Advisory Child Health and Human Development Council (NACHHD) urged the Institute to accelerate its support in the area of reading. The council members, nongovernment experts representing the various fields and disciplines of NICHD's interest, expressed their deep concern over the large numbers of otherwise normal American children who were underachieving as a direct or indirect result of inadequate reading ability. They decried the heavy investment of time, money, and human resources in attempts to apply particular teaching methodologies without an adequate scientific base. They were appalled at the equally large investment in feeble attempts to provide remedial procedures without an adequate understanding of the fundamental processes involved. The advisory council encouraged the institute staff to search actively for new opportunities to support fundamental research in reading by attacking the problems associated with the nature of the reading process and by determining how this complex language-related skill is acquired.

The Growth and Development Branch, one of the institute's five extramural scientific program areas, was designated the focal point within the NICHD for this major "programing" activity. This branch has as its mission, the expansion of all knowledge of the variety of influences which shape individual development from birth to adulthood, and the elucidation of the processes through which an individual with a given genetic endowment interacts with his social and physical environment to achieve maturity.

In February of 1968, the Growth and Development Branch held a research conference on "The Reading Process." Under the cochairmanship of Eleanor J. Gibson and Harry Levin, a group of some of the nation's leaders in this area, and their graduate students, spent several days informally discussing their research into the nature of this ubiquitous, yet mystifying, process.

During the conference several participants attempted to present in an informal way their theoretical models of the reading process. However, because of the "no-paper" informality of the meeting the models could not be fully developed and discussed. We were, therefore, very pleased to learn that the International Reading Association was planning a symposium on "Theoretical Models and Processes of Reading" and welcomed the opportunity to participate in the development of this monograph.

The Growth and Development Branch of the National Institute of Child Health and Human Development continues to search for effective ways to further basic research efforts in learning and in the human communicative processes such as reading.

JAMES F. KAVANAGH

Preface

> And so to completely analyze what we do when we read would almost be the acme of a psychologist's achievements, for it would be to describe very many of the most intricate workings of the human mind, as well as to unravel the tangled story of the most remarkable specific performance that civilization has learned in all its history.
>
> Edmund Burke Huey

This quotation, taken from Huey's classic book on the psychology and pedagogy of reading, was written over 60 years ago.[1] It is nevertheless a pertinent introduction to this volume, which includes current theories and models of the mental structure and processes involved in the reading act.

The volume consists of two parts. The first part contains six papers and their discussions read at a symposium on "Theoretical Models and Processes of Reading," held in honor of the late Professor Jack A. Holmes at the Fourteenth Annual Convention of the International Reading Association, Kansas City, Missouri, May 1-2, 1969. The papers cover the linguistic, perceptual, and cognitive components involved in reading. The models attempt to integrate the variables that influence the perception, recognition, comprehension, and utilization of printed stimuli. Affective factors influencing these variables in both acquisition and performance were also included among the papers and in the models. The final paper in the symposium presents a brief review of the literature on theoretical models in reading and then draws implications for teaching and research from several models selected to represent the reading development continuum from kindergarten through the college level.

The second part of the volume represents published papers on theories and processes of reading. In the first, Holmes explains his

[1] Edmund Burke Huey. *The Psychology and Pedagogy of Reading.* Cambridge, Mass.: M. I. T. Press, 1968. First published by Macmillan in 1908.

substrata-factor theory of reading, illust... it with data. In the second, Singer reports evidence which confirms an hypothesis derived from the substrata-factor theory. Next, Reed presents a theory of language, speech, and writing which posits "linguistic form" as a basic structure of language which links meaning with the symbol systems of speaking and writing.

In the fourth, fifth, and sixth articles, Ruddell, Goodman, and Venezky and Calfee present their psycholinguistically-determined models. Ruddell's is a general model designed to account for the four communication processes: reading and listening, speaking and writing. Goodman tends to stress information processing and decision-making theory in his reading model. Venezky and Calfee, in a paper solicited for this volume, divide their models into two parts: a competency model for the mature reader and an acquisition model for the beginning reader. Carroll describes the nature of the reading process from the viewpoint of the reader and emphasizes facets of the reading process that are still unknown. Hochberg and Brooks, drawing upon an expectancy theory of cognition and a sampling theory of perception, postulate the interaction of "cognitive" and "peripheral search guidance" processes in explaining purposeful behavior in reading. The last paper, by Gibson, reviews a number of laboratory experiments on the acquisition of decoding behavior in the initial stage of development. The editors had also hoped to include an excellent paper by Dr. Helen M. Robinson entitled "The Major Aspects of Reading," in H. Alan Robinson (Ed.), *Reading: Seventy-Five Years of Progress*, Proceedings of the Annual Conference on Reading held at The University of Chicago, 1966. University of Chicago Press. Technical problems related to the reproduction of colored illustrations contained in the article made this impossible; however, the editors strongly encourage the reader to consult this source.

Theoretical models are not only useful for decision making in teaching but also for guiding research along systematic lines. Holmes and Singer emphasized this viewpoint in their recent review of research in reading in which they noted that theoretical models and basic research are nascent and interrelated trends. Currently, the U.S. Office of Education in a grant to Dr. William J. Gephart, Director of Research Services for Phi Delta Kappa, is seeking to construct a model for research in reading that will enable the Office of Education to use a convergence-technique basis for establishing research priorities and allocating funds. Such a model should enable independent researchers to work on different aspects of unknowns in the model and through their work converge their evidence in support or modification of the model. Goodman's paper, reprinted in this volume, contains the model that appears in Gephart's report to the U.S. Office of Education. Although there are some risks in such use of the convergence technique for the field of reading, at least use of a comprehensive model is likely to insure that some components of reading will not be overlooked in funding research. The risks will be reduced if the model is continuously modified as more evidence becomes available. An alternative to use of one model is to utilize all of the models of reading and let the weight of accumulated evidence determine which models need to be discarded or modified and which models constitute better explanations and are more fruitful in enhancing understanding of the reading process. The more we understand the process, the more likely we are to develop and devise instructional programs and materials that will enhance the reading abilities of our students, the ultimate goal of research in reading.

Many people have cooperated in bringing forth this volume. Among them are the Board of Directors of the International Reading Association, Dr. Ralph Staiger, Executive Secretary of IRA; Dr. Ronald Mitchell, Assistant Executive Secretary and Coordinator for the IRA Committee on Research which sponsored this symposium and its publication; and Mrs. Faye Branca, Publications Coordinator of IRA. The lion's share of funds for publishing this volume came from a contract with the National Institute of Child Health and Human Development. The project officer for this contract was Dr. James Kavanagh of the Growth and Development Branch of NICHD. We are also grateful to him for his suggestions which enhanced our symposium and this volume. We also wish to express our appreciation to the people who participated in the symposium and who contributed their papers to this volume. If the volume is used in graduate courses, stimulates research, and leads to the improvement of reading instruction, then it will indeed be an appropriate memorial to Jack Holmes.

Harry Singer and Robert Ruddell

PART ONE

Language Acquisition and the Reading Process

ROBERT B. RUDDELL
University of California at Berkeley

THE ACQUISITION of one's native language is indeed a complex process. In fact, little is known about the exact nature of the development of this miraculous phenomenon. Two language acquisition theories which have received greatest acclaim in recent years hold, first, that in a more traditional sense language is acquired through an elaborate association and mediational learning process (*51, 54*), and, second, that language as the species specific characteristic develops as latent structures are "triggered" physiologically and influenced by the model language available to the child (*9, 27*). Convincing arguments have been posited for both points of view; however, it would seem plausible that both theories contribute in some sense to an understanding of language acquisition. Assuming that latent language structures are present and basic to the development of grammatical competency and language performance (*21*), it is also logical to assume that value stems from consistent social reinforcement and sentence expansion opportunities in refining and extending child grammar (*8*) as well as lexicon (*24*). The purpose of this paper, however, is not to review various theories on preschool language acquisition but instead to examine continued language acquisition in the early school years and explore its relationship to the reading process.

As one reads various language research summaries, it is not uncommon to find conclusions which suggest that upon entrance to the first grade the child's language development is for the most part mature and that he is sufficiently equipped to handle most forms of discourse which embody highly complex structures and vocabulary. Comparatively speaking, the child has made fantastic progress during his six years of life. He can recognize and produce novel sentences; discriminate between grammatical and nongrammatical sentences (e.g., The bike hit the tree. vs. The hit bike the tree.); utilize context and prosodic clues to disambiguate sentences possessing the same surface structure (e.g., They are *visiting* children. vs. They are *visit-*

ing children.); comprehend sentences which possess different surface structures but have identical underlying meaning (e.g., The boy ate the apple. vs. The apple was eaten by the boy.); and also comprehend sentences which possess identical constituent structure but different deep structure (e.g., Miss Rufkin is easy to please. vs. Miss Rufkin is eager to please.).

By the time the child enters the first grade he has made great strides in language maturation but it must be recognized that substantial growth in structural and lexical language components must occur in the elementary school years. In this regard it is important that a discussion of language development account for language maturity not only in standard but in nonstandard dialects as well. It is also important that the relationship between language experience and the reading process be accounted for. The following discussion will thus be mainly devoted to the acquisition and control of structural and lexical dimensions of the language of standard and nonstandard speakers during the elementary school years, with special concern for the relationship between language production and the reading process.

Control of Structural Components

Phonological and morphological development. Various status studies have consistently shown that by the time the child enters the first grade he has a high degree of control over his phonological system (*32, 56*). In fact by the time the child is four to five years of age he has mastered the great majority of English sounds (*13*). Likewise, his morphological development is well along upon entrance to the primary school (*2, 47*). Only on occasion will he utilize an inflectional form (e.g., drinked) which deviates from the adult norm (*29*).

This language progress, however, assumes that the child has been provided with a "standard English" model and that opportunity has been present for language interaction in a wide variety of language environments. If these assumptions cannot be met then the language maturity criteria for the phonological and morphological systems will need to account for nonstandard forms and performance levels in limited language environments.

Recent work on nonstandard dialects provides evidence of highly regular systems which in past years were considered to be degenerate forms of "good English." This regular nature is evident in the l-lessness common to the Southern Negro dialect and results in consistent production of homonyms so that *toll* becomes *toe*, and *fault* becomes *fought*. The simplification of consonant clusters in final positions such as /st/→/s/ and the loss of /t/ and /d/ results in homonyms so that *past* becomes *pass*, *meant* becomes *men*, and *hold* becomes *hole*. The English speaking youngster from a Spanish speaking background may have difficulty with vowel contrasts which distinguish the words b*i*t /i/ and b*ea*t /iy/, b*e*t /e/ and b*ai*t /ey/; and initial consonant contrasts such as *s*ue /s/ and *z*oo /z/. The Navajo child has difficulty with initial consonant distinctions in words like *v*ote /v/ and *b*oat /b/; and *ch*ip /c/ and gyp /j/.

These variations in the phonological system may result in meaning confusion between nonstandard and standard English speakers in situations where sentence context is not sufficient to clarify the intended meaning. If we are to understand the relationship between the phonological system and the graphological system it becomes clear that dialectal variation must be accounted for. Otherwise, the operationalized reading program makes false assumptions about the language performance of the nonstandard speaker and the teacher may attempt to develop sound-letter correspondences which are not possible for the child.

Reading-decoding. Linguists such as Venezky (*59*), Wardhaugh (*61*), and Reed (*41*) have strongly recommended that it is necessary to consider letter patterns beyond the simple sound-letter correspondence level if a more consistent relationship between oral and written language forms is to be realized. This recommendation is based on the linguistic unit known as the morphophoneme, or the intermediate (between phoneme and morpheme) sound-spelling unit. The importance of this unit is obvious at once in the examination of the words supr*e*me and supr*e*mity. On the first consideration the second *e* grapheme would appear to possess little regularity in its representation of a given sound. However, when the large spelling pattern is considered a highly regular pattern becomes evident. In the alterations—supr*e*me supr*emity*; extr*e*me, extr*emity*; obsc*e*ne, obsc*enity*—

we observe a consistent shift in the sound value (/iy/ to /i/) in adding the suffix *ity*. The same principle is present in the letter pattern using the final *e* marker (e.g., *sit* /i/, *site* /ay/).

Consideration also needs to be given to the possible value of utilizing phonological or sound segmentation rather than morphological or word-affix segmentation in teaching decoding skills. An experiment by Rodgers (*42*) asked children to repeat words containing two syllables (e.g., toas-ter) and the same words divided between the two morphemes (e.g., toast-er). He found that the children were more successful in redividing words along syllabic or phonological breaks than along the morphological breaks thus supporting phonological segmentation.

The work by Gibson and her colleagues (*18*) has indicated that children develop higher-order generalizations in the early stages of reading and that these generalizations follow English spelling patterns. The children in the experiment appeared to perceive regularities in sound and spelling patterns and transfer these to decoding unfamiliar trigrams even though taught by what the researchers refer to as the "whole word" approach. The above research thus suggests the possible value and need to consider decoding units which extend beyond sound-letter correspondences and account for more complete regularity in the English spelling system.

As the classroom teacher and the theoretician view the relationship between language acquisition and the reading process, both must not only be aware of the previously discussed cultural levels (*25, 40*), such as standard and nonstandard dialects, but also cognizant of functional varieties of language such as informal, formal, and literary. These varieties may exist within a given cultural level. Additional variation in language performance may be expected to result from the child's limited experience with language forms unique to a particular social environment. As a result one child may be able to function on only an informal functional variety level while a second child from a highly enriched language environment may shift with ease from the informal to the formal level.

By placing oral expression and written language forms on a functional variety continuum ranging from informal through formal to literary (*40*) we can examine the "fit" between these forms of communication for the beginning reader. Figure 1 indicates what we might expect to find.

Functional Variety Level	*Oral Language*	*Written Language*
Informal	Home and school language.	Personal notes, letters to friends, unedited language experience stories.
Formal	Classroom lectures, public speeches.	School textbooks, edited language experience stories.
Literary	Formal papers, speech as an art form.	Literature as an art form, aesthetic dimensions of written language.

FIGURE 1. Levels of functional variety in oral and written expression

Two problems are immediately obvious. First, the written language material which the child initially encounters in the instructional setting will in most cases be at least one level above his informal and familiar oral language style. Second, the child from a limited language environment which has provided little opportunity for the development of shift in a functional variety is at a decided handicap in approaching the printed page which is written for the most part at the formal level. For example, *hafta, gonna, hadda, oughta, hasta,* and *wanna* are quite appropriate in informal conversational settings for oral language, but in written language are realized as *have to, going to, had to, ought to, has to*, and *want to* (*29*). The contractions *I'll, she'll, he'll,* and *they'll* are most appropriate in informal oral language situations; however, the written equivalents *I will, she will, he will,* and *they will* appear in many children's textbooks at the formal level from the child's earliest encounter with printed matter.

The problem, then, for the nonstandard speaker is striking when we consider that he must not only account for dialectal deviations, but also levels of functional variety in the second dialect. Speakers of standard and nonstandard forms, however, must accommodate the functional variety shift from informal to formal or literary styles. As Goodman (*20*) has emphasized, certain oral language sequences, which result from morphophonemic rules cutting across morpheme boundaries in the flow of speech, are so common that the young speaker does not differentiate the individual components in the sequence as in *going to* (gonna), *with them* (with'm), *with him* (with'm), *must have* (must'v) and *should have* (should'v). Thus, oral language at the informal level may use one unit while the early encounter with printed forms at the formal level may require two units. This variation must be taken into account in both the instructional program and abstract explanations of the reading process. More will be said about the problem of stylistic shift in the following discussion which considers syntactical and lexical aspects of language acquisition.

Syntactical development. The control of syntactical patterning by the preschool primary grade child has been demonstrated in various studies including those by Fraser, Bellugi, and Brown (*16*); Brown and Fraser (*6*); Strickland (*55*); Loban (*30*); Ruddell and Graves (*47*); and O'Donnell, Griffin, and Norris (*38*). These studies indicate that by kindergarten and first grade the child is able to comprehend sentences and produce expanded and elaborated sentences through the use of movables (words, phrases or clauses with no fixed position in the sentence) and transformed subordinating elements.

The research evidence also suggests that the developmental sequence in syntactical control extends well into and perhaps through the elementary grades. Menyuk's work (*33*) has identified some sequential components in children's syntax extending from nursery school into the first grade. She noted that even in the first grade some patterns such as "if" and "so" clauses, perfects, and nominalizations were still in the process of development. Lenneberg (*28*) has discussed the difficulty presented by transformations in the passive voice for the mentally retarded child. The work of Strickland (*55*) shows a definite relationship between sentence complexity and grade level. Loban's research (*30*) revealed that throughout the elementary grades the average communication unit length increased indicating a developmental sequence of complexity in sentence structure.

The detailed study by Harrell (*22*) compared selected language variables in the speech and writing of children aged nine, eleven, thirteen, and fifteen using a short movie as the speech and writing stimulus. The investigator found that the length of the compositions and clauses used in oral and written expression increased with age, with a large percentage of subordinate clauses being used by the older children in both written and spoken composition. The children were found to use a larger percentage of subordinate clauses in writing than in speaking. More adverb and adjective clauses were used in written compositions, while a larger number of noun clauses were used in speaking. A larger percentage of adverbial clauses, excepting those of time and cause, were used in the children's speech. The developmental increase of each language variable in relation to age was found to be greater for written compositions than for oral.

The work of O'Donnell, Griffin, and Norris (*38*) at kindergarten and grades one, two, three, four and seven also lends support to the general notion of a developmental sequence of syntax acquisition in the elementary grades. These researchers have observed that some transformations (e.g., relative clause, "The man who was wearing a coat . . .") were used much more frequently in kindergarten than in later grades while other items (e.g., noun modification by a participle, "The man wearing a coat . . .") were more frequent in later grades. The researchers observed that such a developmental sequence would appear to be a logical one from the standpoint of transformational grammar in that many of the later constructions are derived from more complex deletion rules.

Also of interest in the O'Donnell, Griffin, and Norris research was the finding of distinct variation in the syntax of speech and writing in grades three, five, and seven. At third grade, oral expression was deemed superior to written expression in transformational complexity, while at grades five and seven the reverse was true. These findings are similar to those of the previously mentioned Harrell study and suggest that by the intermediate grades the child has some production control over stylistic variations which require more complex constructions in written expression.

By examining research which contrasts the language development of children possessing hearing deficiency with that of normal children the relationship between oral language experiences and written language production is brought into sharper focus. Heider and Heider (*23*) secured written compositions based on a motion picture from a large number of deaf and hearing children ranging in age from eleven to seventeen years and eight to fourteen years, respectively. Although the deaf children were three years older, their compositions were found to resemble the less mature hearing children. The deaf children were found to use fewer numbers of words and clauses than the hearing children while the hearing children used more compound and complex sentences with a larger number of words in coordinate and subordinate clauses, thus indicating a more advanced development in language production.

The written language of normal and defective hearing children has been examined in Templin's research (*57*). Children having hearing deficiencies were found to use more words in their explanations of natural phenomena than hearing children of the same age, grade, and intelligence. This finding was interpreted to reflect less adequate control over vocabulary, and perhaps syntax, rather than representing a more complex type of expression. The children with defective hearing apparently needed more words to express a concept due to low efficiency in expressing their ideas through elaborated sentences and more abstract vocabulary.

Both the Heider and Heider and the Templin studies point to a significant relationship between oral and written language development. The opportunity for oral language experience through hearing would appear to directly influence performance in written language.

The language deviations of the nonstandard speaker also result in significant grammatical variations. The previously discussed l-lessness, for example, may affect future forms where *you'll* becomes *you*, *he'll* becomes *he*, and *they'll* becomes *they*. Thus, when the child reads the sentence "He will go." as "He go." he is consistently translating the sentence in his dialect. An example used by Shuy (*49*) states that the written sentence "John asked if Mary wore a coat." is frequently read by the ghetto child as "John asked did Mary wear a coat." In this instance the substitution of *did* for *if* and *wear* for *wore* does not represent an error in reading in terms of the child's dialect. If, however, the child read "John asked Mary if did she wear a coat." or "John asked Mary if she wear a coat." the alterations do vary from the consistent nonstandard forms and would represent a reading difficulty. The child's consistent performance may thus be interpreted to indicate that he possesses a high degree of language competence in the same manner as the standard speaker of English.

An understanding of the relationship between the communication process and the standard and nonstandard syntactical forms is of importance to both the classroom practitioner and the theorist. Bernstein's research (*3, 4*) supports the viewpoint that the "restricted" code associated with lower socioeconomic status and related language experiences is characterized by limited subordination and is syntactically redundant. In contrast the "elaborated code" uses more complex forms of subordination which can account for logical relationships and greater causality. The "elaborated" code makes provision for meaningful explication of specific topics with strangers or new group members. The contribution of syntactical factors to the "elaborated" code would appear to be in terms of subordination and expression of complex relationships. Although these dimensions can be handled in the "restricted" code, a definite economy is present in the utilization of the "elaborated" code with a majority population that does not possess the competency necessary to comprehend the unique features of the "restricted" code.

The "elaborated" code would also be expected to make provision for easier transition from oral to written language comprehension and production particularly in terms of greater subordination control required in the stylistic shift from an informal to a formal functional variety level.

Reading-comprehension. The close relationship between comprehension ability and language production receives support from a variety of studies. The research of Fraser, Bellugi, and Brown (*16*) supports the view that children must comprehend grammatical contrasts before they are able to produce these contrasts. The previously cited research of Strickland (*55*) and Loban (*30*) report significant relationships between children's reading and listening comprehension achievement and their demonstrated use of movables and subordination in oral language.

From the early study of mistakes in paragraph reading of sixth grade children, Thorndike (*58*) noted that understanding a paragraph is dependent upon the reader's selection of the right elements and synthesizing them in the right relations. The child's ability to comprehend material whether written or spoken would seem to be a function of his ability to see the relationships between key elements in the sentence. Thus relating various subordinating elements to the central idea of the sentence is of basic importance for comprehending the discourse.

Using a "disarranged phrase test," Gibbons (*17*) studied the relationship between third grade children's ability to understand the structure of sentences and their reading achievement. She found a high correlation (.89) between the ability to see relationships between parts of a sentence and the ability to understand the sentence, when intelligence was partialled out. A significant correlation (.72) was also found between the ability to see relationships between parts of sentences and total reading achievement.

The importance of familiarity with syntactic patterning to reading achievement is evident in MacKinnon's research (*30*). In a detailed study of beginning readers he observed that children attempted to substitute syntactic patterns which they had previously read and were familiar with in place of unfamiliar patterns in their attempt to decode unfamiliar reading materials.

A study by Ruddell (*43*), at the fourth grade level, examined the effect on reading comprehension of written patterns of language structure which occur with high and low frequency in children's oral language. By controlling the vocabulary difficulty, sentence length and subject matter content in a series of reading passages, the relationship between reading comprehension and pattern complexity was examined. Reading comprehension scores on passages written with high frequency patterns of language structure were found to be significantly superior to comprehension scores on passages written with low frequency patterns of language structure.

The child's understanding of the sentence structure would be expected to enhance his ability to narrow alternate word meanings and thus contribute to comprehension. For example, the word *that* not only cues a noun which follows but may also clarify or emphasize the semantic nature of the noun (e.g., *That* yellow canary ate the cat. vs. *Some* yellow canary ate the cat.). Miller (*35*) and Miller et al (*36*) have demonstrated that words in context following a similar grammatical pattern are perceived more accurately than when in isolation. Additional support for the importance of context in narrowing semantic possibilities is found in the research of Goodman (*19*). He has shown that although children may be unable to decode words in isolation, they deal successfully with the same words in a running context. These findings support the importance of contextual association which provide sufficient delimiting information to enable the child to determine the semantic role of a word and, further, to recognize and comprehend it in a sentence.

A longitudinal study by Ruddell (*45, 46*) has demonstrated that the sentence and paragraph meaning comprehension of first and second grade children can be significantly enhanced by emphasizing the meaning relationships between key structural elements within and between sentences. Additionally, the doctoral dissertation research of Baele (*1*), which was part of the longitudinal study described above, indicated that by the end of third grade the children who had participated in the treatment stressing the relationship between key structure elements were expressing themselves in written form with longer communication units and with greater clausal depth, thus indicating control over more complex constructions and subordination in the written language performance. This research parallels in some respects the preschool oral language research of Cazden (*8*). Her work with two and three year old children indicated that the use of full grammatical sentences in response to the children's verbal expression and the expansion of their telegraphic speech to full adult grammatical sentences resulted in an increased level of performance on several measures of grammatical development when contrasted with a control group. The "richness of verbal stimulation" appeared to be of great import in extending grammatical control. These findings indicate that language comprehension and production can be enhanced in the preschool and early grades by placing emphasis on structural relationships which influence meaning within and between sentences.

Control of Lexical Components

Concept development. The child's conceptual development makes rapid progress during the preschool years and he will recognize and possess control over many hundreds of words by his first year of school (*52, 53*). During this time a variety of concepts are formulated as the youngster associates common properties of an object with the object label. As Vygotsky (*60*) has pointed out the preschooler calls a *cow* a *cow* because it has horns, and a *calf* a *calf* because its horns are still small, while a *dog* is called a *dog* because it is small and has no horns. Eventually the child comes to conceptualize the arbitrary nature of language itself as he understands that word labels are assigned to concepts and that a particular label may represent several concepts depending upon its contextual use.

There is ample evidence to support the view that concepts develop along a continuum from concrete through the semiconcrete or functional to the abstract levels as illustrated in the research of Fiefel and Lorge (*15*). The work of Russell and Saadeh (*48*) is also illustrative of research supporting such a continuum. These researchers contrasted student conceptual responses at grades three, six, and nine on multiple choice questions designed to measure various levels of abstraction. They concluded that third grade children favored "concrete" responses while sixth grade and ninth grade children favored "functional" and "abstract" responses. As Ervin-Tripp (*14*) has emphasized in her extensive research summary of child language, conceptual maturation moves from concrete referents to "hierarchies of superordinates which may have rather vague features (e.g., mammal, vertebrate) and they [adults] speak of nonvisible referents such as politics and energy."

Various background variables have been credited with enhancement of language performance. John and Goldstein's verbal mediation research (*24*) reveals that a child's verbal interaction with a mature speaker is of importance in making provision for testing tentative notions about word meanings. Such opportunity would appear to produce greater verbal control and enable the child to rely on words as mediators facilitating thought. Vygotsky (*60*) has suggested that the availability of adults for dialogue with the child is of great import to language acquisition. This consideration also receives support from Davis' early research (*10*), which revealed that in families of only children language facility was found to develop more rapidly than in families of children with siblings; and children with siblings were found to develop language facility faster than twins.

The effect of factors in the home environment on language achievement is evidenced in Milner's investigation (*37*). Following the selection of high and low achievers in first grade reading, a depth interview was carried out exploring the children's use of language in the home. Milner found that the high achieving children had an enriched verbal environment with more books available and were read to more often by highly esteemed adults than the low achieving children. The high scoring children also engaged in conversation with their parents more often than the low scoring children. She noted further that in many of the home environments of low scoring children a positive family atmosphere was not evident nor did the children have an adult relationship pattern established. There appeared to be little opportunity for these children to interact verbally with adults possessing adequate speech patterns and who were of high personal value to the children.

In classroom instruction the child is frequently required to provide requested information at the formal functional variety level. As Bernstein (*3, 4*) has emphasized, the child from the low socioeconomic environment using the "restricted" code is required to use language in situations which he is neither equipped nor oriented to handle. This may be due not only to the past discussion of syntactical factors but also to his limited lexical control and ability to shift from an informal and intimate style developed in situations oriented toward immediate and concrete needs to a formal style characterized by abstractions which carry highly efficient explanatory power. Certainly a limited vocabulary represents a most critical factor in reading comprehension. This problem is highlighted in Metfessel's findings (*34*) that second grade children from concept deprived backgrounds possessed a comprehension vocabulary only one-third the magnitude of the average of their age-equivalent peers. Again, the classroom teacher and the theoretician must account for the child's lexical control if the wide range of conceptual variation is to be accounted for in practice and theory, respectively.

Comprehension strategies and objectives. The importance of a cognitive strategy to the conceptualization process has been clearly demonstrated in the research literature (*7*). If the language user is to participate actively in the process of communication he must evolve a symbol-processing system which will provide for the conceptualization of his experience. This is basic to his success in examining alternate approaches to decoding a new word and in comprehending written material which requires high level inference skills. From his concept formation study with elementary school children Kress (*26*) concluded that achieving readers were superior to nonachievers in their versatility and flexibility, their ability to draw inferences from relevant clues, and their ability to shift set when new standards were introduced. There is considerable research to support the relationship between language comprehension and an individual's ability to change, modify, and reorganize previously formed concepts (*50*).

The child's communicative objectives must also be viewed as critical to the development of his communication skills. These objectives must be of a real and meaningful nature to the child if they are to be operationalized as the indivdual confronts the reading material. The reading objectives should provide immediate self-direction for the child and will be of value in developing high motivation as revealed in his persistence and drive. This view also obtains support from the previously mentioned study of Kress (*26*). He has reported that achieving readers demonstrated more initiative in exhausting solutions and were found to persist in problem solving under changing conditions in contrast to the non-achieving readers. Durkin's extensive work (*11*, *12*), with the preschool child suggests that the early reader is an individual who is serious and persistent, is curious in nature, and possesses the ability to concentrate. The research of Piekarz (*39*) has identified the high level reader as an individual who provides significantly more responses in interpreting a reading passage, a trait indicating greater involvement and participation. The high level reader was also found to be more objective and impersonal in synthesizing the information sought which may be interpreted to support the importance of establishing reading objectives.

Thus, an individual's cognitive strategy is seen as a method of organizing and assimilating data as well as making provision for hypothesis formulation and testing. Provision for self-directing behavior through formulation of personal and immediate communication objectives would be expected to enhance the child's participation, persistence, and drive leading to more effective language control.

Summary and Recommendations

In conclusion, upon the child's entry to formal education he displays language performance which reflects a high degree of competence. Even so, however, four significant factors must be recognized and accounted for in any operational and theoretical formulation of the reading process. First, the child's ability to comprehend language precedes and exceeds his ability to produce language. Second, his language comprehension appears to be a direct function of his control over the grammatical and lexical components of the discourse. Third, his language competence and performance appear to move through a developmental sequence during the elementary school years which in some respects parallels the competency model proposed by the transformational grammarian. And, fourth, his language performance is directly related to his language environment, including the available language model and opportunity for language interaction, his comprehension strategies and objectives, and possibly maturation of his latent language structures.

Many essential informational areas which are required to explain the multitude of interactions which occur during the reading process are blank. The reading-language researcher and theoretician must carefully include the following dimensions in future research exploration:

1. A detailed mapping of the child's developmental performance in gaining control over his grammar during the elementary school years.

2. A parallel longitudinal study which examines the relationship between the child's grammatical performance and his lexical control.

3. A parallel longitudinal study which examines the relationship between his comprehension ability and his grammatical and lexical performance.

4. An intensive investigation designed to explore meaning interference which may be caused by variation in standard and nonstandard and functional varieties in language—including phonological, morphological, morphophonemic, syntactical and lexical items.

5. A study of the unique characteristics of "language enrichment" approaches and the relationship between these characteristics and the grammatical and lexical development of standard and nonstandard speakers during the preschool and elementary school years.

6. A study of various decoding units (e.g., grapheme-phoneme, morphographeme-morphophoneme) and the relationship between these units and early reading success.

7. A parallel study which will examine the relationship between

various decoding units, and reading success of children speaking standard and nonstandard dialects.

These problem areas are illustrative of the types of information required in order to formulate a theory of reading which will have explanatory power. Until such information is available our theoretical formulations of the reading process will remain extremely weak. It is obvious that we have far to go.

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Reactions to Language Acquisition and the Reading Process

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ROBERT RUDDELL has lucidly presented the point that significant relationships exist between a child's functional language abilities and the acquisition of the reading process. Although the inferences for reading which Ruddell draws from selected child language studies may be subject to discussion, the fact that he has attempted to translate these research findings into possible implications to be considered in respect to the reading process should be acknowledged. As can quickly be surmised from scanning current reading periodicals, as well as noting the topics of many papers presented at the Kansas City IRA convention, current views of language and its acquisition in relation to reading have generated considerable interest. The tendency of some educationists uncompromisingly to translate theory and research into practice—to seek instructional panaceas—can be a disservice when unconsidered, even irrational, instructional applications are made, thereby demeaning otherwise promising contributions. Ruddell's reasoned and cautious discussion provides a standard which might profitably be followed by others.

A few specific comments seem in order. A most pertinent point in Ruddell's discussion is his reminder that, contrary to some popular misconceptions, language continues to develop beyond school entrance age. This point is important because a model of reading instruction that embodies the premise that children have achieved basic linguistic mastery needs to attend primarily to the refinement and application of those linguistic skills which pertain specifically to reading. On the other hand, a model of reading instruction which posits that linguistic skills are developmental should also take into account that *both* reading materials and instructional strategies ought to lead toward the mastery of skills not yet acquired.

Ruddell's presentation also reminds us that a developmental approach to the study of language acquisition has fostered numerous habits, of course, has partly been a consequence of the view that linguistic mastery has been regarded as functionally complete by school entrance age. His summary of language development studies during the elementary school years provides a useful overview of the kinds of investigations which contemporary language theory has fostered. It should be pointed out, however, that interpretations of these studies ought to take into account the stimulus mode employed in eliciting language samples, since the stimulus situation can have a fundamental effect on the kind of language elicited. Nonetheless, emerging from contemporary language studies is the observation that language, seemingly, is acquired in a rather fixed order, although the *rate* of acquisition may vary considerably due to individual and environmental factors.

In conjunction with this point, also, it is well to keep in mind that many findings reported from child language research are expressed in terms of normative data with the consequence that mean scores on tests or mean chronological ages in linguistic development obscure ranges in individual scores or ages that comprise the mean. Language norms provide important measures for use by the researcher and the practitioner; but language *variation* ultimately must be taken into account. Normative data ought not be used to obscure the fact that ranges around a mean often are far more informative, particularly in regard to a developmental view of language acquisition. As Ruddell has implied, each individual's biological endowments, in combination with the consequences of his particular linguistic environment, can lead to a substantial variation among elementary school children's language performances.

Distinguishing among *causes* of language variation is another implication that can be derived from Ruddell's presentation. Causal factors of language variation might be distinguished in at least three ways: developmentally, dialectally, and pathologically. Each factor raises the possibility that a model of reading instruction should take into consideration how modes of instruction may differ because of possibly different language inputs into the reading process.

done using college subjects. With one exception, the study using college subjects was identical to the one using kindergarten children. Some of the college subjects getting look-say training were able to read words on the transfer list on first presentation whereas virtually none of the look-say kindergarten subjects could do this. An analysis of how the college subjects did this revealed that those subjects who had used their knowledge of reading and who had learned letter sound correspondences on their own, were able to transfer this knowledge to reading the transfer list. Taken together, the two studies give strong support to the notion that knowledge of letter sound correspondence is an important basis for transfer to reading new words.

In the kindergarten study of the effect of phonic versus look-say training, a task analysis of the skills necessary for transfer to reading new words indicated that knowledge of letter-sounds as well as the ability to blend these sounds was required. As the data from the experiment revealed, the group getting both kinds of training was superior to the groups which did not get the necessary training. The implications of this experiment for the teaching of reading are that task analyses can be most helpful in planning instructional sequences. In doing task analyses, specific objectives are identified. Then, preon the other hand, may pose another kind of possible mismatch, that which results from differences between the formal features of the language of instruction and the formal features of language which the child has learned in his particular linguistic community. The instructional resolution of such a mismatch is currently a topic of considerable debate specifically regarding whether or not focus should be placed on altering the language of instruction to match the language of the child or vice versa. Pathological variation, in turn, poses the possibility that, in addition to whatever developmental and dialectal differences might exist, special instructional techniques may be needed that are not ordinarily encompassed in a reading program; as, for example, the techniques that may be used in working with the visually or auditorily handicapped child.

These three factors—developmental, dialectal, and pathological—are not intended as inclusive forms of linguistic variation. Nonetheless, they do call attention to the need for a model of reading instruction to outline instructional interventions which are cued by the kinds of linguistic variations which can and do occur in the language of the elementary school child.

A concluding remark: despite the growing data about language acquisition, Ruddell's admonition that substantial work in other dimensions of language in relation to reading is needed is fully warranted. His presentation clearly indicates that, despite some significant theoretical formulations and equally significant research, there is still a good distance to go in developing a theory of reading and, from such a theory, a model of reading instruction. Ruddell's own contributions, and his comprehensive summary of the contributions of other researchers, are welcome additions to the accumulating data about the reading process and its language base.

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Modes of Word Recognition[1]

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THIS PAPER

1. Examines the strategies used by children in word recognition.
2. Reviews critically some of the classical research which has influenced current thinking about how words are recognized.
3. Presents a five stage model of how words are recognized by beginning readers.
4. Contrasts recent experimental findings of cues used in word recognition with some of the commonly held beliefs about cues used in word recognition.
5. Discusses some of the errors which can be found in classical studies on word recognition.
6. Reviews studies which find that letter-name knowledge has no effect on learning to read.
7. Presents data from experiments on the effect of phonic versus look-say methods of teaching reading along with findings regarding the perceptual unit of recognition.

When a word is presented visually and the experimental subject says the appropriate word, we say the word has been recognized. The purpose of this paper will be to examine the strategies used by children in learning to read words, to review critically some of the classical research which has influenced current thinking about how children recognize words, and to present some of the critical issues regarding word recognition.

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Strategies Used by Children in Learning to Read Words

Before the student has learned enough about reading to recognize words independently, the earliest stages of the learning to read process may be conceptualized within the framework of a five stage model.

1. *Stimulus presentation.* A stimulus complex is presented. This consists of the printed stimulus as it appears in a book or on a screen.

2. *Cue selection-discrimination learning.* Some aspect of the total stimulus complex is selected as the cue to which the response will be attached. In order to determine which aspect of the stimulus complex can be used to distinguish this word (or letter) from others, discrimination learning is involved. For example, the stimulus *h-i-p-p-o-p-o-t-a-m-u-s* may be presented and the student must learn to say the appropriate word. If this word is the longest among the list to be learned, then word length may be the cue. Reading is a complex act and numerous cues may be utilized (*23*). The cue upon which the learner focuses his attention may be a letter, letter group, word shape, in fact, any characteristic which helps to set this word apart from others.

3. *Visual recognition memory.* Having selected a cue, the learner must be able to recognize it again. Travers (*27*) has suggested that visual recognition memory of the cue is part of short term memory. Recent work on paired-associate learning has demonstrated the importance of visual recognition memory in associative learning (*1, 13*). An investigation of the relationship between visual recognition memory and reading achievement disclosed the two were significantly correlated ($r = .35$). To rule out the possibility that the correlation between visual recognition memory and reading simply reflected the well-known relationship between intelligence and reading achievement, the correlation between visual recognition memory and intelligence was computed. The correlation was found to be extremely small (*20*). Thus, visual recognition memory is related to reading achievement independent of intelligence. The correlation between visual recognition memory and paired-associate learning for the above students was $r = .43$.

4. *Response availability*. The appropriate response must be available for hookup with the cue if learning is to take place. By increasing response availability through the control of context and the associative connections between words, learning to read new words can be facilitated (*16, 22, 24*). For example, if the child can already read the word *green* and the new word to be learned is *grass*, response availability for the new word should be higher in the context *green grass* than if the word *grass* is presented by itself. Reading speed and recall are also influenced by the associative connections between words (*17*). When third graders were given a high-association paragraph with sentences such as

> They were all happy to be together again. Outside the moon and stars shone brightly in the June sky, and the green grass sparkled in the night.

they read it significantly faster and with better recall than a group getting a low-association paragraph with sentences such as

> They were all relieved to be together again. Outside the moon and lake appeared clearly in the June evening and the green house sparkled in the valley.

Bormuth (*4*) and Ruddell (*15*) have found that linguistic variables can affect comprehension. It would be interesting to determine if some of the linguistic variables which affect comprehension also affect learning to read new words.

5. *Hookup or associative stage*. When the cue and the appropriate response are hooked up, we can say the learner is able to read or recognize the word, i.e., upon stimulus presentation he can say the correct word. According to Travers (*27*), the hooked up cue and response are part of long term memory.

The unskilled reader who is learning to recognize a word must select a cue, recall the cue, and have the appropriate response available for pairing with the cue. Various strategies have been described which beginning readers use to recognize a word. Some of these are listed below along with critical comments, many of which will be elaborated upon later in the paper.

1. *Recognition of words as sight words*. The words to be learned are presented to the student. His task is to learn to say the appropriate

word which is associated with the visually presented stimulus. This procedure is often referred to as the look-say method and is frequently used in early reading training. What is of concern with the use of this method are the strategies used in learning and their subsequent effect on later learning. The words *boy* and *cat* may have been presented. Although the student learns to recognize the words, he may do so because he used letter *b* as the cue for *boy* and letter *c* as the cue for *cat.* Later when shown the words *ball* and *car* the student may call these words *boy* and *cat* because he relies on single letter cues *b* and *c* as cues for recognition.

2. *Unusual characteristics of words.* The learner may use as his cue for recognition some unusual or striking characteristic of the word. He may use word length as the cue to identify words in a list. For example, the learner may note that the short word is *cat* and the long word is *elephant.* He may note the tail on the word *monkey,* or the spot of ink on a flash card. These may serve as cues to accurate recognition for a while. This strategy becomes ineffective when other long and short words are encountered.

3. *Word shape cues.* If lines are drawn about words printed in lower case, a characteristic outline or shape results. This outline can serve as a cue to recognition. If the same word were typed in uppercase, a less characteristic outline results and, consequently, is a less useful cue.

finger   finish   FINGER   FINISH

4. *Phonics.* Individual letters and letter clusters may be used as cues for sounds. These sounds may be combined sequentially to recognize the word. Critics of the phonic method of teaching word recognition claim that English is not a highly alphabetic language, that is, in English there is low correspondence between letters and sounds. This is true only at the level of individual letters. When individual letters as well as letter clusters and their positions in the word are taken into consideration, recent work in linguistics indicates that English has higher letter-sound correspondence than ever before realized.

5. *Context.* Word associations and information provided in the context of a sentence may provide the response necessary for recogniz-

ing the word. Red, white, and ——. Few English speaking people require the printed stimulus to recognize the missing word. While context provides an important cue for recognition and for learning to read a word, it is important to determine if the reader can recognize a word when it is presented in isolation. If the student does not visually attend to the stimulus when he says the word, he may not learn to read it.

When the beginning reader uses strategies such as recognizing words as sight words, using unusual characteristics of words and word shape as cues, he is learning strategies which not only are not useful for transfer but will have to be abandoned if he is to progress to the point where he can decode words on his own. Teachers who encourage their beginning students to use word shape and the whole word as cues have the mistaken belief that children ordinarily note a whole configuration. One reading textbook (*26*) states, "To start with a whole word is sound psychologically, for young children are not prone to be very analytical in their perceptions. Their natural tendency is to perceive total patterns."

If there is anything which discrimination studies indicate, it is that children select the easiest cue for recognition, and the easiest cue is frequently just a single letter of a word or some incidental detail. Children do not ordinarily attend to total patterns nor to all the letters in a word. It is only when single letter cues fail to distinguish one word from another that children attend to all the letters.

To determine which cues nonreaders and beginning readers use in word recognition, Marchbanks and Levin (*12*) had kindergarteners and first graders select the one word from a set of alternatives which was similar to a standard. The selection could be on the basis of word shape or letter cues. The results indicated that children preferred to use first letters, final letters, middle letters, and word shape (in that order of preference) as cues to word identification. This study is important because it demonstrates that the theories are untenable which propose that beginning readers recognize words as wholes primarily by shape. It also demonstrates the importance of letter cues in the word recognition of children.

Under which conditions will children use single letter cues or all the letters in the word as cues to recognition? To find the answer, Samuels and Jeffrey (*21*) gave kindergarteners a list of four words to learn to read. One group learned a list where the words were easy to visually discriminate from each other. This group was called the high discriminab, , · group and their words were spelled DA, BE, MI, SO. Another grou,,) was called the low discriminability group and their words were difficult to visually discriminate from each other. The words were spelled SE, SA, ME, MA. A comparison between the two groups on speed of learning to read the words indicated that the group getting the list with highly discriminable words excelled. Then a test was given to determine the letters used as cues for recognition. The test revealed that the high discriminability group, which had learned more quickly, had used single letter cues as the basis for recognition. The low discriminability group, although learning less rapidly, had used both letters as the cue for recognition. When children in both groups were shown a word spelled MO, a word they had not seen before, those from the high discriminability group were apt to say the word was MI or SO depending on whether they used a first or last letter as a cue in recognition. Those in the low discriminability group tended to say the word was one they had not seen before. Thus, initial training on a list of words with low discriminability, which forced attention on all the letters, encouraged the child to adopt a strategy which provided a better basis for transfer to learning new words.

In teaching reading to beginning readers, a decision must be made between speed of initial learning and transfer. The decision to foster speed of initial learning at the expense of transfer may be a false economy. Initial speed of learning can be facilitated by using the look-say method with words which are highly discriminable from each other. For example, when given the sentence, "Yesterday our class went to a fire station," the beginning reader would probably learn to read the sentence using first or last letter cues. Although this strategy would lead to rapid learning, it also results in poor transfer to learning how to read new words. In learning to read, the principle of least effort operates. This means that the strategy is to select from the stimulus complex that cue which most easily elicits the correct response. Cues may be word length, shape, or single letters. These cues are irrelevant in that they provide no basis for learning new words and what is learned will before long inhibit future learning.

Teachers who begin the teaching of reading by having the learner recognize a basic group of words as sight words have noted that at first the learning is rapid, but soon the rate of learning new words slows down drastically. The initial rate of learning is rapid because numerous simple strategies provide cues for word recognition. Only so many words can be recognized by length, shape, and single letters before the strategies prove ineffective. When this occurs, the rate of learning new words decreases, and the learner remains on a learning plateau until he learns a rational system for decoding words from symbols to sounds.

One strategy for facilitating word recognition is to use color cues with each word as in the words-in-color system. With this system certain sounds are represented by particular colors. When a word is printed, it is spelled according to standard English orthography, but certain letters are in a particular col. · which represents the pronunciation. While this system may increase rate of initial learning, the critical question is one of transfer. If the learner focuses his attention on color and not letter shape, what happens when the color cues are removed? To answer this question, Samuels (*19*) had first graders and college students learn to read words printed in color or words printed in regular type. Samuels found that rate of learning the words in color was significantly faster than the words in regular type. But on the transfer tests—when the color cues were removed—the subjects had great difficulty in recognizing the words formerly in color. Thus, on the transfer tests the tables were turned. In comparing recognition between the words which were always in regular type to the words which had formerly been in color, recognition was superior for the words which had always been in regular type. What makes these results so surprising is that the college students knew the color cues were to be removed. Apparently, the color cue was so potent they were unable to focus attention on the relevant cue of letter shape. Again this study illustrates the principle of least effort in learning and the dangers of a false economy in which there is rapid learning at the expense of transfer.

Presently, many teachers are of the opinion that letter name knowledge facilitates learning to read. There is mounting evidence, however, that learning to decode words is not aided by letter name knowledge. The basis for the belief regarding the facilitating effect of letter name knowledge on reading may originate from the fact that causation is often mistakenly imputed to correlational findings. Bond and Dykstra (*3*) found in the first grade studies that reading achievement was highly correlated with letter name knowledge; in fact, it was the single best predictor of first grade reading success. Some ten years earlier, Nicholson (*7*) reported that the correlation between ability to identify lowercase letters upon entrance to first grade and the rate of learning to read words was $r = .51$, which was higher than the correlation between IQ ($r = .36$) and the rate of learning these words. In the same report (*7*), Linehan stated that letter name and letter sound training seemed to facilitate first grade reading achievement. Since the group which got letter name and sound training received auditory discrimination training as well, it is impossible to determine from this study if the facilitating effect was produced by the name, sound, or auditory discrimination training. Durrell (*7*) concluded, however, that reading difficulties could be prevented if, among other things, training in letter names and sounds was given.

Several critical questions must be answered regarding the finding that training in letter names and sounds facilitates learning to read words: 1) Is it letter names, letter sounds, or their combination which facilitates reading acquisition? 2) Can the correlational findings between letter names and sounds and reading be an artifact or product of some other factor? Ohnmacht (*14*) used a classroom setting to study the effect of letter name and sound training on reading. One group was given early training in letter names. A second group was given training in names and sounds, and a third group served as a control. She found that the group getting training on names and sounds was superior to the other groups in word knowledge and word discrimination. The group getting training in letter names was no better than the control on these reading measures. It appears, then, that letter name training in an experimental study does not facilitate reading acquisition.

Samuels was interested in the same question. He did a laboratory study (*18*) to determine what component of letter name knowledge, if any, facilitates reading acquisition. One of the explanations offered by educators as to why they believe letter name knowledge facilitates learning to read is that many letter names are similar to the letter sounds. It is possible, however, that reading acquisition may be influenced by the ability to visually discriminate one letter from another and not by knowledge of the letter names. To answer these questions, three groups of children midway through first grade were used. The visual discrimination group was given a paired-associate task in which the subjects had to visually discriminate four artificial letters from each other. The letter name group was given a paired-associate task with the same four letters but subjects had to learn letter names for each of the letters (S, M, E, A). The control group got an irrelevant paired-associate task. Then, the same transfer task was given to all the groups. This task consisted of learning to say the appropriate English word for words constructed out of the artificial letters (SE — SEE, SA — SAY, ME — ME, MA — MAY). Surprisingly, no significant differences were found among any of the groups. Since this finding ran counter to the correlational findings, the study was replicated twice, with different laboratory assistants and different first grade subjects, but always with the same results, i.e., no difference among the groups.

Results from the Ohnmacht and Samuels studies suggest that letter name knowledge has no positive effect on reading acquisition and that the correlational findings between letter name knowledge and reading may be a product of some other factor. There is evidence (*25*) that paired-associate learning ability is significantly correlated with intelligence. Letter naming is a paired-associate task and may be taken as an index of intelligence. Since we already know that in the elementary school IQ is highly correlated with reading achievement, it is not surprising that letter name knowledge is also correlated with reading achievement. Another explanation is that the kind of home background which enables a child to enter first grade already knowing many of the letters of the alphabet would be the kind of home in which academic achievement would be emphasized. Again, it is well known that socioeconomic status and home environment are highly correlated with school achievement.

Although letter name knowledge does not seem to have any beneficial effect on reading, there is evidence that letter sound training does have a positive effect. The Linehan and Ohnmacht studies both suggested this, and a study by Jeffrey and Samuels (*11*), which will be discussed later, gives further evidence of this.

Classical Research Which Has Influenced Current Thinking

The research since the 1960's indicates that children tend to select a detail such as a letter as a cue for word recognition. This finding is at variance with the more commonly held belief that children use the whole word or word shape as the cue. How did this latter view originate?

Prior to 1900, Cattell, and Erdmann and Dodge published studies which led to the current belief that beginning readers use whole words and word shape as cues to word recognition. Over the years, partly to support the whole-word method of teaching reading, books on reading have continued to refer to these studies. Because of their importance, the errors which can be identified in these studies should be pointed out.

Erdmann and Dodge (*8*) were of the opinion that word length and shape were the primary cues used by skilled readers in word recognition. They came to this conclusion after finding that skilled readers could recognize words that were so far from the fixation point that individual letters could not be recognized, and words could be recognized even when letters were too small to be recognized individually.

It seems fallacious to assume that because skilled readers can recognize a word from its shape and length—under experimental conditions when other cues are missing—that shape and length are the primary cues adults rely on under normal conditions. Secondly, if Erdmann and Dodge are correct about adults using word shape and length as the primary cues, which is doubtful, it seems incorrect to assume, as many educators do, that these are the main cues children use in learning to read. Marchbanks and Levin (*12*) demonstrated that shape was the cue least used by children. Furthermore, it is apparent that a strategy of learning to read using word shape and length provides a poor basis for transfer to reading new words.

Cattell (*6*), in 1885, published a study which led to the present belief that beginning readers use the whole word in word recognition. The major finding in this study was that readers could recognize a short common word in slightly less time than it takes to recognize a single letter. There are several flaws in this study which should make the reader cautious about concluding that the results of this study apply to children learning how to read. In this study Cattell used a small number of highly educated adults. He had them read aloud as quickly as possible a passage from *Gulliver's Travels*, spell the letters contained in the words, and then read a passage consisting of 100 common nouns. The most serious error was that the time to pronounce the words is confused with the time it takes to recognize the words. Secondly, he used only skilled readers, and consequently, the findings are not valid for children.

In 1885, Cattell (*5*) also published a study in which he used a tachistoscope, thus eliminating the problem in the other study where the time to pronounce the word was confounded with the time to recognize the word. He found that in a fixed exposure time, two unconnected letters or two unconnected words could be recognized. Again he used adults, but he did mention one nine-year-old boy in the study who was described as being superior in reading ability to some of the adults.

The Cattell studies demonstrate that skilled readers do not engage in letter-by-letter processing. If they did, then the time for recognizing a word would be the sum of the time necessary for recognizing each of the letters. Many people have interpreted Cattell's results to mean that a skilled reader uses the entire word as the unit for recognition. This interpretation is not valid because Cattell's experiments were not designed to answer the question of what cues are actually used by skilled readers in word recognition. It is possible that Cattell's readers recognized just some of the letters in the word and were able to correctly identify the word from a partial percept. To infer from these studies that naive readers use the entire word as a cue in learning to read is an error, partly because naive readers were not used in these studies.

Second, it is now known that naive readers tend to select a detail rather than the entire word. Third, while it is known that the adult can perceive several letters together as a unit in word recognition, no one knows at the present time when beginning readers perceive these higher order units.

A higher order unit is a spelling pattern having invariant spelling-to-sound correspondence. For example, a higher order unit might be *gh* in words like *rough* or *tough*. Adults can recognize higher order units which conform to English spelling rules even when they are presented in nonsense words (*9*). The critical question is: How do beginning readers learn the higher order units?

In order to study how beginning readers learn higher order units, Gibson et al (*10*) gave kindergarteners and first graders a task in which it was possible for them to learn patterns of spelling. The child was given a set of eight cards. Four of the cards had words with a higher order unit such as LACK, MUCK, DECK, and SOCK. The other four cards had words such as LAKE, MUCH, DEEK, and SOAK with no higher order unit. The cards were presented in pairs (e.g., LACK and LAKE), and the child simply had to point to one of the cards. If he pointed to the card with a higher order unit, that is, a word having CK, he was told that he was correct. In order to be able to consistently point to the correct card, the child had to learn a strategy for discriminating the higher order units. Although the task was difficult, Gibson found that for some of the children performance improved, indicating that they were learning how to discriminate and abstract the common spelling pattern.

The final topic which will be discussed relates to the findings of a laboratory study testing the effect of phonic versus look-say reading training on transfer to reading new words. In this study (*11*) kindergarten children were given phonic blend training and then were randomly assigned to a look-say, phonic, or control group. Look-say training consisted of learning to read a list of words. The letters of these words were used in new combinations to form the words used in the transfer list. Phonic training consisted of learning letter sounds. These letters were used in the transfer list of words. The control group got an irrelevant task to perform. Following training, all the subjects were given the same list of transfer words. First the subjects were shown the words and were asked to read them without any help. Then they were given instruction and the number of trials required for learning the entire list was computed. The results indicated that the phonic trained group was significantly better than the other two groups in number of words read without any help and speed of learning the entire list. There was no significant difference between the look-say and control groups on either of these measures, indicating that look-say training did not provide a basis for positive transfer to reading new words. A similar study (*2*) was

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Reactions to Modes of Word Recognition

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PROFESSOR SAMUELS has reported on a topic that is of fundamental importance. Whatever one's ultimate definition or criterion of "reading" may be, word recognition must clearly be included as one of the primary and major component skills. The strategies that a reader actually utilizes in word recognition are far from explicitly delineated at the moment. Since the question is central to any genuine understanding of reading, however, our current hypotheses and rather tentatively held conclusions ought to be given further serious examination.

Samuels has provided us with an extensive list of the various cues and strategies that may be used in word recognition—word length, initial letter, overall shape, context—and he has done an admirable job of explaining how each one of these might be employed as the effective cue by a beginning reader. His warning that "children select the easiest cue for recognition" and that the easiest cue is sometimes an "incidental detail" is very well taken. Moreover, one should not expect that other, more relevant cues will also be picked up by the child. One of Samuels' own experiments illustrates this point. Subjects learned to read words printed in color more easily than words printed in regular type; however, when color cues were removed, they could not recognize the words that had previously appeared in color. In this case, the color cue was so salient that it overrode the relevant cue. Taber and Glaser (*9*) did a similar study in a programed instruction context, in which children learned a paired-associates list of printed color names. The actual color was the supporting cue and was faded out gradually over the series of learning trials. Again, in this experiment, there was little evidence that the children had in fact responded during training on the basis of anything besides the color cue.

One of Samuels' major points was that in developing training strategies, one must often choose between a criterion of speed of initial learning and a criterion in terms of the ability to transfer to new, untrained material. Surely we would not be satisfied if our instructional gains were focused solely on the materials actually encountered in training. Samuels' data, indicating that initial training on a word list of low discriminability leads to the development of a better transfer strategy, are most convincing. It appears to me that the development of an effective teaching strategy must be one that is based on good answers to two questions: 1) what cues must the child attend to, in order to solve the criterion task—which we assume will be a transfer task; and 2) how can we ensure that he will attend to those cues?

I also appreciate having Samuels' description and evaluation of the early work done by Cattell and by Erdmann and Dodge. It is well to be reminded what these old data, from which so many conclusions and implications have been drawn, actually consist of. It is important to note, as Samuels points out, that a demonstration of what a skilled reader does is not necessarily what a beginner will do. But an even more important point, I believe, is that what a subject—naive or sophisticated about reading—*can* do, under certain specified, artificial, arbitrary laboratory conditions, is not at all the same as what that subject *does* do in an ordinary reading situation. To confound these two questions is very misleading, and it is sad to see how often there has been this confusion. Not that this confounding is limited to research in reading, of course: the literature in child development is full of similar instances in which estimates of normative or average performance are confused with data on maximal performance.

I should like to turn now to a discussion of additional data that are relevant to our discussion of word recognition. Before a child can recognize a word, he must have learned to some degree how to differentiate the written symbols, or graphemes, that he finds on the printed page. Gibson (*5*) has suggested that improvement of visual discrimination depends on learning the distinctive features of the forms to be discriminated, i.e., those dimensions of difference that distinguish the stimuli. Precise specification of the critical features of letters of the alphabet, of course, will be a difficult task.

It is obvious in any case that the graphemic characteristics of the word provide an important category of cues in word recognition (*12*). One of my students, Margaret Ackerman, and I (*1*) did an experiment concerned not with the nature of the critical features themselves, but rather with the effectiveness of different training methods in ensuring that attention is focused on the features, whatever they may be.

In this experiment we compared simultaneous and successive discrimination tasks involving highly similar letters (*b* and *d*) and dissimilar letters (*s* and *b*). First grade urban children were used as subjects. In simultaneous training, the two letters were presented at the same time, and on every trial, the subject was reinforced for responding to the same one of these stimuli, regardless of its spatial position. In the successive discrimination problem, on the other hand, only one letter was presented on each trial. The subject learned to press the left of two response buttons when *b* was presented, and the right button when *s* was presented. The response measure was the number of trials required to reach a criterion of nine consecutive correct responses. We found that with highly similar stimuli (*b* and *d*), the successive problem was *less* difficult than the simultaneous problem; while with dissimilar stimuli (*s* and *b*) the successive problem was *more* difficult. Because these findings were unexpected, we replicated the study—and got the same results. Our notion is that for the *s-b* comparison, distinctive cues are easily identified (such as size), and so, in simultaneous training, the subject has from the start some basis for comparison and diff· rentiation. However, *b* and *d* are notoriously confusing to a first grader, and the cues that are to be used in the solution of this discrimination problem must be developed during the training. It is possible that simultaneous training in this case presents the subject with so much information at one time that the identification of some critical feature which can be used in comparison will be hindered.

In a follow-up study, we found that the same results held on a paired-associates task in which trigrams were paired with color names. This task, we felt, simulated the decoding part of the reading task, in which the child must learn to associate phonemes with their graphic representations. An approximation of the simultaneous discrimination problem was attained by the use of the trigrams *bad* and *dab*, which would be paired, for example, with *red* and *blue*. In the successive training condition, *bab* and *dad* were the critical trigrams. Again, successive training proved superior. We are speculat'ing on the implications that might be drawn for the development of workbooks and other practice materials.

Now let us turn from comparisons of training methods to more descriptive data. Samuels mentioned a study of Marchbanks and Levin (*8*) which assessed the relative importance of several graphemic cues in children's matching responses. These investigators asked middle-class children in kindergarten and first grade to select, from a group of three letter and five letter "pseudowords," the one similar to that which had just been exposed to them and withdrawn from sight. They found that the specific letters are much more important in determining recognition than is the overall shape of the word. The beginning letter was the most salient cue, followed by the final letter.

Ellen Blumberg, David Williams, and I (*3*) did the same type of study with disadvantaged urban children to see what true nonreaders would do. Our kindergarten sample had had no formal reading training and had little or no knowledge of the alphabet. We found that these children showed *no* preference for any of the cues; they matched on a random basis. Our first grade sample, which had had some reading training, behaved exactly as did Marchbanks and Levin's middle-class children. That is, individual letters, especially the initial letter, provided the important cues.

What implications are there here for instruction? In view of these and other findings, there really seems to be no justification for developing instructional methods or primer materials based on the use of overall shape as the primary cue. Shape seems a poor choice after reading training is begun, for when children know the alphabet, individual letters become quite salient. Moreover, if one's instructional strategy were to attempt to capitalize on tendencies seen before any instruction is given, shape would be a poor choice, for there was no tendency at all on the part of our nonreaders to utilize this cue.

We also tested some adults on this task. The data were quite different from those of the children; the adults' choices were much more complex. Surprisingly, although the task as presented seemed wholly visual, half of the subjects reported some use of an "aural" strategy—rhyme, for the most part. The other half reported that they used a purely visual strategy, and again surprisingly, half of these described their strategy as one in which they tried to match on the basis of overall shape. This had been the *least* salient cue for the children.

These results remind us once more that it should not be assumed that adults and children behave in the same manner on this type of visual matching task. Indeed, it is most interesting to note the fact that the most widely used reading method over the past thirty years (the look-say or whole word) has stressed identification of words on the basis of overall shape and configuration. But it is adults and not children who sometimes show this strategy in word recognition.

The second general basis for word recognition lies in the relationship between the graphic characteristics and the nature of the spoken language. Early work focused on the correspondences between individual letters and the sounds they represented. However, English spelling is quite irregular when individual letters and sounds are considered. This fact suggested that thinking of correspondences in terms of single letters was not useful, which led in turn to a search for a more appropriate unit. It appears that clusters of letters do have more stable relationships with sound patterns, and it has been suggested that these "spelling patterns" are critical units for perception (*5*). That is, while the letter *c* alone is not sufficient to signal a consistent pronunciation, initial *ca* or *ce* does correlate well with specific phonemic patterns.

Eleanor Gibson's hypothesis (*5*) that spelling-to-sound invariance accounts for the fact that "pronounceable" pseudowords such as *glurck* are more easily recognized in a tachistoscopic exposure than are unpronounceable pseudowords such as *crurgl* has not held up, largely on the basis of her own research showing that deaf children behave in the same way as normals (*6*). This leaves us with the question of what it actually is that makes certain "spelling patterns" or letter clusters more easily recognized than others. Perhaps it will turn out after all not to depend heavily on the spoken language.

Here may be an appropriate point to bring up another experiment that dealt with methods of training. Sometimes assumptions have been made and accepted wholeheartedly with little or no objective data to support them. Such is the character of the recommendation, made by Bloomfield (2) and echoed by almost all other proponents of linguistics reading methods, that only simple, single grapheme-phoneme correspondences be presented to the beginning reader. Evidently this untested assumption seemed commonsensical enough to go unquestioned until Levin and Watson (7) proposed an equally commonsensical point of view. They argued that a child must learn that there are variations in correspondences in English, and that if he is presented with multiple correspondences early in instruction, he will be more likely to develop a useful problem-solving approach to the reading task (that is, a "set for diversity").

These contradictory points of view were tested in an experiment in which fifth and sixth graders learned multiple correspondences in a modified paired-associates paradigm (*10*). The two methods used were: *successive,* where only one of two phonemes which mapped to a particular grapheme was presented for the first half of the training trials, and the other phoneme for the last half of training, and *concurrent,* where both phonemes associated with each grapheme were presented on each of the six trials. When they were asked how many sounds went with each form, subjects were much more accurate at identifying as multiple correspondences the ones that had been trained concurrently. Presumably, then, in attempting to read new words, children would more readily identify such graphemes as multiple and so try out more than one phoneme for them, thereby making it more likely that they would succeed in reading the word.

Additional support of the "set for diversity" hypothesis came from analysis of the errors on another test, in which the subject was to identify all the phonemes that were associated with each grapheme. Here, there were fewer omissions on concurrent items than on consecutive ones. These effects were large, and they remained over two variations in the procedure (which equated first the number of presentations of each type of correspondence and secondly the strength at the end of training of the two successive correspondences).

A second important question, of course, is how much of the material presented in training was actually learned. In terms of this simple performance criterion, there were again differences in favor of concurrent training, but here the effect was small and unstable. Further work indicated that first-graders, tested early in their first semester of reading instruction on a similar task (in which the stimuli were homographs), showed a similar pattern.

Admittedly, much more research is needed in order to apply such findings as these to actual instruction. For one thing, few programs teach letter-sound correspondences in isolation. Further work is in progress, focusing on spelling patterns presented in the context of words. At present, however, in the absence of sufficient data on which to base a final decision, it would seem reasonable to provide at least some variation—some kind of concurrent training—when presenting multiple grapheme-phoneme correspondences. Certainly the data indicate that critical questioning of some of the time-honored assumptions and recommendations is desirable.

There is a third general category of cues that is used in word recognition: the context in which the word appears. That is, a reader makes use of the information contained in the rest of the sentence in his efforts to recognize the word. For example, in the sentence "He walked toward the . . . ," there are certain limitations, of both a grammatical and a semantic nature, on the words that can complete the sentence in an acceptable fashion. Investigators have found that it is indeed easier to recognize a word when it is presented in context than when it is presented alone. For example, Samuels has demonstrated that recognition speed for the response item in a word pair can be facilitated or interfered with by an appropriate selection of stimulus items.

More emphasis is being placed on context, or, to state it another way, the search for cues when units larger than a single word are considered. Only a few years ago, psychologists were comfortable with a very simple and narrow definition of reading, one that concentrated on what was *distinctive* about reading. Such definitions put major emphasis on the decoding process, of course.

Today the focus has shifted. Decoding is necessary but not sufficient, and other aspects of "reading"—notably, of course, comprehension—have been attracting attention (*11*). The emergence of such interest undoubtedly reflects the very strong influence of cognitive psychology. Reading now tends to be tied to information-processing and other related concepts. Definitions also seem to be growing more general and less focused on what is unique to reading. One can reasonably describe skilled reading, I believe, as a process in which the reader samples the cues on the printed page. Using these partial cues together with previous knowledge both about printed pages and about the world, the reader forms hypotheses (or expectations), which are confirmed or disconfirmed by subsequent samplings.

It is clear that whatever the definition of reading, the processes involved for the proficient reader and for the beginner do not completely overlap. Language has a hierarchical structure, and whether we are considering the processing of speech or of text, the identification of the "processing units" is of prime concern. It seems obvious that there are different types of units and different levels of units which depend in part on the characteristics of the reader—his proficiency, his purpose, and so forth. (They also depend on the nature of the material to be processed.) The specification of these units, intraword and beyond, how they are structured and how they are identified and recognized, will continue to be a central focus of the research in this area.

As would be expected, research interest has been shifting to the adult, skilled reader. Certainly, many of the issues arising from cognitive theory are more pertinent to the reader who has some proficiency, that is, an individual who is past the point at which decoding skills have become fully established and automatized. Moreover, a good bit of work on the visual recognition processes has already been accomplished, and it is to be expected that there would be a major push to do the same kind of initial "mapping out" with respect to the other aspects of reading.

I am concerned about this shift in interest, in that findings may not relate very closely to the behavior of the beginning reader, let alone to any ultimate concern with instruction in beginning reading. Other recent interests in the psychology of reading also seem to be leading away from questions of literacy training. The notion, for example, that speaking and writing are both derived directly from underlying linguistic structures, as opposed to the more common view that speech is primary and that writing is simply (or complicatedly) a representation of speech, is most provocative (*4*). Such questions are tremendously fascinating and obviously deserve study. But, again, what about the five year old? How will he gain from this kind of research?

We cannot afford to lose interest in fundamental investigations of the behavior of the beginning reader, investigations that focus on the basic processes of word recognition that are clearly so crucial to the five year old. More work of the type that is so well represented by Samuels' experiments is sorely needed.

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Models of Perceptual Processes in Reading

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FEW AREAS OF KNOWLEDGE offer more promise of providing new insights into reading instruction and remediation than the considerable advances made in the psychology of perception during recent years. The decade between Broadbent's *Perception and Communication* (*20*) and Neisser's *Cognitive Psychology* (*116*) saw growing numbers of researchers publishing in newly founded journals and coalescing into a new branch of psychology. Cognitive psychology takes as its central function the study of the processes by which ". . . the sensory input is transformed, reduced, elaborated, stored, recovered, and used" (*116*:4). Since this function on the visual-verbal dimension could serve as a definition of reading, it is clear that this branch of experimental psychology bears close watching by anyone interested in understanding reading phenomena.

As early as 1964, Holmes and Singer used the trend toward more basic research in reading as the central theme of their review article for the *Review of Educational Research* (*89*) and in it specifically pointed to the importance of the lines of research which were later to make up the area of cognitive psychology. In 1966, the present writer analytically reviewed this research literature and from it suggested a model of perception in reading (*62, 63*). The model and experimental evidence supporting it was reported the following year to the International Reading Association (*64*).

This paper will extract from the growing literature in cognitive psychology several studies which can offer insights into the reading process. Classical reading theory will be briefly presented in its historical context and the assumptions underlying this theory will be stated. Those assumptions will then be examined in light of recent research and alternate models suggested. While a rich array of details are currently being actively debated, there are large areas of agreement with which to support a generalized model as a replacement for classical theory.

Classical Theory

Historical background

The span of attention. Central to the classical theory of perception in reading is the hypothetical construct of the span of perception, a concept which stems directly from the span of attention experiments of early psychology. The second oldest experiment in experimental psychology, the span of attention was a lecture topic in the classes of Sir William Hamilton (*73*:176-177) prior to 1859:

> If you throw a handful of marbles on the floor, you will find it difficult to view at once more than six, seven at most, without confusion; but if you group them in twos, or threes, or fives, you can comprehend as many groups as you can units, because the mind considers these groups only as units, it views them as wholes, and throws their parts out of consideration.

Sir William's marble-throwing demonstration was developed by Wundt, Cattell, and others into precise experimental procedures which became central to the theoretical disputes of the turn-of-the-century. In Germany, Wundt and his pupils Dietze, Cattell, Hall, and Jastrow worked to establish the limits of the *Umfang*, a problem which the latter three were to bring across the Atlantic with them. Exner experimented on the "primary memory" and Richet on the "elemental memory." In England such giants as Galton, Sully, and Bain were concerned with the problem. Their techniques and theories were reflected in France by the work of Binet, Henri, and Simon who were the most successful of all at applying the new techniques to the new field of mental testing. To this latter group of scientists, the measurement of the span of attention was a method by which they could investigate and demonstrate individual differences.

In the United States, the leader of the Wundtian school of Structuralists was Titchener, assisted by a host of students which included Erdmann, Dodge, Huey, Hylan, and others. Their approach to psychology was to determine the elemental units of the mind, chiefly through introspection, and to build these units into larger and larger blocks in a direct analogy to chemistry. Since the span of attention appeared to remain constant under a variety of conditions, they considered it to be the elemental unit of attention. Humpstone (*91*), for example, defines the span as "the ability to grasp a number of discrete units in a single moment of attention and to reproduce them immediately."

Galton's influence in the United States was represented chiefly by J. McKeen Cattell and the Functionalists. Concerned primarily with individual differences and mental testing, the work of this theoretical viewpoint was quickly and naturally applied to the problems of education. When Javal (*93*) established the fact that the eyes in reading do not sweep, but move in a series of saccadic jerks, the relationships between the rapid succession of discrete visual images provided by the fixations and the brief tachistoscopic image utilized in the span of attention experiments were recognized. The tachistoscope became the standard experimental instrument in the search for the primary cue in word recognition.

The "total word picture" concept. One of the earliest and most seminal experiments in the field of reading was conducted by Cattell (*31*). The findings and implications of Cattell's experiment and its influence on our thinking today can be shown by a brief quotation from the definitive work of Woodworth and Schlosberg (*149*:101).

> The use of the tachistoscope in experiments on reading goes back to the pioneer work of Cattell (1885), who found that with a very brief exposure under adequate illumination:
>
> 3-4 unconnected letters could be read.
> 2 unconnected short words could be read.
> 4 connected short words could be read.
>
> Since even the two short words, not to speak of the four-word sentence, exceeded the letter span—and since, as Cattell found in his reaction time experiments . . . a familiar short word could be read as quickly as a single letter—it was clear that the words were not read by spelling them out. What could be the reader's basis for recognizing a word? Cattell reasoned that it must be the "total word picture." His results were confirmed by Erdmann and Dodge (1898), who found the span for unconnected letters to be 4-5, while familiar words, even as long as 12-20 letters, were correctly read from a single exposure of 100 ms. They inferred that the "general shape of the word" must be the primary cue for word recognition, with a few clear letters close

> to the fixation point as supplementary cues. By "general word shape" they probably meant the external configuration of the printed word, while Cattell's "total word picture" covers also the internal pattern of curves and vertical strokes . . . .

These conclusions of Cattell and of Erdmann and Dodge, although much disagreed with, remain the basis of much of the rationale behind our views of perception in reading today. The "span of attention" has become the "span of perception" when applied to reading, but the basic concept and the assumptions underlying it remain the same, *viz.*, that it is a single, unitary act of perception, that all elements of the stimulus field are perceived instantaneously and simultaneously, and that those in the center of the field are perceived clearly while the elements become less clear as they occur farther out in the periphery. As the elemental unit of perception in reading is the word or even the phrase, the letters are important only in determining the word shape. Hence, the whole word method of teaching reading (*5*:212):

> The psychological rationale of the whole word method has been demonstrated numerous times by laboratory studies of the psychology of reading. Cattell's study . . . reported in 1885, is a landmark . . . . If the limit for unrelated letters was only three or four, the words obviously were not perceived in terms of letters. The experiment definitely proved that we do not read by letters but by whole-word units.

Early disagreement with the "total word picture" concept. As well accepted as the "total word picture" concept is, most authors find it necessary to qualify it to some extent due to persistent experimental findings which appear to contradict it. The studies which require such reservations are discussed in several textbooks covering perception in reading and will only be overviewed here. The objections to Cattell's concept of the "total word picture" as the basic elemental cue began early. Zeitler (*150*) found, through a study of errors made during tachistoscopic presentations, that the capital letters at the beginnings of the words were invariably reported accurately and that the rest of the word reported bore certain relationships to the letters within the stimulus word. He, therefore, discounted the influence of word shape and suggested instead that the subject was constructing a word from the letters he obtained during the brief flash. Zeitler concluded

> The apparent simultaneous apprehension of a word as a whole is an illusion of assimilation, that *the real apperceptive process consists of successive apprehensions of the word, part by part, by a movement of attention from left to right, in which part of the letters of a word are passed over rapidly while the attention fastens upon the dominating letters* [translation by Bonny (*16*:28); italics added by present writer].

Goldscheider and Muller (*68*) had likewise held that the letters were important and that the "determining letters" were the initial letter, "ascenders," "descenders," and vowels. While certain words might be read from word shape, they concluded from their experiments that such reading was not the rule. Crosland and Johnson (*42*) attempted to rank the letters in terms of relative legibility and found their results in general agreement with Goldscheider and Muller. The determining letters were thought to arouse an auditory image of the word, and the word was then completed by means of associations. Huey (*90*), in the first comprehensive treatment of the psychology of reading, presented essentially the same view and further suggested that the speed of association was determined by "expectancy."

Pillsbury (*121*:349-350) projected words with omitted letters, incorrect letters, or an *x* overprinted on one or more letters. His five subjects were all mature readers and trained introspectionists as well; in fact, one was Titchener. His results indicated that

> . . . there is a striking decrease in the percentage of recognition [of disfigurements] as we proceed from the first letter to the last throughout the word . . . . This seems to indicate a general tendency of the subject to *read through the word from left to right* (emphasis in original), and thus to give the first letters in the word a more prominent part in the recognition of the word as a whole.
>
> Further evidence of the same tendency is offered by the fact that in the words with more than one letter changed, whenever

> [only] one disfigurement was noticed . . . it was the first alteration that was noticed in the greater number of cases.

By presenting words to peripheral vision, Korte (*98*) found that isolated letters could be read farther in the tail of the eye than could words. He also found that the longer the word, the closer it must be brought to a central point in order to be identified. Since general outlines are discriminable in peripheral vision where the individual letters making up the word are not, he concluded that identification of a word proceeds from identification of its letters and that the "total optical form" was relatively unimportant.

That shape alone can provide useful cues was demonstrated by Erdmann and Dodge (*52*), who found that words can be identified at distances beyond the maximums for the determination of individual letters. This, as Woodworth (*148*:741) pointed out, does nothing to demonstrate that the same phenomenon occurs at the normal reading distance. Grossart (*70*), Kutzner (*101*), and Wiegand (*146*), utilizing the distance experiment, showed that as the words were brought closer, more and more letters became identifiable and that guesses might be made at any stage. The closer the word, the more letters were identifiable, and these, together with some general characteristics such as length, provided better and better guesses.

The early experimental findings tending to contradict the "whole word" view could be extended considerably. That the conclusions arrived at during the last century by Cattell and by Erdmann and Dodge should have survived so many years in the face of a large amount of contradictory evidence seems due to two primary factors. In the first place, these experiments went to the heart of the extremely bitter theoretical warfare being waged between the Structuralists and the Functionalists. When the introspective base of Structuralist methodology was discredited by the rising tide of Behaviorism, the Functionalists were left with the field. Secondly, at the very time that the Functionalists needed explanations to discount the experimental findings of the Structuralists, these explanations seemed to be offered by the Gestalt psychologists who enjoyed an immense wave of popularity in the decades following World War I. (For a thorough, if somewhat overly critical review of the influence of Gestalt psychology on reading theory, see Diack, *46*.)

Classical reading theory and its underlying assumptions

The concept of reading by word shape combined with an extensive eye-movement literature provided this classic view of perception in reading. The eye moves in a series of saccadic movements. Little or no vision takes place during the movement, but at each fixational pause the visual field is flashed to the brain. Words and phrases within these visual fields are identified primarily by their general shape, and growth in reading is a function of how many words the reader can "take in" during each fixation. That is, the "span of perception" is thought of and measured as a spatial variable, all parts being "taken in" and processed simultaneously. The span becomes larger with training and practice because the reader learns to "take in" and process progressively larger elements—from parts of letters, to letters, to syllables, to words, and eventually to phrases. It has been argued that it should be possible to perceive a page at at a glance.

It is thought that approximately 100 msec. are consumed at the beginning of each fixation in clearing and refocusing time. Other temporal portions of the fixational pause length are devoted to perceiving and responding to the stimulus. The reading process is conceived of as a series of tachistoscopic presentations flashed to the brain by the saccadic movements of the eye—a series in which both the stimulus and the response are immediate and based on the whole word or phrase.

Regressions are generally ascribed to "faulty oculomotor movements," particularly the regression commonly found at the beginning of the line, or to difficulty in trying to understand what has been read. For one reason or another, the reader moves his eyes so that his "span of perception" does not overlap his previous span, and he must move his eyes again so as to include the missing words. At one time there was a considerable dispute over whether "faulty eye-movement patterns" were the cause or result of poor reading. Most authorities agreed that ". . . the number and duration of fixations, and hence the speed of reading, are limited by central, rather than peripheral factors . . ." (*149*:506). Yet the central factors were vague and peripheral measures lead to inadvertent peripheral interpretations. Woodworth and Schlosberg should have written ". . . the speed of reading, and hence the number and duration of fixations . . . ." The difference is not trivial.

This classic view of perception in reading with its emphasis on the span of perception was an outgrowth of span of attention concepts and makes the same basic assumptions. Chief among these assumptions are:

1. *That perception is a unitary phenomenon, or, at least, that sensory and perceptual processes are isometric.* Thus Tinker (*137*:478) concluded that ". . . perception begins in the initial part and is completed in the final part of a . . . fixation. These two parts of a . . . fixation appear to be phases of a unitary whole." As Hebb (*85*:26) has recently pointed out, this assumption was based on the neurology of the turn of the century and had a purely theoretical origin. It was stoutly maintained because to do otherwise would have lent respectability to the method of introspection which had suggested that a number of things may happen between the objectively-measured stimulus and the objectively-measured response.

2. *That within the "single perceptive act" isolated by the span of attention experiment, all elements of the visual field are perceived instantaneously and simultaneously.* This assumption is a necessary correlate of the first, for if it were not true, the span of attention would not be unitary, nor necessarily isometric.

It will be argued in the remainder of the paper that neither of these assumptions is correct and that whatever vestiges of classical theory remain should be honorably retired. That the first assumption is false is attested to by a large body of evidence and overwhelming agreement. With the first assumption false, the second becomes the very complex focus of much current research. In the current vocabulary of the field, this research is concerned with determining what portions of the perceptual act employ sequential processes and what processes are accomplished in parallel.

The Assumption of the Unitary Nature of Perception

The fading memory trace

The memory afterimage. One of the most persistent introspective reports made by subjects in tachistoscopic experiments is that they saw all the elements but forgot some before they could be reported. This report is so universal and so tenaciously believed by the subjects, that even its introspective origin was not sufficient to discard it altogether.[1] That such reports contradicted the assumptions underlying the span of perception and "total word picture" views of reading was recognized, but the implications were largely ignored. Thus while Woodworth and Schlosberg *(149)* tell us on page 104 that "as children advance in reading ability they become familiar with many word pictures, and their span for words increases much faster than their span for unconnected letters," they also tell us on page 102 that

> . . . the visual impression received during a brief exposure must be much more complete and detailed than is implied by the phrase 'general word shape' . . . . Even when a subject can report only a few of the letters shown, he firmly believes he has seen all of them during the actual exposure. He forgets some before he can report them all because mere memory cannot retain so many disconnected items.

Woodworth and Schlosberg's more detailed view of perception in reading seems to imply immediate and simultaneous sensing of all the parts of the visual field, but successive identification of its component parts, limited in a brief exposure by immediate memory. On page 507 they describe the reading act as a ". . . continuous process in that the perceptual development of meaning goes on steadily. Perhaps one can think of it as a continuous production process, a machine into which the raw material is tossed by the shovelful."

One of the experiments which forced this more detailed view was that done by Glanville and Dallenbach *(66)*. In a definitive study of the span of attention, these investigators exposed two rows of letters across the visual field for an exposure length of 78 msec. Light pre- and post-stimulus fields were used, a factor the importance of which will be discussed below. Their results showed that the letters

[1] Sperling *(131)* gave the following as "representative examples" of experimenters who reported this introspection: Bridgin *(17)*, Cattell *(30)*, Chapman *(33)*, Dallenbach *(44)*, Erdmann and Dodge *(52)*, Glanville and Dallenbach *(66)*, Kulpe *(100)*, Schumann *(129)*, *Wagner* *(141)*, Whipple *(143)*, Wilcocks *(147)*, and Woodworth *(148)*. The list could be extended considerably.

to the left of center in the upper row were most correctly reported. Introspective reports given by their highly trained observers indicated that most of the letters were reported from a "memory afterimage." Glanville and Dallenbach (*66*:225) concluded that:

> . . . the usual order of report followed by the *O*'s was to name the letters from left to right, and those in the top row before those in the bottom. This plan places those in the upper row at an advantage over those in the lower. This theoretical advantage is borne out by the objective results.

They also reported that the subjects could change the order of report at will.

Very similar results were found by Crosland (*40*) when he exposed random letters in series ranging from 1 to 9 for exposures of 100 msec. A falling shutter tachistoscope of a type which gave approximately equal lighting of the fields was used. His results showed that most letters reported were from the left field, and that the curve of correct reports by letter position declined rapidly from left to right. The sharpest decline came between the fourth and fifth positions. Since it was clear that these findings did not agree with the doctrine of the day which held that perception of all elements was simultaneous and that vision was clearer in the *center* and less clear on the periphery, Crosland explained these results as indicating a "left-to-right mindedness."

When Crosland (*41*) extended his experiment to groups of good and poor readers of elementary school age, he found the left-to-right effect more pronounced in the good readers than in the poor but apparent in both groups when the letters were flashed to the center of fixation. When the word was presented to the left of fixation, however, the poor readers reported more of the letters at the ninth position. Anderson and Dearborn (*5*:231) find this to be evidence that "good readers are attracted by the beginning of words. Poor readers not so much so."

The experimental findings were further extended in an unpublished experiment by Crosland and, presumably, Anderson (reported in Anderson and Dearborn, *5*:227-228), by repeating the procedure with bilingual Jewish children. In reading English, these children showed the same results as had been obtained before, but in reading Hebrew, the results were reversed showing a "right-to-left mindedness" in reading Hebrew.

That these results were contradictory to the current assumptions and beliefs concerning perception was recognized by Crosland, and attempts were made to explain them in terms of laterality. When results in further experimentation showed no laterality effects, Crosland suggested they were due to a "left-to-right progression of attention" (*4*). The importance of these implications was not followed up, however, and as is often the case, it was only when the issue became central to a theoretical dispute that its importance was recognized.

The retinal locus controversy. In his very influential work, *The Organization of Behavior,* Hebb (*84*) chose the operation of vision in tachistoscopic presentations as a central issue in the theoretical dispute of functional organization *versus* equipotentiality. Lashley (*102*) had argued that the phenomenon of serial order could not be accounted for neurologically in terms of associative chains, nor in terms of the sensory control of movements. He felt there must be some process whereby traces and motor neurons can be scanned in sequence. Hebb, noting that speed of reading ". . . depending on the instantaneous recognition of larger and larger blocks of letters . . . increases up to the age of 12 to 16 years, or perhaps even later . . .," argued for a *structural differentiation of the retina* due to training in reading. He cited the results of an experiment by Mishgin and Forgays (*111*) which, in Hebb's words, ". . . show directly that reading does not train all parts of the retina in the same way, even when acuity does not enter the picture."

In the experiment cited by Hebb, Mishgin and Forgays had presented eight-letter English and Hebrew words to bilingual subjects for an exposure length of 150 msec. The subjects were directed to focus on the usual prestimulus target, and the words were presented to the left or right of this focal point. The English words were found to be more easily recognized when presented to the right visual field, the Hebrew words when presented to the left. These findings were interpreted by the investigators, as by Hebb, as showing differential training for the different areas of the retina with resulting structural differentiation.

The results of Mishgin and Forgays' experiment had been much more clear-cut for the English words than for the Hebrew, so Orbach (*118*) replicated the experiment and extended it by analyzing the results for his Hebrew-speaking subjects in terms of which language had been learned first. These findings indicated that bilingual Hebrew-English reading subjects perceived Hebrew presented to the left field best if Hebrew had been the first language learned.

Forgays (*60*) tested whether or not the differential results from the left and right loci were due to training and/or maturation by testing 12 subjects in each school grade from grade two through grade fifteen. He exposed three- and four-letter words to the left or right of fixation for 150 msec. His results showed that the total number of words recognized increased significantly with the increase in age and/or educational experience up to grade fifteen. While at the lowest grades little differentiation of the right and left visual fields was apparent, the amount recognized to the left of fixation increased only to grade five. After grade seven, the right field superiority was clear. These results were, of course, interpreted to support Hebb's position of differential training of the receptors of the retina.

That Forgays' results were due to educational experience and not maturation was shown by Kimura (*95*), who exposed 24 different arrangements of letters and geometric forms to two groups similar in age but differing in educational level. The first group was composed of 40 army personnel with an average educational level of grade eight. The second group was comprised of 23 college students. The differential effect was found to be more prominent in the students than in the soldiers. Other findings of this experiment will be discussed below.

Some years prior to Mishgin and Forgays' experiment, Anderson (*3*) had presented English and Hebrew nonsense words to bilingual subjects. His presentations were to the central focus, and his findings under this condition were the reverse of those found by Mishgin and Forgays—that is, Anderson found more English "words" were recognized to the left of focus and more Hebrew to the right. To explain these results, Anderson postulated a "left-to-right mindedness" in English-reading subjects, by which he presumably intended something similar to his earlier "left-to-right" progression of attention (*4*).

Noting the above differences resulting between presentations to the central locus and those to either side, Heron (*86*) reviewed all previous work in the area, conducted a comprehensive experiment, and collected the following facts: 1) If English letters are exposed simultaneously to both sides of the focus, those on the left are reported best; if to one side only, those on the right. 2) If the subject knows where the letters will fall, the knowledge makes no difference in the report of the right field, but improves the left. 3) When four letters are presented in a square pattern, subjects report the upper left, upper right, lower left, and lower right in that order, whether the group is to the left or right of fixation. 4) In a series of letters, subjects report the beginnings better than the endings. 5) When letters are double-spaced, the superiority of the left field in equidistant presentations is greater. Putting these facts together, Heron postulated that differences found in the "retinal locus" experiments could be best explained as due to "post-exposural attentional processes" on the remaining neural traces. While Heron's conclusions were carefully worded to avoid any hint of the Platonic *sensorium* observing the *eidola*, they seem to postulate what later investigators refer to as a scanning of the memory trace.

Kimura (*95*) replicated Heron's findings that when letters are presented in a square pattern the subjects report them in an UL, UR, LL, LR order and that errors increase in that order. When the letters were spread out horizontally and presented across the center of fixation, the less educated soldiers tended to report the right-field elements and, consequently, reported more of these correctly. The students, however, tended to keep the left-to-right pattern and reported more of the left elements correctly. Kimura, therefore, settled for a compromise position which acknowledged Heron's conclusions but said that other things were operating as well.

Terrace (*136*) exposed words and nondirectional forms to the right or left loci of 30 college students. His results agreed with the previous findings that under these conditions words are best perceived in the right field, but no difference was found for the nondirectional forms. Terrace agreed with Heron's attentional scanning hypothesis.

In a series of experiments utilizing a variety of techniques, Harcum and others (*9, 75, 78, 79, 81*) showed that readers of English normally reproduce binary numbers in a left-to-right order and "exhibit superior tachistoscopic perception for elements at the left" when these elements are projected across the center of fixation. But when the subjects were instructed to respond from right to left, they showed a strong right superiority. When horizontal patterns of ten circles with five blackened were presented to Israeli and American students the results (*78*:368) indicated that

> The basic difference between these observed groups apparently is that the American "instructs" himself to perceive and respond from left to right, whereas, the Israeli "instructs" himself to perceive and to 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 . . . . The perceptual process involves a spatial-temporal sequence whose directionality is influenced by factors probably acquired through experience in reading.

Bryden (*24*) had found results similar to those of Harcum and Friedman when using nondirectional geometric forms. Requiring subjects to report from right to left did not produce the corresponding directional effects, however, when letters were used as the stimulus material. The major effect under these conditions was a reduction in the number of letters reported. His subjects frequently stated that they first had to repeat the letters silently in a left-to-right direction before they were able to report them in the prescribed direction. These results indicated to Bryden that the trace systems which are excited when letters are tachistoscopically exposed are "polarized" in a left-to-right direction.

Bryden's work with differing types of stimulus materials was extended in experiments by Bryden and others (*26, 27*). These experimenters concluded that left-field superiority could be best explained by postulating a sequential processing of a fading memory trace but that differences in right-field superiority were strongly affected by the familiarity of the stimulus. Subjects were able to process nondirectional forms most flexibly, digits less flexibly than forms, but with more flexibility than letters. They concluded that the inability to process letters flexibly resulted from reading experience.

The relative inflexibility with which alphabetic materials are processed suggested that further insights into perceptual processes could be gained by utilizing various transformations of normal letters. An early study by Wolfe (1939) reported that a "set to read backwords" could be induced in 9 to 11-year-old children by presenting mirror reversals of words. Harcum and Finkel (*77*:224-225), combining this technique with the retinal locus experiment, presented English words and left-right mirror images of English words to the left and right of focus. While the words were read best in the right field, the mirror images were read best in the left. Harcum and Finkel concluded that these results could be thought of as being due to

> . . . a temporal distribution of attention across the persisting physiological traces of the projected stimulus elements. The sequence of attending to the traces is assumed to correspond to the sequence of successive eye fixations across the visual field with the stimulus present, if eye movements could be made. Thus, having fixated on the center of the target-field, in order to perceive the word to the left of the fixation cross, the observer must direct his scan all the way to the beginning of the word at the left, and then read it from left to right. This initial tendency to scan toward the left conflicts with the tendency to read toward the right and perceptual accuracy suffers. When the word is presented to the right of the fixation cross, however, the beginning of the word is near the fixation cross, and the tendency to scan from the beginning of the word toward the end supplements the tendency for the left-to-right scanning sequence.

Harcum's explanation of retinal locus effects being due to conflicts in scanning tendencies receives some support from the finding by Goodglass and Barton (*69*) that the superior perception in the right visual field is accompanied by a lower threshold. If a subject must first scan to the beginning of a word, as in the case with words in the left visual field, it would be expected that such scanning would require additional time. In two rather extensive follow-up studies, Harcum and Filion (*76*) and Harcum and Smith (*82*) extended their findings on the effects of various letter reversals and found further evidence in support of a scanning hypothesis and against the original structural hypothesis proposed by Hebb. In the same year, Hebb (*85*:25-26) rejected his earlier hypothesis and suggested an explanation quite similar to Harcum's:

> what common features do [the word FRANCE and its mirror image] have, as visual configurations, that are not common to other words: Not much, considering them as static wholes. But as one moves his gaze from left to right in the upper word, or right to left in the lower, an identical series of events occurs . . . .
>
> Now suppose that perception of . . . the word FRANCE is a serially ordered activity of mediating processes or cell assemblies, even when the object is recog.ized at a single glance, and that the orientation is a function of serial order. What change is required . . .? A change in the order of firing of cell assemblies, only, and such a change is easily understood.
>
> What I mean to emphasize here are the new possibilities of explanation that open up when one separates sensory from perceptual process^s, and recognizes that identifying the two had a purely theoretical origin, and neurological to boot.

The Heron-Harcum model (1966)

The implications of the research discussed above, as Hebb recognized, were far-reaching. By making untenable the long held assumption that perception is a unitary phenomenon, many old questions were reopened and many new questions suggested. If sensory and perceptual processes are separate, then the response cannot be used as a measure of sensory input. (In the reading case, the span of perception as generally measured would be less related to a visual span than to complex interactions of processing systems.) What interacting systems are involved? How is information processed through these systems? What variables account for the retinal locus effects?

Harçum (*74*) reviewing his own extensive research and the related literature, suggested a model which postulated that sensory processes established a fading memory trace of the stimulus elements which were sequentally scanned until the trace faded. To account for differences resulting from interactions of retinal locus and letter orientation, Harcum postulated two post-exposural scanning tendencies: 1) a left-to-right tendency learned through normal reading experience, and 2) a tendency dictated by the material or experimental procedure. When the two tendencies are in agreement, as in words printed normally and presented to the right hemifield, maximum performance results. Under conditions which bring the scanning tendencies into conflict, however, performance suffers. A block diagram of this model (prepared by this writer) is shown in Figure 1.

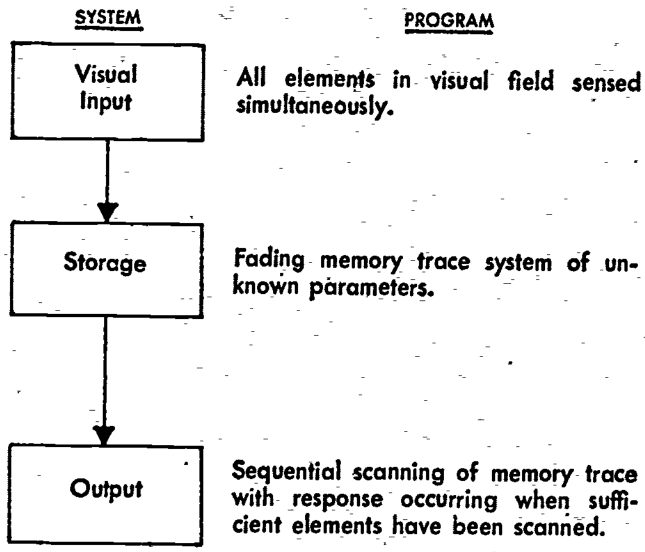

FIGURE 1. Block diagram of Heron-Harcum model.

While the Heron-Harcum model suggested more questions than it answered, a large body of evidence could be cited in support of its general outlines. There is wide acceptance today that perception is not a unitary process and that the sensory and response phases are more independent of one another than had long been assumed. Recognition of stimulus elements continues after the cessation of the physical stimulus. The sequential order of perception and, consequently, the response can vary independently of any variation in the external stimulus. In pursuing the various lines of research involved in the research on subception (Pierce *119*), investigators have shown that certain factors long known to influence perception, in fact influenced the recognition phase only. The factor of familiarity, for instance, known to significantly influence thresholds for visual presentations, has been shown to be entirely a response factor which fully operated in the tachistoscopic situation when *no* stimulus material was actually presented (*67*).

The Assumption That All Elements of the Visual Field are Perceived Instantaneously and Simultaneously

If perception is not a unitary phenomenon, then it cannot operate instantaneously and the elements of the visual field are not processed simultaneously. Visual perception is an event which occurs over time and entails complex processes. While this seems self-evident today, it has only been a decade since the importance of the concept was recognized (*20, 130*). Yet, to discard the assumption of the instantaneous and simultaneous nature of overall perception does not mean that the assumption could not hold for certain systems and processes. Almost all experimenters to date have maintained this assumption in regard to the sensory input phase of visual perception. The model presented in this paper (*61, 62*) and the well-known model by Sperling (1968) differ primarily concerning this assumption. It is an essential point if we are to understand Cattell's 1885 findings covering the differences in processing letters and words with the attendant implications for reading. Heron's "scanning" hypothesis was clearly a response scanning—a sequential processing of responses from an established memory trace. Since he used random letters as stimuli, his hypothesis was silent on the question of how words are scanned. Harcum and his coworkers have extended the scanning hypothesis to cover words by postulating that each element within the word is scanned in an appropriate direction. Hebb (*85*) apparently agrees with this position. While these investigators do not specifically discuss this question, they seem to imply that the memory trace is established by "parallel" sensing and that their hypothesized scanning takes place sequentially across the memory trace. According to this view, presumably, the subject scans the elements (e.g., letters) of the memory trace sequentially and responds when he has scanned all of the elements making up a response unit (e.g., a word).

Neither Heron nor Harcum specify the time parameters of either the hypothesized memory trace or the scanning thereof. If this hypothesis were used to explain Cattell's findings that more "letters" can be processed when organized into words, we would have to assume either that the memory trace lasts longer for words than for letters or that the scanning rate is faster for letters than for words. The first of these seems improbable since a memory trace is presumably a physiological function which would not change to suit differences in the subjective organization of stimuli. The variable scanning explanation seems somewhat more probable, but it leaves much of the data unexplained. For example, it fails to account for the persistent belief among subjects that they saw all the individual letters but could not remember them. Heron's subjects (*86*) reported that they fixated each letter in turn, although the tachistoscopic presentation was too short for any eye movement to have taken place. If every letter is "fixated," yet some cannot be reported because they are lost from memory, then the "fixating" must occur prior to the memory trace.

The variable scanning rate hypothesis also is contradicted by Heron's finding that double-spacing the stimulus elements increased the differential effects shown in reading from the two visual loci. This finding seems to suggest a constant scanning rate uninfluenced by the spatial characteristics of the field, since the farther the stimulus elements are from center, the more pronounced the effects. The finding by Goodglass and Barton (*69*) that words printed vertically and flashed to the right locus have shorter thresholds than similarly-printed words presented to the left locus would seem also to suggest that distance and direction from the center of fixation are important factors. This, in turn, argues against a variable scanning rate which presumably could compensate for these differences.

The Heron-Harcum model, then, runs into considerable difficulty where applied to the often-replicated findings of Cattell (*31*). In the model suggested by this writer (*62, 63*), these difficulties were met by dropping the assumption of instantaneous and simultaneous input and postulating the operation of two scanning rates in visual perception, *viz.*, 1) a sequential-response rate operating from a fading memory trace, essentially as postulated by Heron (*86*); and 2) an entirely different scanning subsystem, similar in operation to that postulated by Harcum and Finkel (77), but operating in the sensory input phase and whose function is to *establish* the memory trace. The evidence for this hypothesis will be developed below.

Visual image and iconic storage

It has long been known that minimum tachistoscopic exposures necessary to perception are not good measures of perception time, since the incoming information is processed for some time before identification is achieved (*140*). Any model dealing with visual perception must be able to account for this phenomenon and the fading memory trace of the Heron-Harcum model was one such mechanism.

In a series of ingeniously designed experiments, Sperling (*131*) investigated the fact that observers in tachistoscopic experiments commonly report that they have seen more elements than they can remember. Using dim pre- and post-stimulus fields, he found that his subjects reported slightly over four random letters from exposure durations ranging from 15 to 500 msec. This constant number reported over a wide range of durations is, of course, the phenomenon which led early-day experimenters to consider the span of attention as an elemental unit and was a major factor in the reasoning behind the classic theory of perception in reading based on the span of perception. Sperling's procedure of using dim pre- and post-fields was essentially the procedure followed by the early investigators.

Sperling, having determined the basic "span of perception" of his subjects, conducted a series of experiments utilizing the technique of "partial report." In these, several stimulus elements would be arranged in several rows (e.g., 16 letters arranged in 4 rows of 4 letters each) and the subject would be called upon to report a specific row by the sounding of the tone. Sperling found that his subjects were able to report any row called for *even when the command tone was not sounded until after the cessation of the light source.* Since the fields used were well beyond the memory span limitations of the subjects, he concluded that the subjects were reading the stimuli *after the light had ceased* from a "visual image."

As Sperling's study sought to find some explanation for the persistent reports of subjects that they can see more than they can remember and report in tachistoscopic experiments, he interpreted his findings as affording experimental confirmation of this report. In his discussion of the data and in subsequent writings, he seems to equate the "visual image" with the fading memory trace of the Heron-Harcum Model. Other investigators have agreed with this interpretation. Mackworth (*108, 109*), for example, equates Sperling's "visual image" with her own use of the term and with Glanville and Dallenbach's "memory after-image." But there are difficulties with this interpretation when applied to normal reading conditions.

In the normal reading situation, all "fields" are equally lighted at the level to which the eye is adapted. Tachistoscopic variations from this luminance procedure create difficulties in applying the results to normal reading phenomenon. Figure 2 plots the data of Sperling with data reported by Mackworth (*110*), showing the effects on number of elements reported by an interaction of exposure duration and various luminance schedules. In the area below 50 msec., the luminance schedule is critical. The use of dark pre- and post-stimulus fields at short exposure duration provides the subject with a visual input equal to that provided by much longer durations. Cattell's results (*31*), therefore, reflect response variables such as familiarity and contextual constraint, and provide no data for inferences regarding the "primary cue" in reading.

The effects on form recognition caused by varying the luminance of tachistoscopic fields has been extensively investigated by Eriksen and coworkers (*53, 54, 55*), who ascribe the effects to a combination

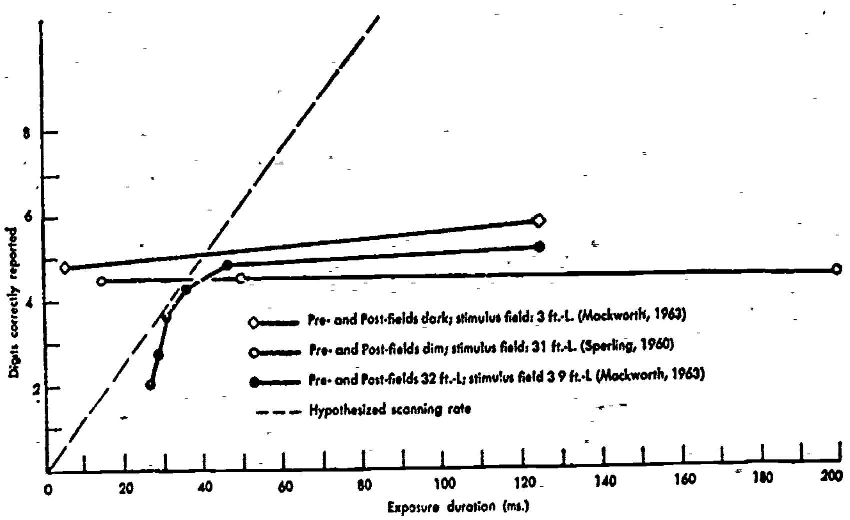

FIGURE 2. Interaction of luminance and exposure duration in relation to hypothesized scanning rate.

of luminance summation and reduction of contrast. Deviations such as those found below 50 msec. in Figure 2 seem to fall under Block's Law which states that at brief durations the length of exposure and intensity level of light are interchangeable in effect. That is, presenting a stimulus field at a higher intensity of illumination than that to which the eye is adapted has the same effect as increasing the exposure duration. The common finding is that holding exposure duration constant, an increase in illumination of one log is required to add one stimulus to the report. Efron (*50, 51*) reported that a reduction in intensity by one log unit increased the latency of the visual process by 8.17 msec.

Sperling's "visual image," while a genuine effect in the specific tachistoscopic situation, cannot be the "fading memory trace" found in experiments using equally-lighted fields nor can it be considered a storage system in normal reading. In experiments employing stimulus fields unequal to the adaptation level, these two phenomena would be temporally confounded. Therefore, in the discussions below, "visual image" will refer to that portion of the fading memory trace attributable to luminance differences. The term "iconic storage" will be adapted from Neisser (1961) to describe the fading memory trace produced by tachistoscopic conditions comparable to those found in normal reading. This usage may prove confusing since Neisser used the term "icon" to replace Sperling's "visual image."

Characteristics of the icon

Of considerable theoretical interest are the temporal characteristics of iconic storage. Using tachistoscopic conditions equated to normal reading, what is the minimum exposure necessary to establish iconic storage and how long does the icon remain in usable form? The answers to these questions depend largely on the assumptions employed in arriving at them. Most investigators of these questions have maintained the assumption that the icon is established through a parallel process and elements are processed sequentially from the fading trace (e.g., *71, 108, 109, 116*). This is the Heron-Harcum model with the additional assumption that the length of iconic storage varies with the luminance-duration parameters of the stimulus presentation. Thus, longer exposure durations produce longer lasting icons enabling more elements to be reported. While attractive, this model suffers from severe flaws which will be discussed below.

Establishment of the icon. The minimum exposure duration necessary to transfer elements from the visual field to iconic storage is an important theoretical question for it would specify the processes acting during a known initial portion of visual perception. More importantly, perhaps, it would provide significant evidence as to whether these initial processes acted sequentially or in parallel. If the same amount of time were required regardless of the number of elements reported, this would be in keeping with the expected actions of a parallel system. If additional increments of time were required for each additional element reported, however, sequential processing would be indicated.

Since Sperling's classic experiment (*131*) revealed dramatically the fact that processing does not necessarily stop with the cessation of the physical stimulus, additional control procedures were required. For this, Averbach and Sperling (*8*) used the classic procedure of employing a masking field. This procedure, first demonstrated by Baxt (*12*), has long been an important tool for the study of visual processes and a center for theoretical debate in itself. It has been thoroughly reviewed by Kahneman (*94*) and cannot be extensively discussed here. In the following paradigm of importance to this paper, the procedure consists of following a stimulus field with a field composed of "visual noise" designed to destroy the informational qualities of the visual image. If the analysis in this paper is correct, immediately following a stimulus field with an adequate masking field should result in the same effects as the use of stimulus fields illuminated equally and exactly at the level of the subject's adaptation. This analysis has not been empirically verified, however, and remains an assumption.

Baxt (*12*), using single letters and series of letters followed by a bright flash, found that 10 msec. free of interference was necessary for the perception of a single letter and that an additional 10 msec. was required for each letter reported in a series. Since his masking stimulus was brighter than his stimulus fields, this time estimate is probably slightly excessive. Averbach and Sperling (*8*), however, report the same estimate for the use of "parts of letters" as the mask. Sperling (1963) again found that 10 msec. of exposure was required for each letter reported and that the effect was independent of the number of letters in the field (from two to six).

The question of sequential versus parallel processing would seem settled were it not for the careful work of Kinsbourne and Warrington (*96, 97*). These investigators presented tachistoscopically single letters followed by a masking field composed of a statistically random pattern with all fields illuminated equally. All subjects achieved complete identification of a single letter from a stimulus presentation of 2.5 msec., but at this exposure duration a relatively long interval must elapse prior to the presentation of the masking stimulus for identification to be possible. At progressively longer stimulus durations the necessary interstimulus interval lessened until at exposure durations of 8 msec. masking was no longer effective even when presented instantaneously after the informational stimulus. The masking effect was all or none. It was specific to the area of the visual field covered; that is, a section of the random pattern just large enough to cover the area occupied by the letter was as effective a mask as was the larger random pattern, and the large random pattern from which the section had been cut produced no interference.

Kinsbourne and Warrington investigated the question of sequential versus parallel processing by presenting 2- and 3-letter groups to two of their subjects. Their results indicated

> . . . that the threshold for the correct identification of all the letters in the tachistoscopic group never exceeded that of identification of one of the group by more than one tachistoscopic step. In most cases, two and three letters were simultaneously identified at the same exposure duration as single letters . . . . It appears that under the present conditions simultaneous perception is influenced by the aftercoming random pattern much as is single perception.

In their conclusion, Kinsbourne and Warrington very reasonably applied this finding specifically against ". . . serial perception of the type postulated in 'filter theory'" (*20*). Their results agreed perfectly with what would be expected from the assumption of parallel perception, namely, a certain minimum time necessary to the sensing of the visual field regardless of the number of elements present. Their finding, if left unchallenged, would constitute a severe difficulty to any scanning hypothesis. However, the conflict between these results and those reported by Baxt (*12*), Averbach and Sperling (*8*), and Sperling (1963) requires that a closer examination be made.

The subjects used by Kinsbourne and Warrington were highly practiced in tachistoscopic viewing, having previously been exposed to the hundreds of presentations involved in the other sections of the study. They knew that no more than two or three letters were to comprise the stimulus field and that the exposure duration was to be extremely brief. These experimental conditions would be expected to encourage a viewing strategy of "attending broadly" (discussed in a section below) and the results obtained would apply only to these particular conditions.

By varying the amount of alphabetic material in the stimulus field and the length of the exposure, Gilbert (*65*) obtained masking effects at each of a series of exposure durations ranging up to 168 msec. The effects were a function of the number of elements in the field, the elements on the right being lost in each case (Gilbert, personal communication), as would be expected from the retinal locus studies. Gilbert's data will be presented and discussed in detail below. The important point here is that masking effects of alphabetic material can be obtained from exposure durations many times as long as 8 msec. if the number of elements in the field is sufficiently numerous and if the stimulus durations are randomized. Therefore, while the careful illumination controls used by Kinsbourne and Warrington give credence to their finding of 8 msec. as the minimum exposure necessary for the processing of a single letter under the illumination conditions of normal reading, their finding that two or three letters require no additional time would not apply except under the procedures they report. Scharf and Lefton (*124*), for example, studying the effects of luminance and masking on thresholds for letter recognition, report 8 msec. *per letter* as the average rate of acquisition for their subjects.

If 8 msec. is accepted as the exposure duration necessary for a single letter to become immune to masking effects under the illumination-adaptation conditions present in normal reading, and if a similar period of time is required for each additional letter, then the Heron-Harcum model runs into difficulty. Certainly identification of a letter cannot be accomplished in 8 msec., but *something* happens which prevents further interference of a masking nature. Sperling (1963), using his estimate of 10 msec. (the difference is trivial), suggested a model wherein the visual field is transferred in parallel to iconic storage and the subject "reads out" from the icon until it is "erased" by the mask. But this requires a reading rate of 100 elements a second. Therefore, the model has been dropped (Sperling, 1967).

Another difficulty is the constant 4 or 5 element report given by subjects from a wide range of stimulus durations where a dark-light-dark tachistoscopic procedure without masking is employed. This finding, the classic "span of attention," is consistent across groups and generations (*31, 40, 131*). Since Sperling's experiment showed that this procedure actually provides long viewing durations, what subsequent systems limit the report well below average memory span?

The hypothesis advanced at the beginning of this section would seem to account for these phenomena. Once the assumption of instantaneous and simultaneous input is dropped, the rate of 8 (or 10) msec. per letter becomes that rate at which letters are transferred *to* iconic storage. Masking would interrupt this process but would not effect those letters already in storage. These elements would be read out at the rate of silent speech until the iconic storage faded.

Duration and nature of the icon. Very little can be confidently stated concerning the parameters of iconic storage. Neisser (*116*) estimated its duration as from one to two seconds, but this estimate includes variations in luminance schedules. Mackworth (*108, 109*), using equally-lighted fields, estimated storage as "about one second." A storage limit of one second would explain the "span of attention" effect, since 4 or 5 letters a second is a reasonable silent reading rate. Geyer (*62*) postulated iconic storage as the basis for eye-voice span in oral reading and predicted that the temporal span would remain relatively constant in smooth reading at a span of approximately one second. This prediction was confirmed from data generated by eight subjects reading three passages of varying difficulty. The overall mean was 1004 msec. and individual subject means for all passages combined ranged from 904 to 1088 msec.

Even less is known of the nature of iconic storage. Introspection identifies it as being auditory in nature (*90*). Several studies showing greater confusability from letters which sound alike could be interpreted to support this position. Sperling (1967), for example, reports that when 3 letters make up the stimulus, it makes little difference in performance if the letters sound alike or sound different. Performance deteriorates for more than 3 letters, however, if the letters sound alike. Since memory span can typically reproduce seven letters without confusion, it is difficult to ascribe these findings to limitations of subvocal rehearsal. Taylor and Posner (1968), on the other hand, have presented evidence for visual storage prior to the verbal storage, although their use of dark interpolated intervals makes their data difficult to understand in the present context. The question at present is too complex for fruitful analysis here.

Viewing strategies

The analysis presented above and the retinal locus experimentation can provide some insight into the possible strategies available to subjects in tachistoscopic experiments. Reading can be thought of as a process by which spatial sequences are converted to temporal sequences. This is accomplished by processing on at least three levels loosely identified with sensory, recognitional and motor processes. Directionality is initiated at the sensory level but is apparently determined by the desired sequence of the final report. Thus, if a subject knows before the exposure the sequence in which the response will be made, he scans the material in the direction which produces that sequence. Internal recognition takes place in the same sequence, and the external response is made as recognition occurs, or from a storage of a covert response. If the same sequence is maintained from input to output, the systems operate at maximum efficiency. If a sequence of external response is required which is counter to the direction of scanning, however, the most effective strategy would be to store the total internal response and the report in the reverse direction. This would limit the final report to backward memory span, while preserving a semblance of the directional effects imposed by the fading icon.

Long practice has apparently made the English-reading subject more proficient with the left-to-right scan direction. Thus, while he shows right field superiority when required to respond to nondirectional material in a right-to-left order, his right superiority is not as great as his left field superiority when his response is in the normal order (*9, 76, 79*). Given a choice, he responds in the normal left-to-right pattern. If he is instructed to respond from right-to-left *before* the exposure, he shows a marked right field superiority. If the instructions are given *after* the exposure but *before* the response, his accuracy is reduced, and a slight left superiority is shown (*79*). Bryden (*24*) also found that with nondirectional material the lateral superiority was a function of the order of report. But with alphabetic materials, the effect of requiring a right-to-left report was to reduce the numbers of letters reported while preserving the left field superiority. Bryden's subjects frequently reported that in order to report the letters in a right-to-left direction, they first had to repeat them to themselves in the normal order.

One additional sensory strategy seems possible under certain tachistoscopic conditions. The classic studies of Schumann (*129*) and Wagner (*141*) do seem to indicate that subjects *can* attend to a total stimulus. This is the strategy of "attending broadly" mentioned above in relation to the studies of Kinsbourne and Warrington. Wagner, for example, exposed a long series of unconnected letters for a duration of 100 msec. and urged his subjects to attend broadly to the whole row. His results showed that the subjects repc ted letters which had occurred throughout the row, although most letters reported were from both ends and the center. Several factors in these classic experiments need discussion. The fact that Wagner had to *urge* his highly practiced subjects to "attend broadly" is significant. That this procedure is not the normal strategy with large arrays of alphabetic materials is clear from the studies presented above. The reason that it is not the normal procedure is apparent from the results obtained. If the row of letters had comprised several words, the subjects presumably would have perceived the first two or three letters of the first word, a scattering of a few letters from the center words, and the last two or three letters from the final word—certainly a poor strategy for reading. When the visual field contains more alphabetic material than can be processed in a brief flash, the best procedure would seem to be to scan from left to right in order to perceive as much of the material as possible in a meaningful way—and this is apparently the procedure that subjects follow typically.

When the stimulus field is small and the presentation very brief, however, experienced subjects might develop the "attending broadly" technique.

The Geyer Model (1966)

The model

Figure 3 presents a block diagram of an initial heuristic model of reading developed by Geyer (*62*) from an analysis of the literature similar to that presented above. The model does not purport to be a complete representation; such obvious processes as feedback systems, for instance, are not represented. The systems presented in the figure and described below are those hypothesized as functioning between the moment in time when the stimulus is presented and when it is reported, and the order in which they are presented is the order of their functioning in processing a given stimulus. In an ongoing perceptual task such as reading, the system would tend toward an overall steady state based on the "channel capacity" of the slowest system.

Sensory input (scanning) system. A major hypothesis of the model is that visual input is sequentially ordered within the fixational pause. In reading English, the input is from left to right at a rate of approximately 8 msec. per letter-space. If this hypothesis is accurate, then the major function of the saccadic movements would be to keep the eyes in a position where the covert or attentional scanning is within the retinal area of fine discrimination and input could take place during any time segment of the fixational pause.

The input of importance to this model is that portion of the visual environment central to the reading act of the moment. Other types of visual information may be processed simultaneously through other systems. The contents of the visual field have many characteristics, e.g., presence versus absence, shape, color, size, location and brightness. There is growing evidence that some of these characteristics are treated separately by the visual system (*34, 57, 58, 125*). The sequential input hypothesis relates to the "figure" and not to the "ground."

Sensory organizational systems. Immediately upon input from

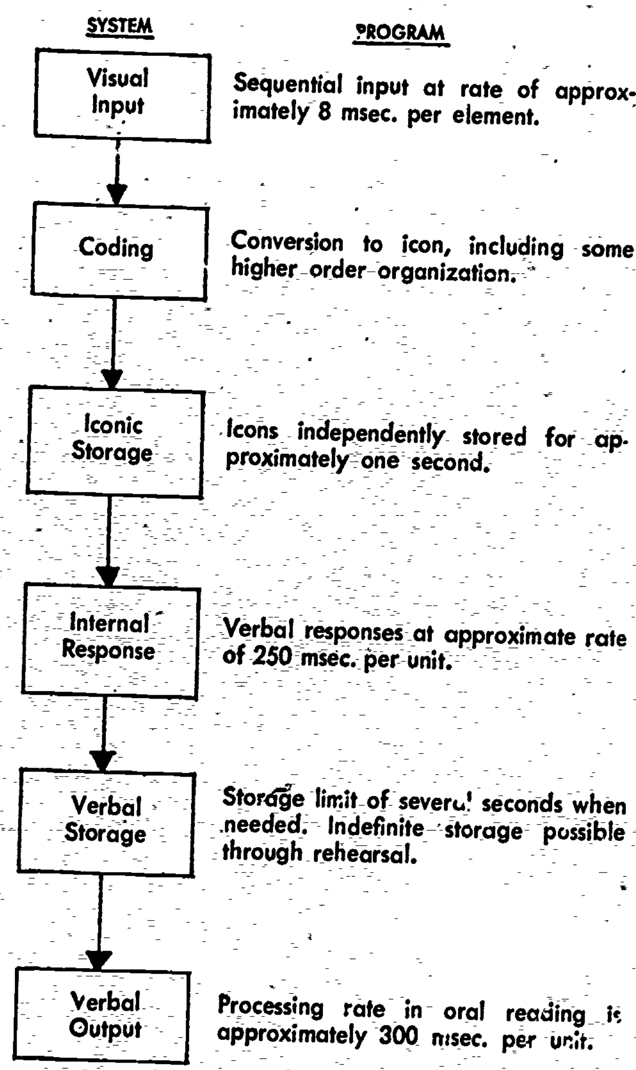

FIGURE 3. Block diagram of Geyer model of oral reading.

the above system, organizational and associational processes would begin. From this point in time, the development of meaning would continue until well after the processing of a given word was completed. The logic of the model, however, requires that prior to transfer to the next subsequent system certain transformations be completed. In the case of unconnected letters or digits, relatively little transformation would be required for conversion to icons. In reading words, however, the letters would be transformed to higher order units (presumably phonemic) prior to storage. It should be specifically noted that in this model, the stimulus elements are scanned and undergo some processing prior to their transfer to the iconic storage system.

Iconic storage system. Once the elements of the stimulus are organized into units (e.g., letters into words), these units are delivered to an iconic storage system. Each unit remains accessible for response for approximately one second, but if no response is made the units are lost. This storage is thought to be identical to that which Glanville and Dallenbach (*66*) studied as the "memory after-image." Sperling's "visual image" (*131*) would include this iconic storage but would confound it with unknown amounts of time due to luminance variables artifactual to this model since they do not occur in normal reading. The primary function of this system is to act as a temporal buffer between sensory and response phases to allow integration of the differing processing rates.

Internal response system. The possible responses made during reading are many and complex and would involve varied systems. Of interest to this paper are the verbal responses required in tachistoscopic experiments and most, if not all, reading. The interactions between the rate at which responses can be made, the elements making up response units, and the length of time icons remain in storage are seen as the major factors governing speed of reading and eye-movement characteristics.

Several investigators, using quite dissimilar experimental situations, have postulated a 5- or 6-cycle per second central nervous system response rate (Blackwell, *14*). Lansing, Schwartz, and Lindsley (*103*) have postulated a physiological basis for such a response rate, centering around the action of the ascending reticular activating system on cortical resolution and the transmission of incoming messages. As recognized by Davis (1963), these postulated response rates agree quite well with the long known (but little understood) fact that the mean pause length in normal silent reading remains remarkably constant at around 250 msec. and that differences in reading rate are a function of wide variances in number of fixations used (Stone, 1941; Tinker, 1951; Walker, 1933).

It seems entirely possible that the physiological response rates, Heron's "scan" rate (identified here with the system under discussion), and the relatively constant fixational pause in reading are functions of related phenomena. Lichtenstein, White, and Siegfried (*105*:544), studying the perception of series of brief flashes delivered at various retinal eccentricities, found that the flashes were counted at a stable 5 to 6 per second at each eccentricity although the subjects judged the flashes to be occurring three times as rapidly at the fovea as at the most distant point of the periphery. The concluded that

> The results of our study . . . have implications which should serve to modify current conceptions of psychological duration units and associated 'scanning' units in vision. In those conceptions there is the overt or tacit assumption that only one basic 'scan' rate is operant in the visual system. They fail to recognize the possibilities emphasized by results of this study that more than one basic 'scan' rate may be operating simultaneously and that each 'scan' rate may be associated with a different visual function or set of operations.

Secondary (internal response) storage system. Once the covert verbal response is made, the name of the stimulus is transferred to a second storage system with a time capacity of several seconds but with limited unit capacity. In oral reading overt responses could accompany the internal responses or, when required, the internal response could be stored momentarily until the overt responses could be made. This system, then, could operate as a temporal buffer between the recognitional and motor phases in a way analogous to the operation of the initial storage system operating between the sensory and recognitional phases.

Considerable research activity has been devoted to delineating the characteristics of this system under the rubric of short term memory (*1*). Questions currently being debated include whether the basis of storage is primarily visual or auditory in nature (*47, 48, 115*), whether coding is by semantic or acoustic parameters, (*10, 38, 144, 145*) and whether the limiting processes are decay, interference, or displacement (Conrad, 1967; Murdock, 1967; Schonfield and Donaldson, 1966). Much of this research confounds the two storage systems hypothesized in this paper and in some cases Sperling's "visual image" is further confounded. A clear delineation of the interacting systems would seem to be necessary before their properties can be confidently sorted out.

External response system. No attempt will be made in this paper to analyze the properties of the external response beyond acknowledging its existence.

The model in operation

The model can be differentiated into three processing systems associated with sensory, recognitional, and motor processes. Interspersed between the three systems are two storage systems which make smooth information processing possible by acting as buffers for the differing operational rates of the processing systems. These differing rates are thought of as being based on physiological functions.

The model does not purport to represent "the visual system," many well-known functions of that system are not included and the last two components of the model are not directly part of vision. The model is concerned specifically with reading and the discussion of its operation below will be limited to three situations: 1) the tachistoscopic situation where the response unit and stimulus element are the same, 2) the tachistoscopic situation where the response unit is a combination of stimulus elements, and 3) normal oral reading.

Condition 1. The response unit and stimulus element are the same. Under the experimental condition where the response unit and stimulus element are the same, as with digits or unconnected letters, the effects of the initial scanning system would be apparent only at the briefest exposure durations. If a subject can process four digits from iconic storage, it would only be at the exposure durations allowing the input of less than four digits that the initial scanning system would be the limiting system.

The broken line on Figure 2 shows the hypothesized scanning rate, if the digits were presented so that there was no necessity to scan to the beginning of the array. For each 8 msec. of exposure duration, one digit would be added to iconic storage where it would be available for one second. If a response were made every 200 msec., four or five digits could be reported before the icon faded. Additional increments of time added to the stimulus presentation would add additional digits to the report up to a maximum of approximately 40 to 48 msec. For longer exposure durations, the limiting factor would be the interaction of response rate and the duration of the iconic storage. Additional increments of exposure time would not add to the report until the duration was long enough to allow the first digit to be processed before the exposure was terminated—a duration of approximately 250 msec. From approximately 50 to 250 msec., then, the result would be the relatively constant report of four or five digits, although the subject might indeed remember having "seen" more at the longer duration.

With a large number of digits in the stimulus field, longer exposure durations could result in smaller reports. A subjct scanning 12 digits during an exposure of 100 msec., for example, would read in many more digits than he could process and the superfluous time spent in scanning would lessen the time available to process the icon. Since the final digit would be available for almost 100 msec. after the first digit faded, it might he read out from the fading icon. These effects are commonly reported in the literature.

For each subject there would be an optimal field size which would be just large enough to permit maximum use of iconic storage but not so large as to encourage overscanning. Mackworth (1963) reported that individual subjects varied in their optimal field size but in each case it was one element larger than the subject's largest report. In addition, in experiments where field size and exposure duration are independently varied, there would be an optimal field size for each duration and vice versa. Fraisse and Battro (*61*) have reported data in agreement with this deduction from the model.

Condition 2. The response unit is a combination of stimulus elements. All the effects described in the section above would be expected to apply to the situation where the response unit is a combination of stimulus elements. In this situation, however, the number of stimulus elements which would be scanned effectively would be much larger. If a subject scanned 12 letters in 100 msec., there would be little change from the digit example above, if the letters were unconnected. If the letters combine[illegible] make short familiar words, however, they could all be processed from iconic storage in the three or four responses ncessary and possible.

In a section above, an experiment by Gilbert (*65*) was cited as evidence that masking effects can be obtained following relatively long durations if the amount of material in the field is adequate. Gilbert tested 64 college students on their ability to read short, familiar words in contexts ranging from a single word to five word sentences from masked tachistoscopic presentations of varying duration as well as from an unmasked presentation of 84 msec.[2] In keeping with his experimental purposes, Gilbert's data were reported in terms of per cent correct. Of more interest here, is the average number of words reported from each condition and the data have been so converted. This is legitimate in terms of the scanning hypothesis only if all subjects invariably reported the words from left to right. Gilbert (private communication) has stated that such was the case. The converted data are presented in Table 1.

TABLE 1

MEAN NUMBER OF WORDS CORRECTLY REPORTED

Number of words in stimulus field	*Exposure duration (ms.)* 84	126	168	210	252	84[a]
One word	.81[b]	.98	.99	1.00	1.00	1.00
Two words	1.73[c]	1.96	1.98	2.00	2.00	1.97
Three words	1.93	2.81	2.89	2.95	2.90	2.88
Four words	2.25	3.35	3.42	3.72	3.71	3.67
Five words	1.80	3.20	3.32	3.60	4.07	3.78

[a] This presentation was unmasked; all others were masked.

[b] Above the dark line are figures for reports limited by the number of words available in the stimulus.

[c] Below the dark line are figures for reports limited by the amount of time available for input.

Note. The figures in the cross-hatched boxes represent two important exceptions in the data.

[2] Gilbert used procedures yielding time measures in 24ths of a second. These have been converted to milliseconds here to facilitate comparison with other studies.

An examination of Table 1 shows two main effects, *viz.*, reports which were limited by the number of words available in the stimulus, and reports limited by the amount of time available for input. The first of these effects is obvious in the data. The second effect, that of time limitation, is derived from the unmasked presentation. Since at each field condition the unmasked reports were the same as the maximum masked reports, it is assumed that the visual image resulting from the luminance conditions of the experiment was of sufficient duration to make the systems subsequent to input the limiting factor in the unmasked presentations. If this assumption is tenable, then the masked presentations which yielded smaller reports must have been limited by the time available for input prior to the mask. The five-word-252 msec. cell is an important exception which will be discussed below.

Several interesting effects can be seen in Table 1 as divided by a darkened line. Under the masked condition, additions of time increased the reports until the maxima possible were reached. Adding words to the fields also increased the reports up to the four-word field, but the addition of a fifth word was detrimental. This is the optimal field phenomenon discussed above. In this case the optimal field was four words which is just larger than the maximum reported (with one exception discussed below).

All cells in Table 1, with two important exceptions, are either time- or word-limited. The line separating these two effects forms a diagonal across the table. The agreement between this line and the hypothesized rate of action of the initial scanning system can be seen graphically in Figure 4 which plots the data from Table 1 with the estimated systems-parameters. Except for one point, the one- and two-word fields were too word-limited to show the action of the initial scanning system with the durations employed. With more words in the field, however, the points follow the estimated line of the initial scanning system until they taper off as they approach the limitations imposed by the interaction of the iconic storage and recognition systems. Those points, then, which were not limited by the number of words in the field are in essential agreement with the "prediction" of the model.

Two cells in Table 1 are of particular interest. The model would predict that at some point the variables of time and number

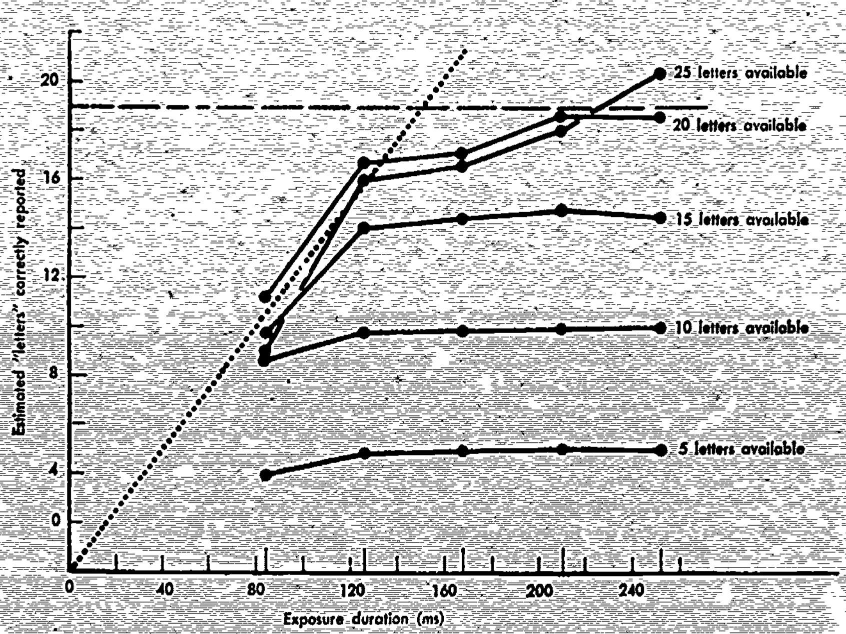

FIGURE 4. Mean estimated "letters" reported from masked presentations. The dotted line indicates hypothesized scanning rate; the broken line, the storage-response limitations. Data from Gilbert (1959).

of words available should approach a balance which would yield a maximum report. The one cell in Table 1 where an additional increment of time *or* words did not result in a larger report was the four-word-210 msec. presentation, which yielded essentially the same report as the maximum unmasked report. This report was improved upon only by the addition of words *and* time. At this combination of word and time parameters, therefore, the subjects most nearly achieved a balance between systems. It is perhaps significant that 210 msec. is the commonly reported modal pause length for good readers reading silently (*2, 142*).

If the four-word-210 msec. cell of Table 1 is considered to represent the point at which all systems were operating at maximum balanced efficiency, some explanation must be sought for the increase shown in the five-word-252 msec. cell. This was the only presentation condition which yielded larger reports than the unmasked condition. Since all individuals could have read all five words had the exposure duration been long enough, this cell seems to have pinpointed another important point in the processing. It seems reasonable to suggest that a presentation of 252 msec. was adequate for the fastest reacting individuals to process the first word from storage before the exposure terminated, allowing three additional words to be effectively processed from storage following the termination. This suggestion agrees with the commonly reported figure for the mean pause length in reading easy English prose and may be a key to understanding the often reported stability of that measure (*6*).

Condition 3. Normal oral reading. The above discussions relate to the tachistoscopic situation only. In reading digits where exposure time is not limited, the subject would fixate each digit at a rate in keeping with his ability to process them. The most efficient strategy in this situation would be to have a continuous supply of digits read in, processed, and stored in the iconic storage which then could be read out as fast as the motor components allowed. Additional digits would be added to storage at the same rate, so that the number of digits which could be stored without loss would be the number which the subject could report in the amount of time the icon lasted. The eye-voice span (in numbers of elements) would be a function of how fast the subject was reading, as this span could not exceed the time limits of the iconic storage. For example, if a subject reported digits at the rate of three per second from an iconic storage lasting one second, then his most efficient strategy would be to have three digits in process at all times. As he read out the first digit, he would read in the third. The second digit would be in storage available for report. The use of the icon in this way would allow steady, smooth processing.

A change in the mode of response would change the number only. In reading digits silently, the subject could process perhaps four or five digits per second. He would therefore keep this number in process at all times for smoothest processing. If typewriting, the numbers would depend on speed of typing. Butsch (*29*) noted in a study of the "eye-hand span" that typists average a span of words equal to the number they type in a second.

In normal oral reading of prose, once the reader had scanned an amount equal to his storage response capabilities (that point at which Gilbert's data stops), the effective rate of further reading would depend on the rate of processing of the slowest system. If input proceeded too far ahead of the response system or if coding difficulties occurred, the scanned elements would be lost from storage before they could be processed, and the subject would be required to make a regressive eye movement in order to again read in the lost elements. In smooth reading, then, the systems would tend toward a steady state between input and output systems made possible by the buffering action of the initial storage system. This steady state is characterized empirically by a relatively constant temporal eye-voice span regardless of the number of words or syllables being processed within that span (*62*).

Conclusion

The model presented above is tentative and incomplete. Yet even at this stage, it is possible to state with considerable confidence several generalizations concerning the reading process. Reading is not a matter of an instantaneous recognition of the contents of a visual span, but is rather a function of the interaction of complex systems over time. Regressive eye movements (at least in oral reading) do not result normally from nonoverlapping visual spans of perception and are not caused normally by oculomotor difficulties. Most typically they are a device for keeping input and output within certain critical temporal limits (*62*). The central, unifying eye movement measure in ongoing reading is the time between the input of a word and the time the response to that word is completed, not because word A cannot be held in short term memory, but because until word A is completed, words B, C, etc., cannot be processed from a rapidly decaying icon. This icon is available for approximately one second and it is this storage system which makes possible smooth processing and, probably, reading by phrases.

It seems possible, at the present state of knowledge, to suggest a simplified model which would be more useful in visualizing reading processes than the classic span of perception model. Figure 5 presents this model. Reading is represented as taking place through a pipeline to illustrate that words can be in various stages of processing simultaneously and that the flow is more continuous than the fixational pause-tachistoscopic flash analogy would suggest. Meaning is derived throughout the process and is shown as being outside the pipeline since it is possible to read words quite smothly while understanding very little. While this model gives little indication of such important variables as timing, it does emphasize the need to maintain an adequate flow of words from which meanings must be actively extracted. It might also discourage the erroneous emphasis on optical span.

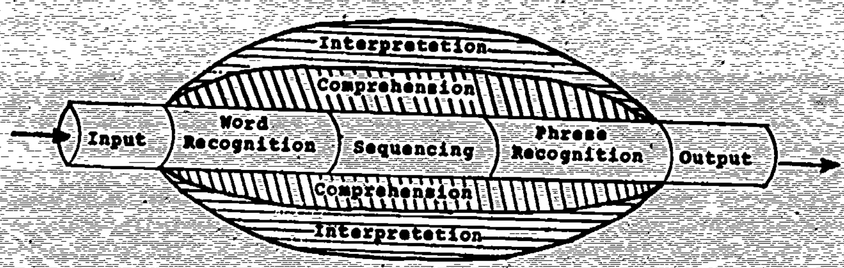

FIGURE 5. Generalized model of reading.

Among the alternate research models reported in the literature, the best-known is that of Sperling (1967). It is not possible in this paper to do justice to the fruitful research and insightful reasoning which has contributed to this model and the interested reader would do well to consult the original sources. In orientation and broad outline, Sperling's model agrees remarkably well with the model developed in this paper. The disagreements which do exist, and they are important, would seem to be experimentally testable. It is through such testing of disagreements, of course, that new understandings evolve—understandings with high potential for suggesting new and more specific diagnostic and remedial techniques and, perhaps, new instructional procedures.

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style might prove to be among the more important variables of the working system for reading. Gardner has suggested that the cognitive style may represent "a superordinate level of control within the personality system," while the cognitive controls may be subordinate measures possibly more responsive to specific situational requirements. In other words, the cognitive style would determine the general orientation with which the individual tended to approach an intellectual task, but the cognitive controls would represent other characteristics which might be called into play for specific purposes, much as phonetics or Latin are called upon in response to the specific task.

The function of the preschool and elementary school, then, is to extend the child's repertoire of ways to solve problems, perhaps to make him more flexible in his use of different cognitive styles as the situation demands. In this way, he will learn not only specific content, but new ways of promoting his own learning, and new ways of solving his own problems.

The ability to cope with one's problems is the *sine qua non* of mental health. Some years ago, a group of clinical and psychiatric experts met to formulate a set of criteria which could be considered the primary indicators of mental health. Among these indicators

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problems. He generates questions, and actively seeks solutions to them. He learns because he wants to know, and because one problem opens up others in a continuously expanding panorama. The mentally healthy child is the one who wants to learn, and this includes most children of preschool and kindergarten age, except for those whose egos have been seriously assaulted by ill-treatment or deprivation.

To bring these threads of discourse together: The child comes to school having learned certain ways of dealing with problems occasioned by his inner needs and cultural demands. The school must accept these coping styles, however inappropriate or limited they may seem, as being the only ones the child could have learned, given his particular circumstances. It must keep the classroom situation flexible enough to accommodate many different coping styles, and must teach the child alternative ways of coping which are more efficient or more socially acceptable. On the other hand, the child who has had many experiences of the satisfaction to be obtained from successfully coping with problems will be ready to meet new problems with zest and confidence. He will, in fact, seek out his own problems, his own worlds to conquer. Even animals who have received adequate stimulation and affection in infancy will seek out

Reaction to Models of Perceptual Processes in Reading

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DR. GEYER points out that perception seems to progress from left to right and forward according to the direction of the language; that initial letters, ascenders, descenders, and vowels trigger recognition; that certain letters are less legible than others; and that errors within the word tend to be noticeable most of the time when they are near the beginning of the word. These observations prove that words are not recognized, perhaps, on an all-or-none basis but by specific types of cues, perhaps by beginning letters or by other distinctive letters which may not even be recognized as letters. It does not prove, in my opinion, that the reader tends to perceive letter by letter. If the "eye-count," as Geyer calls it, or the word is stored as letters or if it were a letter-oriented image, not a word-image, then why can't we spell many of the words we can read? This implies that we attend to the shapes of words rather than their constituent letters or their orthography.

Why do errors in oral reading and spelling tend to fall on the medial letters of words? You may say, "Well, they are vowels, they're variable in spelling, and, therefore, they would be a cause of difficulty." Thirty-five percent of spelling errors are phonetic substitutions, offering a letter which resembles in sound the correct letter or can be used in the same sense of sound as the original letter, implying, obviously, an auditory image, not a letter-by-letter image. Another thirty percent of spelling errors consists of omissions of letters or syllables—again, an illogical kind of error if the image were concerned with sequence of letters, or letter-by-letter image. Only sixteen percent of all spelling errors are additions of letters in an attempt to reproduce a correct sequence of letters.

How do we explain the fact that, particularly in the early stages of reading, the meaningful associations attached to words play a very significant part in their recognition and their eventual learning. For example, many reading errors are present in small words, prepositions, conjunctions, and the like. They tend to cluster there rather than on nouns and verbs. Why? Words like *Halloween, Jack-O-Lantern, Christmas,* and the like are learned quite readily by primary children, particularly in the language experience approach, and are learned in writing as well, when they are obviously very difficult in terms of length.

What evidence is there that order or number of letters influence learning in reading as it does affect spelling? Length is significant in spelling, but not in reading. The length of a word is immaterial in your ability to learn it or retain it. The order of the letters, I am saying, is immaterial. Why?

How can we explain the addition or substitution of words that seem to fit the context, if we do not recognize an important role of familiarity with language patterns, of auditory memories, of the way that sentences should be read, in other words, rather than their obviously being dependent on what is there.

How can some individuals read very well and spell abysmally if the images that they had stored are letter-oriented? How do we explain that pupils speaking a nonstandard English dialect read standard English—printed standard English—(omitting endings, auxiliary verbs, using wrong inflections, dropping past tenses, etc.) in their dialect? Are they attending to letter sequences, to what's there, or only in a very gross sense?

I am not arguing that all elements of the visual field are perceived instantaneously and simultaneously. Dr. Geyer is quite right in attacking this false basis for what is called the whole-word method. Even beginning readers involve several fixations of the word, usually, but not always, in the left-to-right direction, as any primary teacher can tell you. The question is whether the processing or the recognition of the stimulus is letter-by-letter, or even letter-oriented. Dr. Geyer's model is perfectly acceptable, if I read him correctly, except for this aspect of it.

Geyer's response

I would like to make a couple of points. I have really said nothing about the clue or the cue in reading. For instance, I talked about a rate of eight milliseconds per letter space. It is just a rate of input. It may very well indicate that the letter is more important than some people thought it would be, or it may not indicate that, but that would take other kinds of experimentation.

What I am interested in now—to use a kind of standard analogy to a computer, and it's only an analogy and shouldn't be taken too far—is in the program itself. I am trying to figure out what happens to the stimulus as it is processed. I think ultimately my way of looking and many people's way of looking, will contribute to many of the questions that Dr. Spache has asked, by allowing us to refine and define the process more closely.

My type of research has very little to do with the classroom now. I want to emphasize that again. Yet, I can think of instances that might be applicable. For instance, if we do scan on an input basis and if this scan can be from left-to-right or right-to-left, then it becomes relatively easy to understand how reversals can occur in small children. If we can break down the reading process into smaller increments, then it might be possible to test children with reading problems to find out at which point they are deficient and perhaps train them more specifically.

Spache has raised many basic questions and we do not have all the answers. For instance, little is known about the relationship between spelling and reading although we are sure they are related in some ways.

My model is concerned with the reading performance of good readers. At this moment, my approach is to try to find out how good readers read. The second step might be to find out how they learn to read that way and why poor readers might have learned some other way. At this point, how my model relates to learning to read is not known.

It would take a great deal of investigation to answer Dr. Spache's questions, and until that research is conducted, we will be unable to answer many of the points he raises.

Affective Factors in Reading

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IT WOULD SEEM APPROPRIATE, in a memorial symposium to Jack Holmes, to discuss the role of affective factors in reading within the framework of the substrata factor theory, since this was his major contribution to the psychology of reading, and perhaps more broadly, to the psychology of cognitive processes. Such an approach poses an immediate problem, however, for reasons which will become apparent.

Holmes was seeking to develop a model of the intellect which would be applicable to any cognitive activity, but he chose to concentrate on reading partly because of its focal point in the educational process, but also because, being a highly complex ability involving a wide variety of different kinds of factors, it provided a perfect illustration of the intricacies of his hierarchical model of the intellect.

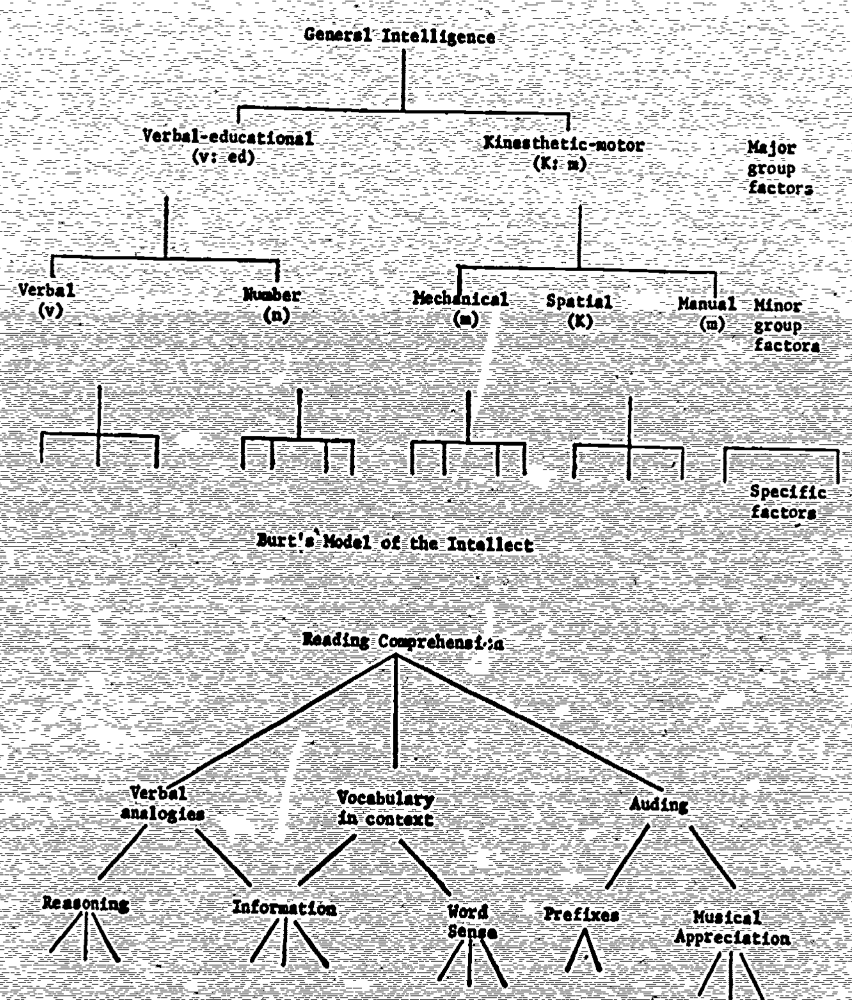
Models of the intellect are by no means a new phenomenon on the educational scene. We are all familiar with the various constructs which have been advanced at different times to explain the operation of the mind, ranging from Plato's dichotomy of the rational and irrational soul to Guilford's "three faces of intellect" (*25*), or the information-processing models based on computer simulation techniques. The controversy among two-factor, multiple-factor, and sampling theories has been well documented elsewhere (*70*). Guilford's theory is an important advance on these in that it expands the concept of intelligence to include such operations as divergent thinking (the core of creativity) and evaluation (also important in creativity) in such areas as social problem solving. Yet the 120 abilities appearing in Guilford's cubic model all seem to

Editor's note: An empirical investigation, based on the rationale presented in this paper, resulted in the development of a reading-personality scale. At the junior high school level, this scale was found to have an unusually stable and relatively high correlation of .36 with reading achievement (*3*).

have equal status; and there is no obvious reason why one should not continue to proliferate at will the number of abilities one is willing to regard as constituting intelligence. Whether one espouses a one-factor or a multi-factor theory seems to be a matter of the way in which one wishes to consider intelligence. One may, in fact, attempt to effect a compromise among the various theories by arranging abilities in a hierarchy as Burt (*11*) has done, placing Spearman's general intelligence *g* at the apex, and subsuming under it two major group factors, verbal-educational (v:ed) and kinesthetic-motor (k:m), each of which in turn comprises a number of minor group factors such as verbal, number, mechanical, or spatial, corresponding to Thurstone's primary mental abilities. Finally, under each minor group factor is a cluster of specific abilities which together comprise it. Many of Guilford's specific abilities might be found at this level. Presumably one could, if so inclined, continue to fractionate each of these into even more restricted abilities to the point where one arrives at the multitudinous specific connections posited by the sampling theory of Thorndike and Thomson.

There is a very obvious resemblance between Burt's theory and the substrata model, but Holmes used the hierarchical concept as a means of viewing any intellectual activity in terms of the subabilities which enable it to function, in other words as a way to examine the structure of the mind as it engages in different cognitive tasks. The term "structure" implying as it does, a static quality, must be used in a purely metaphorical sense in this context; and must include the notion that the structure changes from one activity to another, or perhaps even during the course of the same activity, in order to restore in some measure the dynamic flavor which is an essential feature of Holmes' theory. It is this dynamic quality which makes the basic difference between this theory and other hierarchical models, and brings the former closer to the more recent view of intelligence as an information-processing activity.

An element common to all the above theories is that they appear to deal exclusively with cognitive abilities, and one may ask whether the substrata theory differs from its predecessors in assigning a role to nonintellectual factors. It will be remembered that the technique of substrata analysis devised by Holmes to correspond to his psychological model, operates in the following way: A single variable (in



Holmes' Model of a Working System for Reading

FIGURE 1. Comparison of Burt's and Holmes' Theoretical Models.

this case reading comprehension, but any continuously distributed variable may be used) is selected as the criterion. The investigator then feeds into the analysis any or all variables which, on the basis of theoretical inference or empirical research, he has reason to expect will contribute to the variance in the criterion variable. He specifies a stringent test of acceptance, that is to say, a variable must make a statistically significant contribution (usually at the .01 level) in order to be accepted. Usually four or five variables are selected in this way, and are designated as Level I of the analysis, being the variables most closely related to the criterion. The next step is to analyze these variables in the same way, i.e. each one becomes a subcriterion, thus producing Level II of the analysis. Obviously, this process may be continued for as many levels as the investigator desires, or until a point of diminishing returns is reached which, in practice, usually occurs about the third level.

Now in all the studies by Holmes and his colleagues using the substrata model and technique, personality and attitudinal factors failed to appear among those variables making a statistically significant contribution to the variance in reading ability. This finding has been replicated in elementary (*69*), junior high (*38*), high school (*31*), and college (*29*). Should we then conclude that affective factors make no contribution to reading ability? A survey of the literature on this question immediately belies such a conclusion. Moreover, as the authors of the substrata studies point out, when the sum of the contribution made by each of the selected variables is computed, approximately 25 percent of the variance in reading comprehension remains unexplained. They surmise that motivational factors, either stable or temporary, may be operating, but these factors are other than those measured by the personality tests employed. As a matter of fact, the relationship between measured personality variables and reading is usually so tenuous as to prevent their appearance at any level of the analysis.

How can we explain the low correlations usually found between reading and scores on personality tests? They could be due to several factors, among which the following may be mentioned:

1. Nonintellectual factors are usually measured by personality tests which have been standardized on gross differences in clinical samples. These tests may therefore be insufficiently sensitive as instruments for probing differences among readers of varying levels of accomplishment.
2. The aspects of personality with which these tests are usually concerned may simply not be the ones which have most bearing on school learning.
3. The relationship between reading and personality may be different at different age levels and for different groups (*30*).

These aforementioned difficulties arise from the content and methodology of personality testing, and might be met by devising new instruments and techniques relating specifically to the affective aspects of school learning. We do not as yet have personality measures corresponding to the standardized achievement tests because the school has been much less concerned with the affective objectives of education or the means to assess them. An initial attempt to identify some of the specific personality characteristics related to reading was made in a study by Athey and Holmes (*3*).

There is also a theoretical possibility to account for the way in which affective factors function within the framework of the cognitive model. Holmes and Singer, to paraphrase their definition, view reading as a symbolic reasoning process, in which the various cognitive skills are mobilized into a working system (*one* particular working system from the many available to the individual). By a working system is meant the interaction of whatever aptitudes and skills are mobilized into the hierarchical pattern best suited to accomplish the chosen task—in this case, comprehending what is read. Computing an arithmetical problem, or detecting a logical fallacy, or even skimming the same passage to extract the main idea, would call for a different constellation of abilities.

Now it is obvious that some of the abilities which are drawn upon when one engages in a given task must be present whoever it is who is doing the task. Reading with comprehension cannot take place unless one has the minimal vocabulary, some knowledge of the grammatical structure of the language, and a certain background of information pertinent to the reading material. These are basic requisites for the task. Over and above these basic requisites, however, an individual may increase his comprehension by calling upon skills he has which another person does not have, or may have to a lesser degree. For example, he might fall back on his knowledge of Latin roots to assist him in analyzing the meaning of a key word in the sentence, or he might call on his knowledge of grammar to understand an ambiguous sentence in which one or more words could be functioning either as nouns or verbs. Hence, even in the cognitive realm, everyone's working system for a given task must be somewhat different, depending on the experiences he has undergone in developing the many strengths he is able to muster at a given time. Holmes' research suggests that some of these strengths may lie in areas which seem somewhat remote from the criterion task. If we had good measures of the appropriate affective variables, many of these "hidden" strengths might be found to lie in the kind of nonintellectual factors which appear in the research literature, that is to say, they would appear at various levels and points of the statistical model illustrating the working system. In addition, it is almost certainly the case that it is affective factors such as the desire for information and enjoyment which propel the working system into action, sustain it throughout the duration of the task, and terminate the activity as the initial purpose is fulfilled or modified.

We have spoken earlier of the "interaction" of the variables drawn into a working pattern, and it is interesting to speculate on the form this interaction may take. In the definition of reading previously alluded to, the word used is "interfacilitation." This notion has also been expressed in terms of a mutual and reciprocal causation hypothesis, that is to say, the two-way interaction of each of these variables with every other produces changes in all of them and in the overall performance of the criterion task.

Thus, if we consider an affective variable, say self-confidence, its role in the working system might be to enhance certain cognitive skills which in turn affect others, leading to improved performance in reading, which in turn leads to increased self-confidence. A more complex example might be anxiety. There is some research evidence (*48, 63*) to suggest that a relatively simple skill such as verbal fluency is facilitated by a high level of anxiety, but the broader, more complex skill of reading comprehension is depressed, because in this case the verbal fluency may take the form of irrelevant responses which interfere with understanding.

The mutual and reciprocal interaction (the world "causation" seems inappropriate in this context) has a further corollary which has been well expressed by Maruyama (*45*). Maruyama introduces the notion of "initial kick," which, in view of the process of self-amplification of a working system previously described, may assume tremendous importance in the eventual outcome.

> The process of self-amplification has a profound significance for the philosophy of causality. This process makes it possible

> that dissimilar developments may take place from similar backgrounds due to small, possibly imperceptible differences in the initial kick. 'The same cause produces the same effect' was an axiom in the traditional philosophy of causality. If there was a difference in the effect, a difference of a corresponding size was sought in the cause. . . . Now . . . we know that the difference may be due to nothing but the difference in the initial kick, which may be imperceptible or at least disproportionately small compared with the difference in the subsequent development. This amounts to saying that 'very similar initial conditions may produce 'entirely different developments.'

If one looks at learning in the context of the individual's life history, it may be seen that the initial kick which starts the learning process in a given direction, resulting in the development of highly complex knowledge and skills, may be some personality characteristic, some attitudinal trait, some value system, or even more specifically, the emotional aspect of some event, or even some unrelated affect which, by virtue of occurring simultaneously with a particular segment of learning, becomes associated with it. This association (by contiguity) of events may thus start the whole network of interaction processes leading to the establishment of interests and achievements. Many events in the form of external or internal reinforcers will subsequently be fed into the working system, which is thus constantly changing in both its cognitive and affective composition, and in the learning outcome which in turn is both cognitive and affective.

From this discussion there emerges a view of the substrata theory as a dynamic, information-processing system in which the input consists of both complex skills and attitudes toward the particular learning task in question, or perhaps more broadly, toward learning in general. The hierarchical model used by Holmes et al, rather than a graphic representation of the structure of the mind, becomes a convenient device for portraying the hypothesized interaction of the many variables constituting the input which results in the output we call reading comprehension.

When he look at some of the charts portraying the various working systems of boys versus girls, high IQ versus low IQ, etc. with the separate percentages attributed to the many skills involved, the model appears rather static, somewhat cut and dried, unless we remember that it represents a flash photograph so to speak of the working system of a particular group at a particular point of time. To study a defined group, e.g. bright high school boys, is a first approximation to studying an individual reader's working system as it is at the time of testing, which is somewhat different from the way it may be one year later, or perhaps even 15 minutes later. Ideally we would want to test all the inputs—skills, aptitudes, feelings, attitudes—as they are called into play while the reading act is actually in progress, much as the eye-movement camera records the reader's eye movements without affecting the ongoing process. In this way we would be able to observe moment-to-moment changes in the working system as the reader drew upon his phonetic skill at one moment, recalled a piece of information the next, or became anxious as he made certain inferences from the content read. Such a procedure would call for greater technical sophistication than we currently possess, but the idea is feasible in principle. An approach to this procedure is to be found in an old study by Vernon (*73*), in which irregularities in the eye-movement records of adults were compared with introspective recall data, showing the effects of interests, emotions, and imagery on comprehension. Certainly introspection is an inadequate method for studying cognitive processes, but with improved technology we may hope for significant advances in understanding the dynamics of thinking which, in essence, the substrata theory attempts to explain.

The conception of attitudes and emotions as potential "initial kicks" which may initiate a spiralling network of learning systems, immediately suggests that such affective influences may have their most profound, if imperceptible, effects in the years of early childhood and elementary school. Early childhood education is, of course, an area which has recently become a focus of attention among psychologists, primarily because they have come to view it as a period of great potential for learning. No one who has had day-to-day experience with young children can doubt that the first four or five years are a period of tremendous learning, but we should hasten to add that, in this context, learning has a broader connotation than is normally given to it in the school years. It does not mean learning to read at two years of age, or acquiring the basic "readiness" skills for learning number series, or learning how to think scientifically, though it may include any or all of these. Especially at this age, we make a false dichotomy if on the one hand we insist on accelerating school learning on the grounds that these years are being "wasted" in play, or equally if on the other hand we are opposed to such learning as being "forced." For the young child there is no division between his cognitive, emotional, and social learning; these are merely convenient ways for us to look at what is happening, and like all frameworks, they can be misleading if we place too much reliance on them. What the child is learning is ways of coping with his environment and manipulating it to fulfill his needs. Any so-called cognitive learning which takes place provides, or should provide, additional fuel for continued problem solving. The problems are of two kinds: those stemming from the child's internal needs, and those stemming from the external demands imposed on him by the physical and social environment. Young children, when they first come to school have, by virtue of their home experiences, already begun to manifest individual styles of coping with both these kinds of problems. Researchers in this area (*20, 36, 76*) have referred to these ways of coping as "cognitive styles," by which is meant a style of cognitive functioning related to one's personality makeup. In bringing together threads from perception, concept development, and personality, the concept of cognitive style may have important implications for reading, though it should be emphasized that these are still highly tentative. Kagan views cognitive styles as "stable individual preferences in mode of perceptual organization and conceptual categorization of the external environment" which are related to the sense of identity, the self-concept, and the level of emotional maturity. He has presented evidence that these cognitive styles are acquired early in life.

Perhaps the most comprehensive work in this topic has been done by Gardner and his associates, who have explored six dimensions of cognitive style, which they call "cognitive controls" or "control principles." A detailed description of these principles would be appropriate here only to the extent that it could lend insight into the reading process, but the research on this topic is still very scarce, and only suggestive at best. However the parameters of cognitive ogy of his culture, his enthusiasm for "projects," in brief, his willingness to engage in experiences from which he learns to expect the pleasure accruing from work, an expectation we hope he will retain throughout his life.

Thinking about the relationship between this aspect of mental health and learning, and the way in which reading fits into this perspective leads one to a consideration of the various aspects of mental health enumerated by the panel of experts on the Joint Commission, and to wonder to what extent the research literature has confirmed the relationships between reading and the dimensions considered by the panel as indicative of mental health. Following the line of reasoning which views reading as one in a series of culturally imposed developmental tasks, one might hypothesize that the good reader will be the child whose home background has equipped him to cope with successive developmental tasks, and has thus placed him in the best position to meet the challenge of new tasks imposed by the school. We may leave aside for the time being two related objections—that reading may provide an escape for many poorly adjusted students from social and emotional problems, and that some well adjusted children who are poor readers can find a sense of well-being through other avenues such as sports. If the first is true, it probably applies to older children; and if the second is true, it cannot continue to be true for very long, by virtue of the tremendous pressures brought to bear by both home and school in connection with learning to read. Perhaps we need to consider the relationship between mental health and adjustment, and to ask ourselves whether a person cannot achieve mental health without being extremely well adjusted in the social and emotional sense.

The Joint Commission's criteria have been used therefore as a guide to organizing the research literature on affective factors in reading. If the relationship with reading turns out to be positive in most of these categories, we may assert with rather more confidence that, within the age-range considered (which in this case is preschool through high school), those children who are superior readers tend to be the ones who exhibit characteristics stipulated by experts as criteria of positive mental health. Accordingly, the research will be discussed under the following headings as they appear in the report (*34*). The order has been changed somewhat, and two new categories added, *attitudes toward learning and anxiety* (*3*). For a fuller review of the literature, see Athey and Holmes (*3*).

Self concept

In general, the research literature suggests that good readers tend to have more positive self concepts than poor readers (*26, 40, 41, 43, 57, 78*). This finding seems to hold for a variety of measures of self concept, and for all grade levels from one through nine. More specifically, feelings of adequacy and personal worth, self-confidence and self-reliance seem to emerge as important factors in the relationship with reading achievement. Conversely, underachieving readers tend to be characterized by immaturity, impulsivity, and negative feelings concerning themselves and their world (*7, 8, 56, 69*). The work of Bricklin (*10*) and Sopis (*64*) suggests that the relationship may be defined in terms of particular reading deficiencies and the self image as a reader. Wattenberg and Clifford (*74*) suggest that indices of the sense of personal worth and competence, if used in kindergarten, would add significantly to reading prediction.

Autonomy

Shatter (*59*) found that fourth grade boys who were retarded readers made significant gains in reading and in maturity, independence, and self-reliance as a result of a group therapy program. McGinnis (*47*) found that parents of good readers manifested attitudes favoring growth of independence and exposed their children to democratic practices and environmental activities which would encourage such growth. Conversely, Carrillo (*12*) found poor readers to show lack of independence, avoidance of leadership opportunities, and a poor attitude to responsibility. On a nonverbal task requiring the subject to place himself in relation to a triangle with points labelled parents, teacher, and other children, poor readers placed themselves within the triangle significantly more frequently (*28*).

Accurate perception of reality

There is some suggestion that poor readers may be less aware of (*44*) and more prone to hold erroneous conceptions of their environment (*33*), specifically their teachers and peers (*32*). They have been found deficient in ego strength, defined as "the ability to gauge reality and synthesize behavior in appropriate goal-directed activity" (*4*). Ramsey (*53*) and Lasswell (*39*) have remarked that poor readers are less realistic in their estimates of themselves as readers, while Bouise (*9*) and Van Zandt (*71*) have demonstrated a similar lack of realism with respect to educational and vocational aspirations. In a series of carefully documented case studies, Shrodes (*60*) has described changes in students' self-awareness and growth of insight into the motivations governing behavior as the result of a course of bibliotherapy.

Holzinger (*32*) found that poor readers in the first grade scored significantly lower on peer and teacher perception, while those in the fourth grade, in addition to the above measures, were also significantly lower on self perception. There is some suggestion that poor readers may be more interested in the world of fantasy than in the realities of the school situation. Gates (*21*), for example, observed 26 cases of recessive behavior, including chronic mind-wandering and daydreaming, among 100 poor readers.

Environmental mastery

Blackham (*7*) found ninth grade overachievers in reading to have a greater amount of intellectual energy at their disposal, to be more spontaneous and creative, and able to make finer intellectual discriminations. Tabarlet (*68*) found fifth grade children, two or more years retarded in reading, to be inferior to normal readers in interpersonal skills, social participation, satisfactory work and recreation, and adequate outlook and goals. Carter (*13*) reviewed the later careers of retarded readers of normal intelligence, and found that their vocational mobility and aspirations tended to remain horizontally oriented. Norman and Daley (*49*) found clusters of items suggesting feelings of "environmental deprivation" and maltreatment to differentiate poor male readers in the sixth grade, while Spache concluded from two studies (*65, 66*) that the typical retarded reader in the primary grades had less insight into the human dynamics of a situation, and manifested less solution-seeking behavior. Abrams (*1*), likewise concluded that nonreaders were more impulsive and less able to respond appropriately to environmental stimuli than good readers.

Attitudes toward learning

Since reading is the basis of learning most other school subjects, it seems logical to suppose that when the child finds reading a pleasurable experience, his positive attitudes toward reading will rapidly become generalized to most other subjects. Conversely, his expanding interests should lead to a deeper love of reading as a primary source of information and enjoyment. Such burgeoning curiosity may find many other avenues of expression besides reading, of course, but in this society reading still remains one of the major vehicles for satisfying a desire for knowledge. Some authors have suggested that curiosity may be a basic drive (*75*), and the members of the White House Conference panel assign it high priority in their list of important indicators of mental health.

The available evidence tends to support the view that good readers are likely to be more intellectually oriented (*21, 23, 77*), exhibit higher aspirations (*39*) and drive for achievement (*5*), and to show more curiosity (*46*) and more positive attitudes toward school in general (*13, 23*) and reading in particular (*24, 27, 37*). Johnson (*35*) found that by categorizing first grade children as "eager" or "reluctant" readers, he could predict reading success in the second grade, even though the two groups made comparable scores in initial reading readiness tests. Attitudinal factors have similar implications for remedial reading (*51*).

Biel (*6*) and others have hypothesized that the known sex difference in the number of reading disability cases may be attributable in part to the difficulty boys experience in identifying with women teachers in the primary grades. Gowan (*22*) and Fliegler (*18*), after reviewing the literature on gifted underachievers, point out that the underachiever is usually characterized by an inability to identify with authority figures, or to create warm relationships with either teachers or peers. Dorney (*15*) found that delinquent adolescent boys improved significantly in their attitude toward authority figures after a course of reading instruction.

Anxiety

Smith and Carrigan (*63*) have suggested that anxiety is an important dimension in reading disability, its role being to excite some functions such as fluency, and to depress others such as word recognition and day-to-day memory. A number of investigators have found a significant negative relationship between reading comprehension and anxiety (*14, 19, 48, 50, 52*) or neuroticism (*54*). Other authors have suggested that the influence of anxiety may lie in its interaction with other variables such as perceptual . dity (*61*), introversion (*72*), intelligence (*55*), socioeconomic st. . (*16*), and disparity of reading and arithmetic performance (*42*). On the other hand, some researchers have failed to find any relationship between reading ability and anxiety (*2, 58*), so the role of anxiety in reading success or failure remains in some doubt.

In summary, the organization of some of the research literature into domains corresponding to the characteristics which the Joint Commission on Mental Health identified as major dimensions of the healthy personality does suggest the possibility of a relationship between all of these dimensions and reading success or failure. It lends credence to the notion that, if learning to read is viewed as a developmental task imposed by the society at the time the child enters school, then the child's previous history in coping with earlier problems and challenges will be an important determinant of his style of approach to this latest challenge. In fact, the link between the two theoretical models discussed—the substrata model and the developmental task model—must be sought in the early experiences of autonomy, mastery, etc. which initiate the whole process of cognitive-affective growth and are bound up with the individual's cognitive style. Thinking again in terms of an individual's dynamic working system for reading, that small "initial kick" which starts the child on the road to self-confidence or environmental mastery may, through its reciprocal interaction with the intellectual and psychomotor variables involved, produce a high level of achievement on a complex variable like reading ability out of all proportion to its original power.

In view of this complex interaction, it is apparent that the school can no longer afford to devote the major part of its resources to teaching only in the cognitive domain, and an insignificant portion, if any, to the affective domain. As pointed out earlier, we need not only greater clarification of our educational objectives in the affective domain, but much better methods for evaluating our accomplishment of these objectives, so that evaluation of the cognitive and affective can proceed hand-in-hand in a coordinated fashion. On the research front, such measures would be invaluable in sharpening up the picture of the precise relationships between affective factors and school learning. Until such time, we must remember that learning to read, or even school learning as a whole, is not an end in itself, but a means toward greater self expression through successful coping with problems and the invention of new problems with which to challenge the developing organism.

> The role of the intellect is to enrich rather than curb the emotions, to direct their expression toward goals emerging from viable knowledge and cultural ideals (*67*:13).

If we want our children to be intellectually literate, perhaps we should concentrate on making them emotionally sound as the most efficient route to our dual objective. Perhaps we should worry less about Johnny's reading ability, and more about Johnny.

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Reactions to Affective Factors in Reading

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I AM IN TOTAL AGREEMENT with the basic notions presented by Irene Athey in her paper "Affective Factors in Reading." Feelings *are* important when a child is learning to read; feelings are important at any stage of the reading process; and even more fundamental, feelings are a major factor in learning and must be taken seriously by the teacher. The major contribution of Dr. Athey's paper is to provide the empirical evidence to support these rather obvious notions.

It would appear, however, that many people concerned with teaching reading may have lost sight of the importance of feelings in learning. A quick look around the materials exhibit and a glance through the titles of major papers presented at the 1969 International Reading Association Convention leads one to conclude that the reading profession is now dominated by linguists and machine-oriented psychomotor skill enthusiasts. The influence of those who think that a sequence of skills in the reading process can be identified and taught directly in some kind of neat program with little regard for the learner as a human with desires, interests, and needs seems to pervade the profession at this time.

In this short paper I intend to take the theoretical notion developed by Athey that feelings are important in reading and apply it to the real world of the classroom. I shall suggest three specific possibilities for the classroom teacher who is concerned that she may be neglecting the affective domain in teaching reading:

First, a paradox: the reason so many teachers neglect the feelings children bring to the task of learning to read is probably because they spend so much time and energy teaching reading. The teaching of reading in most primary classrooms has become such a serious, grim, and time-consuming task that teachers have little time to help children cope with their fears, frustrations, pride, desires—in fact, the children are kept so busy going through the basal reader game that they have little time to express openly these basic human emotions. Perhaps teachers should spend less time in the reading circle and more time in something like the "magic circle" as proposed by Bessell (*1*) in his *Human Development Program*. Bessell gets children from the age of four up to thirteen to sit in a circle and talk about what they do well, what they fear, etc., and has developed a program for teachers to use in the classroom. There is much evidence to indicate that most teachers in our present day society need the assistance of such a program to get them to focus on children's feelings. Since most teachers grew up in a society in which they learned to repress their honest feelings rather than express them openly, they carry their tendency to fear expressions of emotion into the classroom. Teachers are relatively secure when their children are locked into a basal reading program in which expressions of real personal emotion have little chance to erupt. In a society in which children must be encouraged to be spontaneous and open to counteract the restrictions of external control, teachers cannot afford to place so much emphasis on teaching reading and neglect important human emotional development.

Second, teachers who are concerned with children's feelings in learning to read should examine carefully the model for a primary school and beginning reading program found in the Leicestershire County Schools in England (2). The Leicestershire County Schools have developed a model of a primary school which is much like our idea of a nursery school except that this model is carried up into the lower and middle grades. Visitors from our country have returned with glowing reports about happy, industrious, self-instructed children who seem to be thriving emotionally and intellectually under a system in which there is a minimum of pressure to follow a structured curriculum. The dimensions of the Leicestershire model that seem to have direct bearing on children's feelings in reading include the following: 1) *Older and younger children in the same class.* There are several advantages of this situation as far as reading is concerned. The older children who are already reading present a model for those who are still learning. The young children watch the older children reading; in fact, read along with them in choral reading experiences. Older children frequently are found reading to their younger siblings. Then there are the numerous opportunities for the older children to teach the younger children spontaneously throughout the day, helping with an unfamiliar word, helping with spelling, etc. We have known for years that the best way to learn anything is to have to teach it. 2) *A curriculum built around areas of interest rather than content subjects.* As far as reading is concerned, there is no formal reading period but reading goes on informally throughout the day. The teacher tries to spend some time each day with each child, either individually or in a small group, keeping close check on each child's progress in reading. 3) *A slow, relaxed, anxiety-free introduction to reading.* The child has an opportunity to take about four years, from the age of five to nine, to break the code. There seems to be no pressure put on him by the teacher or apparently by the parent to show significant progress in code-breaking by Christmas of first grade, as is true for many of our first graders.

It seems obvious that this natural, pressure-free, learning-to-read process in which older peers play a major role provides children with a learning environment that is highly conducive to expressing openly and coping with feelings.

The final suggestion for those teachers who are concerned about children's feelings in reading is to reexamine the literature concerning individualized reading. In the early 1960's there was an obvious trend toward an increase in individualized reading programs, but in the last few years that trend seems to have reversed. We hear little about individualized reading and see few examples of it in the classroom.

As far as feelings in reading are concerned, the most important element in an individualized reading program is free choice of reading material. When the reader is able to choose what he wants to read, we maximize the chances that material will have high personal meaning for him. We also maximize the chances that reading experience will be involved rather than superficial, thus increasing the reader's opportunities to practice "good" comprehension skills.

The literature concerning individualized reading reveals one irrefutable impression: children who go through an individualized reading program seem to read significantly more and seem to enjoy reading more than those who go through a basal program. How many teachers ever consider the effect on children of continually going through a reading program in which they have a minimum of control over what they read? Free choice responds to personal feelings and, therefore, would seem to be an important element of any reading program.

Summary

We live in a society in which the pervasive effects of external control on humans must be counteracted by encouragement toward spontaneity, open expression and recognition of basic feelings and emotions. The major purpose of this paper was to suggest several possibilities for creating and modifying a reading program in the schools to enable children to express and recognize these feelings rather than repress them.

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Reading as Cognitive Fu: ·ioning

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FOR MANY YEARS authorities have contended that reading is an intellectual process akin to thinking. Much speculation has been done about the concepts and cognitive skills used in this process. Huey said that when reading was done for the attainment of the reader's purposes, it became excellent practice in the higher thought processes. The feeling for values and the choosing of the relevant requires, he said, a mental discipline that is ". . . golden practice in the training of judgment" (*15*:363-364). He went on to say that "real reading" whereby the reader actively and sympathetically follows the ins and outs of an author's intentions, his fidelity to truth, his accuracy and method, ". . . cannot but train the mind to modes of functioning that are similar to his" (*15*:365). By so doing it "acquaints one with the more effective ways of thinking, and develops them in the reader . . ." (*15*:365).

Apparently not all of the variability of attainment in reading is attributable to conditions within the learner. Some of it results from differences existing among authors as reflected in their thinking and their writing. Both conditions, author and reader differences, are encompassed by a host of variables which affect success in comprehension and concept learning. If, as Bacon said, writing maketh the accurate man, then the degree to which authors observe the disciplines of accuracy permits an imitation by readers that should be cognitively productive. It would be dangerous to assume, however, that reading the classics resulted in automatic acquisition of cognitive skill by-products.

The admonishing of many scholars about the proper business of schools, and particularly the teaching of reading, has until only recently been negated largely by teaching practices that produce nonthinking parrots and word callers. Many so-called authorities in reading have been writing glowing accounts of the need for efficient reading and the use of higher mental processes and at the same time attaching their names to reading instruction materials that cultivate passive mastery. Recent advances in the understanding of concept attainment and the maturation of thought processes have great promise and may offset such compromising.

Reading is a mental process—a dynamic, active process and it can be taught that way. Teaching strategies that can elevate cognitive effectiveness are being developed. As a result we need no longer wait for the superior children to discover the strategies of thinking by slowly and painstakingly examining the writing of scholars to determine their modes of functioning and in the meantime see the less able either drop out or become semiliterate robots.

Language and Thought

The role of language in cognitive development is undoubtedly significant. It is largely because of language and symbolization that most forms of cognitive functioning become possible. In this regard, however, Piaget has been quite clear about the relationship between language and intellectual operations.

The source of intellectual operations or cognitive functioning resides in the sensorimotor period in which the intellectual instruments consist of percepts and movements (*25*: Chap. 3). Even though objects and events are experienced only in their perceptual immediacy, elementary forms of conservation and operative reversibility are to be found. For instance, recognition of the permanency of objects represents a first invariant. Thus the changes that occur in intellectual operations when language is acquired show that language is not fully accountable for the transformations.

The beginning of representation and of representative schematization or symbolic functioning in general appears at about the same time as language. Symbolic or imaginative play is a source of personal cognitive and affective representation that is contemporaneous with the appearance of language but is independent of it. By the end of the sensorimotor period, thought with its roots in action, has permitted a child to overcome initial perceptive and motor egocentrisms. He can attain practical aims by activity that yields success cognitively speaking and pleasure affectively speaking. Deferred imitation, or imitation that occurs in the absence of a model, and mental imagery, or the sonorous imagery of a voice represent two other possible links between sensorimotor behavior and representative behavior.

Sinclair-de-Zwart, a linguist on Piaget's staff, uses an apt illustration to distinguish between symbols as signals and as signs. The former leads to what is signified much as the part leads to the whole. In addition they are usually personal. Signs, on the other hand, are distinct signifiers that are arbitrary and can form systems. For instance, a child pushing a shell along the edge of a box and saying "meow" illustrates signals as signifiers. The shell has a resemblance with the object (cat) and the word *meow* is a signifier (*28*).

Such acts of practical intelligence accompanied by words (language) are thus a part of a much larger process constituting intellectual operations. Even though language is necessarily interpersonal and a system of arbitrary signs that frees the individual from the immediate, it is a particular form of symbolic functioning. Sensorimotor schemata seem to be of importance not only from the beginning of intellectual operation but continue to develop and structure thought up to the constitution of formal logic. "It is permissible to conclude," writes Piaget, "that thought precedes language and that language confines itself to profoundly transforming thought by helping it attain its forms of equilibrium by means of a more advanced schematization and a more mobile abstraction" (*25*:91-92).

While it appears to be true that language and the like make possible most of the complex forms of cognitive functioning, it is not the source of all coordinations. School learning and reading instruction cannot overlook such truths. Many operations are basically coordinations among actions before they are transposed into language and the operations of thought. Children can classify collections of objects or seriate objects before they can do so linguistically.

> The question is also whether language is sufficient in and of itself to give rise to these [formal] operations *ex nihilo*, or whether, on the contrary, its role is limited to allowing the fulfillment of structuring which originates from the systems of concrete operations and, therefore, from the well-springs of action itself (*25*:95).

Undoubtedly language permits symbolic condensation and social regulation and the integration of actions into simultaneous systems, but also it is linked with actions in continuous reciprocity. Sinclair-de-Zwart, after summarizing her studies on linguistic development and research on deaf and blind children, said results confirmed Piaget's views that "... language is not the source of logic, but is on the contrary structured by logic" (*28*:325).

Cognitive Development

Cognitive development is a continuous construction of intellectual operations that evolve toward a subtle and mobile systemization essentially directed toward equilibrium. Intellectual operations, or the organization forms of mental activity, are rooted in action and are always a part of a system of operations or structured wholes. At all levels of development there are constant functions common.

> . . . action presupposes a precipitating factor: a physiological, affective, or intellectual need. (In the latter case, the need appears in the guise of a question or a problem.) . . . in addition to the constant functions, there are the variable structures (*25*:4-5).

The constant functions assure transition from one period of development to another and the variable structures provide the organizational forms of mental activity, intellectually as well as affectively.

The developing child acquires complex sets of learnings based on discrimination, perception, transposition, and generalization. In so doing he acquires concepts and a set of appropriate behaviors. Concepts and processes enable a child, according to his capacities, to cope with his environment, to organize his mental activities along two dimensions—intrapersonal and interpersonal (social), and to form attitudes that are emotional and intellectual.

The *stages of intellectual development* as described by Jean Piaget provide a schematic description of developmental cognitive changes that occur through time. His stages are open-ended enough to allow for the fact that children show different levels of ability, knowledge, and skills as a function of the rate and quality of the learning experiences they encounter.

The first two years of life are described as the *sensorimotor* *period.* The infant, using the inherent reflexes of his biological endowment, interacts with his environment. The interplay of internal and external conditions through stimulation and response characterizes the normal development of infants. Gradually from the maze of undifferentiated, unreflective, and unspecified experiences the child attains rudimentary knowledge. To accomplish this, he "... establishes a differentiation of himself from objects; he localizes himself in space; he establishes a beginning awareness of cause and effect, of time and space" (*27:215*). By the time most children are eight to twelve months old they have shown intention or goal-directed activity. Purpose, or the intentionality of purpose, now begins to influence their interactions. This is a big stride intellectually as awareness of "means-end relationships" helps the child to cope with the physical and social complexities of his world. By the end of this stage the child is well on the way to dealing with his environment symbolically and conceptually. He can already invent solutions in his mind rather than acting them out by trial and error.

It is apparent, then, that in the first two years of life children live in a world, albeit a concrete world, and in a series of situations. The interaction that is going on between a child and his physical and social world permits him to separate himself from his environment as well as to realize that the environment has certain properties of space, location, permanence, and causality. Increasingly, he is able to operate symbolically by classes or groups. He can tell that a dog, Silver, is a member of the dog family but cannot deal with the category *animal.*

The next five years of life Piaget describes as the *preoperational phase.* In this phase language plays an increasingly important role as the child acquires concepts through a complex set of processes. To attain concepts he has to become increasingly sensitive to objects in his concrete world. He has to learn not only that they exist but, also, that they have many characteristics and attributes. In addition he sees that diverse items can be organized into classes or categories (Silver, collie, dog, animal, vertebrate) and that language can facilitate as well as direct the process.

At the *sensorimotor period,* a giant intellectual stride noted was the influence of intention or purpose, the sensing of means-end relationships. At the operational stage an equally significant stride is made as the sensory-motor infant becomes, through symbolic functioning, a manipulator of representations. The act of symbolic functioning is the result of the generalized capacity to differentiate between signifiers—symbols which stand for something, and significates—the objects. This representational intelligence through its possession of symbolic functioning sets the stage for the upper limits of cognition and the manipulation of reality.

At this stage, though, conceptualization is dominated by the world of percepts. The potency of physical attributes to a large degree determines the concepts formed. Piaget calls this the preconcept period because children grasp first-level concepts primarily. They can grasp the fact that peaches and pears are food but cannot distinguish between different pears. Or, they can recognize that certain very different things belong together: daddy's watch, daddy's chair, daddy's hat.

In the four to seven years of age phase, increased symbolic functioning is possible. Signs—linguistic signs—are acquired from the social surroundings and are socially shared. Words are the commonest signs of our codified and socially shared linguistic system.

The private signifiers or symbols as well as the early use of linguistic signs provide the focus for Piaget's saying that children are egocentric. They lack generally the ability to take the role of another person and to treat their own thought processes as the object of thought. Over and over again Piaget indicates that it is in the context of social interaction as a member of a learning group that a child, forced to take cognizance of the ideas of others and forced to become increasingly cognizant about his own thoughts, their reliability and validity, emerges as a sociocentric objective scholar.

In addition to grasping the function of images and signs as signifiers, the child learns to use them as anticipative mediators of future actions. Starting with imitative images which serve as anticipative schema, the child begins to direct future action. He begins to evoke acts and deeds in thought, as opposed to actually carrying them out in reality. This ability to anticipate, to look ahead, to conjecture, to speculate leads to the ability to hypothesize, to deal with variants and covariants, and to test logically. In the life of a learner this ability signifies advance of the utmost importance. It is the pattern of inquiry which George Kneller defines as, "... to analyze the problem and to consider ways of dealing with it—that is, to set up hypotheses" (*22:42*). Now the learner is becoming more reflective and less impulsive. He is beginning to want proof, to suspend judgment, to think of information as tentative and relative. Rather than seizing on the first idea that occurs to him, he pauses (suspends judgment) to note whether or not there are better ways or other alternatives.

Another cognitive advance that occurs at this stage is the ability to use numbers, not only to order things in terms of quantity, but also to see that relationships can exist on a numerical basis. A system such as the number system has properties too—formal properties that are agreed upon by mathematicians. The child who can produce a sum deals with an abstraction based upon formal properties of mathematics. Interestingly enough, Piaget makes it quite clear that the understanding of numbers does not begin by learning numerals.

The latter part of the preoperational stage finds children making judgments largely on the basis of partial and immediate perceptions and/or on the basis of objective similarity. They judge by the way things look and usually in terms of just one of a number of relevant dimensions. Even so, three fundamental operations can be determined. They can think in terms of classes. When presented with a group of circles or squares, they can classify the items on the basis of roundness. They can think in terms of relationships; i.e., Mr. Jones is the father of Ralph, Mr. Jones is bigger than Ralph, and Ralph is the oldest of three children. They can think in terms of quantity or by handling number concepts.

In the *concrete operations* period the thought of the seven to eleven age group is more like that of the adult in that they think more in logical terms. Operations is used by Piaget to refer to mental acts or imminent acts of an internalized nature and taking place in the mind. These mental acts represent a process of interaction and development whereby new syntheses are formed by discovery. Attributes are noted, objects are classified, and categories determined. These syntheses are real in the sense that they not only have a location in time and space but also that they take place in the minds of human beings. In the process of cognitive growth through discovery and synthesis the individual is merely the neural medium in the resynthesis of cultural elements.

Three significant operations described by Piaget are *reversibility* as in arithmetic ($2 + 3 = 5$ or $5 - 3 = 2$), *classification* or the organization of objects into classes (desk, chair, table = furniture), and *seriation* or arranging ideas along a spectrum of increasing values (2, 4, 8, 16, 32). In brief at this stage the child is able to treat objects as alike (desk-chair) (furniture) even though different, to note that they can be in more than one class and that come classes can be subordinate to others, and to count one item as first and another as second.

In addition the child has to understand the concept of conservation. In other words, he has to see that certain properties of objects such as quantity can remain invariant even in the face of certain changes. For instance, two circles with a diameter of six inches remain alike even though one is cut into quarters and the other is cut into thirds. Cutting the circles doesn't alter the amount or quantity of the circle.

To arrange items in a series along a continuum a child must grasp the principle of transitivity. He must understand such ordering whereby he recognizes that if *A* is larger than *B*, and *B* is larger than *C*, then *A* is larger than *C*.

In this concrete operations stage, even though the child's thinking may be logical and systematic, his thoughts are limited to the direct experiences he has had. When he has no direct experience, he tends to reason by analogy to something he has experienced. In this regard, the crucial element may be verbal ability, as well as physical activity and social interactions with verbal ability, acting as a support to help a child overcome the influence of his visual perceptions. While training designed to increase the appropriate vocabulary may facilitate the development of logical thinking and help resolve the perceptual-cognitive conflict, it is "equilibration" or self-regulation that takes on greatest significance. To permit a child ". . . to learn an appropriate answer without making certain that he can retrace his steps, or arrive at the same result in another way, is to encourage the erection of a verbal superstructure that may crumble under even minimal cognitive stress" (*1*:123).

The fourth stage or that of *formal operations* is the time when abstract thinking develops. The child enters this stage at about the beginning of adolescence. Now he begins to grasp the ability to deal with the possible without reference to the actual; he begins to grasp the complexity of human knowledge by learning how to construct theories and make logical deductions about their consequences without the need for empirical evidence. As J. McV. Hunt puts it, "... instead of observation directing thought ... the adolescent's thought directs his observing" (*17*:355). In all this, language, or representational thought, plays an important role, but Piaget is of the opinion that ability to use language to express logic is an outcome of activity, and that attempts to improve a child's logic by teaching him in the use of language is apt not to be very successful.

It seems then that language development as a part of maturation or all round mental capacity influences much of the child's progress, from thought that is predominantly perceptual and intuitive to thought that is more conceptual and logical. A child's verbal accommodation to a learning experience is helpful but it will produce lasting effects only if, through further self-regulation, generalization to other tasks has resulted. It is not enough just to have had an experience, even verbally, unless it affects a child's way of organizing his experiences.

Finally, as Piaget has declared, the key factors in the transition from one level of thought to the next involve maturation, social interaction, physical activity, and, most important, the process of equilibration or self-regulation.

Children's cognitive actions and interactions, intellectually and affectively, as described by Piaget, suggest that reading ability to the degree that it is cognitive in nature represents similar potential. It remains for us to account for the reading-thinking processes in as definitive and astute a manner as he did. Reading tasks structured carefully both syntactically and semantically may reveal the "how" of the reading-thinking act and the "why" of different strategies for attainment and assimilation. Developmental stages may be determined and reading materials prepared to foster growth in subtle and mobile skill acquisition and functioning.

Piaget's theory of cognitive development advanced over the past half-century reflects an empiricist-idealist base and has only recently met with wide acceptance in the United States. He starts from the central postulate that action (motor) is adaptive and is the source from which mental operations emerge. Intelligence is viewed as an adaptation, an organizing activity whereby there occurs a progressive balancing of increasingly complex forms under the impact of experience. His work in cognitive development and critical thinking now represents a major influence upon basic research in psychology and education.

Concept Learning

Concept attainment is now generally considered a part of the psychology of learning and the development of cognitive processes (*12:37*). Attention is focused on the logical form of concepts with studies of concept attainment generally based on inductive methods and the strategies used (*6:37*). Strategies differ from person to person, from discipline to discipline, and from one level of sophistication to another. While many concepts are acquired by discovery, learning through discrimination, abstraction, differentiation, hypothesis generation and testing, and generalization, many more are acquired through school learning and/or reading. In the latter, the concepts are learned by means of criterial attributes presented and the relating of them to established ideas (*2*). Thus the acquisition of concepts can be accomplished inductively by concept formation or deductively by concept assimilation. Even so, there is a considerable likelihood that the learner must use much of the same processes of concept formation even when appropriate contexts are presented as in concept assimilation.

At the Wisconsin Research and Development Center for Cognitive Learning (*20*), *Concept* is treated as a superordinate category of which all concepts are instances and differentiated from other products of learning such as facts, principles, and problem-solving skills. A concept is referred to as having four characteristics—definability, structure, psychological meaningfulness, and utility. Four bases of *defining* concepts are identified in terms of perceptible defining properties, semantically, operationally, and logical or numerical relationships or axioms. *Structure* is determined by the form in which the concepts are experienced. *Psychological meaningfulness* refers to the phenomenological or idiosyncratic nature of concepts and the internal representations held by an individual. *Utility* is related to the use of a concept which is determined primarily by how well an individual has formed a concept.

Bruner (*6*) in his *Study of Thinking* defined strategies as regularities in decision-making and indicated that they provided the basis for making inferences about the mental processes involved in concept learning. He identified four strategies under the selection paradigm and two in the reception paradigm. Under the former he defined the strategies as 1) simultaneous scanning, 2) successive scanning, 3) conservative focusing, and 4) focus gambling. Under the latter he labeled them as 1) wholist and 2) partist. Byers' study (*7*) done at the Wisconsin Center designated the strategies used as one of three variants of a conservative focusing strategy or as one of two variants of a focus gambling strategy.

Byers found that practice modified the probability with which subjects used various strategies. Use of conservative focusing strategies increased while use of others decreased. Attempts at instruction in the use of strategies (*21:32*) showed that subjects were readily taught the conservative focusing strategy and did better than those not taught. On the other hand they could not be taught to use focus gambling strategies consistently and tended toward use of conservative focusing strategies.

Concepts are utilized when reading. The meanings of previously learned concepts and propositions are perceived and dealt with and the acquisition of new concepts is facilitated. The cognitive processes of concept attainment and concept assimilation are used most likely both in simple and more complex varieties of reading.

In addition it may be noted that insofar as the central role of cognitive variables are concerned the distinction between formation and utilization on the one hand, and problem solving on the other, becomes less definitive (*16, 18, 19*). This is true of concepts acquired by discovery as well as by meaningful reception learning. It is true of simple as well as complex problem solving.

Reading is a form of problem solving in much the same way as is concept development. All three—concept attainment, problem solving, reading—are active cognitive processes of seeking relationship to, differentiating from, and reconciling with, existing ideas, and the processes therefore overlap in many ways. Some of the principal ways are hypothesis-generating and testing, abstracting and generalizing. The efficient reader reads with a purpose, abstracts information, tests its value, and then accepts or rejects.

Singer (*29, 30*), after reviewing the literature on conceptualization and reading behavior, and in an examination of the variance in the substrata theory of reading, said that the formation and use of concepts needed to be accounted for as it entered into the development and dynamics of general reading ability. Similarly, Kress (*23*), using a battery of clinical tests of concept formation and comparing "achieving readers" and "nonreaders," concluded that capacity for conceptualization was specifically related to reading achievement.

As is already stated, to read requires a reader to employ the concepts he has acquired and provides opportunity to attain new concepts and remodel old ones. The act of acquiring concepts being so much like that of problem solving and in turn like reading, the analysis of concept acquisition can in turn be suggestive about ways of analyzing the reading-thinking act.

Critical Thinking and Teaching Strategies

Even though Huey (*15*), in 1913, stated the case for critical reading in a professional text on the teaching of reading, his account did not have the impact on thinking about reading as did Edward L. Thorndike's "Reading as Reasoning" report. (Thorndike concluded in 1917 (*35*:329) that

> . . . understanding a paragraph is like solving a problem in mathematics. It consists in selecting the right elements of the situation and putting them together in the right relations, and also with the right amount of weight or influence or force for each. . . . all under the influence of the right mental set or purpose or demand.

More recently Ennis (*9, 10*) has said that critical reading is the use of critical thinking in the act of reading. Russell (*26*) maintained a similar position and defined critical thinking as a three factor ability. He included an attitudinal factor of questioning and suspending judgment, a functional factor of logical inquiry and problem solving, and a judgmental factor in terms of some norm or consensus.

A significant study by Taba (*34*) was concerned with teaching strategies and thought processes. Her multidimensional analysis of classroom transactions in terms of measurable changes in levels of thinking had several advantages. Results showed that children can learn to make inferences, to generalize, and to make logical assumptions if they receive systematic instruction. The enormous influence of teacher behavior on the thinking of students was most impressive.

The Productive Thinking program of Covington and Crutchfield (*8*) showed that instructed children were more willing and able to make use of the cognitive skills and strategies common to both creative problem solving and to discerning reflective reading. They developed a general problem solving program of 16 self-contained problem solving episodes. Creative problem solving strategies were taught as well as a number of thinking strategies.

A comprehensive study done at Ohio State University had as the major purpose to determine whether or not children in the elementary grades could be taught to read critically. This required the development of an extensive operational definition of critical reading and the identification of specific skills. It also required the development of an observation instrument for classroom use. Bloom's approach (*5*) to ways of ordering knowledge influenced the development of a classification system for teacher's verbal behavior and Guilford's structure (*14*) of the intellect proved useful in determining the separate types of thinking of the pupils. Twelve teaching units were developed and a test labeled the Ohio State University Critical Reading Test (*37*). Results indicated that teaching critical reading is feasible to children of both sexes and that achievement is influenced by intelligence, general reading ability, and personality, and that teaching skill, especially the ability to ask questions and interpret pupil responses was a key factor (*36*). In this latter respect it is interesting to note that Gallagher (*13*) showed how the questions a teacher asks determined the kind of thinking the student did.

Ennis (*9, 10*), in a project on critical thinking, set as his goal to contribute to knowledge about what critical reading is and about when it can be taught. The report covering the first phase dealt with deductive logic in adolescents. He defined logic as that part of critical thinking which deals with whether a conclusion follows necessarily from the premises that are offered in support of it. Of the types of logic that exist he studied two: conditional logic and class logic. In general he concluded that progress in mastering class logic and conditional logic could be made although instructional time required varied.

Suchman (*32, 33*), has been experimenting with the teaching of strategies and tactics of scientific inquiry to children and devised a method known as inquiry training. He states that inquiry is "the pursuit of meaning" and his major emphasis appears to be on the means by which knowledge is acquired. While the training increased the numer of valid questions asked, he found no significant differences between two groups.

A longitudinal study to learn the nature and direction of changes from freshman to senior year in critical thinking ability, in attitudes of stereotypes and dogmatism, and in traditional value orientation was done at Michigan State University. There were marked changes in critical thinking ability, attitudes, and values from the freshman year to the senior year with the changes in critical thinking of greatest magnitude occurring during the freshman year (*24*). It might be concluded that students come to college with the hope that centers of higher learning are also centers that foster and require critical thinking. However, by the end of the freshman year they have discovered apparently that conformity and intellectual bondage win the higher grades and please the professors.

Berlyne (*4*:19) concentrated on directed thinking and defines its function as "to convey us to solution of problems." In so doing directed thinking involves both epistemic behavior and symbolic behavior. Such thinking is launched by a "felt difficulty," a problem, a question, a conflict, uncertainty, or disequilibrium and is in turn motivated thereby. The native propensity of the mind to ask "why" from age three on and its compelling force are still far from understood psychologically or physiologically, but there seems to be little doubt about the potency of the desire for equilibrium in the function of learning and thinking and their responsibility for adaptive change.

Strategies of thinking, of problem solving, of concept attainment must be learned and therefore can be taught. Similarly, strategies for effective reading-thinking must be learned and can be taught. It is significant and directive to note that a basic operational mechanism in problem solving and in concept formation is a problem, or a question or a mental set, and that a question well asked can be half the answer. Similarly it is the purpose of a reader that determines not only his rate of reading but also the nature and depth of his achievement. At the same time the most essential pedagogical skill is the teacher's resourcefulness in the art of questioning. As Piaget has said, "It is so hard not to talk too much when questioning." The unequivocal role of "the question" in learning as well as in the directing of learning is a point that has not been sufficiently appreciated. Undoubtedly there can be no learning without a problem and it is in this regard that the studies reviewed here are highly suggestive.

Conclusion

Sam A. Fleming (*11*:'2) said

> Dedication and clear thinking are our need today. It is ironical that in this period of so much learning . . . a specter of ignorance should hang over us . . . that there should be irresolution about many of the true values which are fundamental to our way of life.

Much the same might be said about what is reading and how to teach reading. Universal agreement can be obtained supporting the conclusion that comprehension is the invariant condition of reading. Almost universal agreement can be obtained regarding the conclusion that reading is a process akin to thinking. Some few agree that if the first two premises are true then reading should be taught as a thinking process (*31*).

This review of theories and practices concerned with cognitive functioning and development and its possible relationship with reading per se and with the teaching of reading may prove helpful if it will stimulate research that will define ways and means to more effective reading. Specific thought processes involved in reading for various purposes and with varied materials should be identified.

There seems little doubt about the nature of the strategies involved in reading-thinking acts. Increase in task complexity most likely requires cognitive functioning that ranges in complexity from stage to stage of maturity similar to the stages Piaget and others have declared. Like related intellectual tasks such as concept attainment, reading requires of the reader problem solving ability that is logical and mobile. Undoubtedly, too, achievement is influenced by a reader's intellectual potential, his attitudes and values, his intrapersonal and interpersonal dimensions, and the teaching and testing to which he is exposed. Even though at the college level a renewed attempt at critical thinking is made by college freshmen, pedagogical demands do not foster similar changes across the four years.

Children deal with means-ends relationships as early as the sensorimotor period. They learn to deal with variables selectively and to act reflectively in the preoperational period. They make decisions on logical terms through immanent acts of an internalized nature. This they do by discovery and synthesis as they resolve perceptual-cognitive conflicts of the operational period. Finally at the logical stage they can construct theories and make sound deductions without the need for empirical evidence. And in all this, language (oral or written), or representational thought plays a highly significant role.

If reading is akin to thinking and represents a means of generating predictive systems, and if science is a search for relationships, then the science of critical reading requires that such actions be central. We cannot be satisfied with passive reading accomplished through passive processes and directed by passive teaching and least of all at the college level. We must require that reading be a thinking act and teach it that way. If thought has its roots in action then reading does too within a developmental interactionist theory of cognitive activity.

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Reactions to Reading as Cognitive Functioning

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CONTINUING STUDY of the development of cognitive processes has revealed much of significance about children's learning in general and has many implications for their learning of the reading process and their growth toward real maturity in reading. However, dissatisfaction continues with the current status of reading instruction. Perhaps the key lies, at least partially, in these statements from Stauffer's conclusion:

> Universal agreement can be obtained supporting the conclusion that comprehension is the invariant condition of reading. Almost universal agreement can be obtained regarding the conclusion that reading is a process akin to thinking. Some few agree that if the first two premises are true, then reading should be taught as a thinking process.

The implication seems strong that there is a divergence between the product which is expected and the process by which it might be reached. It is as if the child were expected to apply in something called reading cognitive learnings which he has acquired in other situations, without guidance in cognitive functioning as an essential ingredient of his reading instruction.

Characteristically, the learner has been asked to master a series of skills and abilities, understandings and attitudes and, by applying these appropriately, to read—to deal thoughtfully with printed material. Such an expectation seems unrealistic in terms of what is known about learning and thinking. The problem appears to be that the cognitive functioning which is necessary for the mastery of the skills and abilities has not been considered. It is the thesis of this paper that complex thinking processes are involved in the acquisition of the components of reading ability and in decisions about their appropriate application. Unless a child has *thought his way* to a particular ability, it is unlikely that it will ever be his to use spontaneously when it is called for. Certain of the basic understandings which are necessary for successful reading, fortunately, seem to arise from children's own thinking activities with little or no structured guidance from either parents or teachers. From consideration of his own observations about labels on cans and packages, his name on articles of clothing or toys or envelopes, and myriad other experiences with visual symbols of language which are already his at the aural-oral level, the child usually generalizes that these visual symbols are another way of representing the things and people and ideas which make up his world. He may not be so fortunate, however, in independently thinking his way to all the other things he needs to be a mature reader at his level of general development. Therefore, an example of how he might be helped to think his way to a serviceable word analysis skill or a particular comprehension ability seems in order.

Word-form analysis skills

Before a child can become proficient in any word analysis task which requires association of a visual representation (letter or letter combination) with a particular speech sound or combination of speech sounds, he must have *made* that association. How can he most effectively accomplish this task? It is obviously possible for him to acquire the association, at one level, on a simple conditioning basis. He can be told repeatedly, in a variety of ways, that a particular visual symbol is likely to represent a particular speech sound and he can usually be counted on to respond with one member of the associated pair when he is given the other as a stimulus. However, this stimulus-response type of conditioning frequently fails to function spontaneously in a real word recognition situation. On the other hand, if the child thinks his way to the association, it becomes a part of him which operates appropriately across a broad spectrum of situations. His thinking his way to this kind of association results from his observations of known words in which he hears and "feels" the speech sounds as he listens to and says the words. He perceives the visual likenesses and the phonetic likenesses in the words as he develops the ability to abstract them from the total words. Ultimately he generalizes that when he sees a particular visual pattern in a word, it is likely to represent a particular speech element. It is the teacher's responsibility to see that when he has sufficient raw material, in terms of known words, his observation is guided so that he does perceive the likenesses and his thinking guided by appropriate questions so that he is led to generalize. A further responsibility is that of assuring adequate practice in the application of the generalization to reduce it to the level of virtually automatic response.

Although a child of the Quinn family does not come with a built-in knowledge that qu- usually represents a blend of the consonant sounds normally associated with *k* and *w*, he has, as soon as he knows his family name, a first step toward that knowledge. As he learns to read the words *quack, quart, queen, quick,* and *quit,* for example, he is building up the body of raw material which will allow him to discover this knowledge. Through his work in auditory perception and discrimination, he will have learned to recognize that all these words start the same way his last name does. To assure that he now observes that all these known words have, also, the same visual pattern, the same letters, at the beginning, the teacher can structure the situation. Placing all the words in a list in which the *qu*'s appear in exact vertical alignment and asking him to see in what way they all look alike forces the focus of his attention to the basic similarity. He reads them all; he knows they all begin with qu-. Now he can be questioned about what he would expect of another word with *qu* and led to generalize that it will probably have the sounds with which his last name begins. He can be confronted with other words (in which all other elements are known) with which he can test out his generalization. Whether or not he knows, at this point, that these blended sounds are normally represented by *k* and *w* is actually immaterial. He still has a serviceable analysis skill. When he has the proper resources in terms of other observations and generalizations, he will be able to add the usual representation to *his* generalization. The important point is that he has been helped to observe raw materials of language with which he is already secure, has abstracted similarities from these raw materials, and arrived at *his* generalization on the basis of *his thinking*. He has learned the word analysis skill by using *his* thinking processes and it is, therefore, a part of him—to serve him as he needs it.

Comprehension abilities

The development of any one of the commonly listed reading comprehension abilities must proceed along similar lines. As an example, how can a child most effectively learn to respond to and interpret metaphors? The essential process that he must learn is to recognize when an author is labeling someone or something in a way that implies a similarity to something else and to figure out what the intended similarity is. To learn this process he must again think his way by observing and analyzing language situations which are familiar to him, which he already understands. In these he can see that the label is ridiculous if it is interpreted literally. He knows perfectly well that there is no intention to say his sister *is* a rodent with a long, skinny tail when he says, "She's a rat!" Since she is a human being, albeit a rather distasteful one to him at the moment, it is patently impossible for her to be some other kind of animal. The likeness that he is implying may be only the distastefulness to him of both his sister and a rat, nothing more specific. When he uses the metaphor, *he* knows what *he* means. In the same fashion, he has learned to know what his mother means when she says, "Don't storm at me! I didn't break it." He tells someone he got an icy stare or a cold shoulder with no sign of shivering.

The fact that the child has learned to interpret and to use certain metaphoric language in slang, in name calling, and in a variety of other ways does not, however, guarantee that he is prepared to interpret new instances of metaphor which he meets. Of course, even recognition of the need for nonliteral interpretation demands an awareness of the literal meaning. Without this, the child might not realize that a literal translation was not intended, could not actually hold up logically. Beyond this, he must have observed many similar experiences with the particular kind of metaphor and observed the signals inherent in them. He must have generalized his observations to the degree that he knows the essential similarity intended can be a physical characteristic or something else. It can be based on some reality about the compared object or on some myth about it. It can reflect the personal attitudes of the author of the metaphor toward the things being compared. All this he cannot learn at once. He needs to think his way through one kind of situation at a time.

The effective teacher, therefore, must again help him by structuring the raw materials for his observation and analysis. One group of metaphors familiar to him may all rest on some physical likeness in the compared objects (beanpole, giant, midget, squirt). Working with these, he can be helped to see that this is one avenue of approach to the meaning of a metaphor—how do these things look or sound or feel alike? From another group of familiar metaphors he may abstract another kind of similarity and generalize some other possibilities for arriving at an interpretation. Only after a series of such experiences in thinking his way through a variety of types of metaphoric situations can he generalize at the level which will make him master of the process of interpreting all metaphors.

Conclusion

It is not too surprising that in considerations of cognitive functioning in reading far more attention has been given to dealing with specific ideas in reading materials than to learning the components of reading ability. Early investigations of children's concepts followed the same pattern—dealing with the question of what concepts they had and had not developed to the neglect of the processes of concept formation and attainment. The day is gone, however, when attention can legitimately be given to the products without full study of the processes by which they are produced. The child's ability to deal cognitively with reading materials will be determined by the degree to which he has learned reading as a cognitive process.

Theoretical Models of Reading: Implications for Teaching and Research

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ALTHOUGH the term "model" has multiple meanings, Kingston (*59*) defines a scientific model as an analogue of the thing being modeled and states that a scientific model is useful only when it is isomorphic or similar to something, but such a model is not a "synonym for theory." Lachman (*62*) agrees that a model is a separate system from a formal theory and asserts that more than one model generally functions for a theory. Models are categorized by Lachman into four types: 1) representational, a new way of thinking about objects and events, e.g. the model for conditioning theory; 2) inferential, a system of relationships and rules by which theoretical symbols are manipulated to arrive at new relations, e.g. rules for inferring one sentence from another; 3) interpretational, an explanation and test of a theory in terms of a model, linking theory to experiment, as in the establishment of empirical definitions of a theory; 4) pictorial visualization, reproduction of a theoretical construct in terms of a visual image, a first step towards theory construction or useful at least as a didactic technique.

For the field of reading, Robinson (*73*) has suggested that confusion might be reduced if models would be subgrouped into three categories: models representing 1) theories or procedures of teaching, 2) processes utilized or mobilized in reading, and 3) skills and abilities required for reading attainment. This tripartite division would provide suitable categories for the teaching machine model, i.t.a. model, linguistic model, substrata-factor model, and mixed dominance model identified by Holmes and Singer (*52*). But Robinson's tripartite division is not mutually exclusive. For example, the teaching machine model, although obviously a member of the teaching category, could also be placed into the process category, especially when learning or acquisition of responses is emphasized. Also, in the construction of a program for the teaching machine, an hierarchical model of skills and abilities has to be followed implicitly or explicitly. Nevertheless, this tripartite division is a useful one not only for differentiating the categories but also for understanding their dynamic relationships. For example, the teaching machine model contains a program based upon a logical organization of skills and abilities, which through a process of learning becomes incorporated into the mental repertoire of a group of individuals, and this product of learning can be empirically and statistically constructed into a model of knowledge, abilities, and capacities that can be mobilized for attaining speed and power of reading (*44, 51, 53, 79, 88*). Such a model identifies the essential variables and processes that the average individual can mobilize in response to a printed verbal stimuli; the model also depicts the general organization or interrelationships among these variables. These definitions of models will be used in reviewing the literature.

Review of the Literature

Since 1960, a large number of models have been explicitly and implicitly formulated (*20, 52, 57, 78, 94, 101*). Many of these models can be organized under the rubric of a logical organization of skills and abilities or processes for teaching purposes (*18, 29, 40, 73, 77, 99*). Some can be categorized as process models based on psycholinguistic theory (*39, 75, 94*), or neurological theory (*98*). Some models deal with a part of the process of reading, such as perceptual (*32, 33*), cognitive (*58, 90, 99*), or an interaction between physiological and cognitive processes (*21, 22*), while others are intended to be comprehensive (*18, 66, 99, 104*). Although the substrata-factor theory of reading was intended to be a comprehensive theory, models representing it are a cross section of factors that could be mobilized at a particular grade level for a particular criterion of reading.

While all of the models listed may be based upon some empirical data, only a few have been empirically or statistically constructed (*21, 22, 44, 51, 53, 61, 79*).[1]

[1] The basic assumptions underlying these models were made explicit by Holmes and critically evaluated by Sparks and Mitzel (*103*) and Raygor (*71*).

From this extensive list of models, several will be presented in detail. Because models of reading must and do change qualitatively and quantitatively to fit developmental changes in the reader (*56, 88*), the set selected for detailed presentation tends to span the developmental continuum from kindergarten or the initial stage of reading to the college level or the mature stage of reading development. Although not comprehensive at each level nor continuous, the models tap segments of the developmental continuum which can be described in the following way (*94*):

> An average child's receptive, mediational, storage, and oral subsystems for processing and responding to spoken language are fairly well developed before he systematically starts to form his subsystems for decoding, comprehending, and encoding responses to printed language. Consequently, the popular strategy in teaching the child to read is to have him learn to reconstruct printed messages into spoken language through use of vocal, subvocal, or even inner speech so that he can then comprehend printed messages with his subsystems for spoken language. In the process, intermodal communication subsystems between auditory and visual systems are developed which are necessary for transfer of meaning from one modality to the other (*45*).
>
> Individuals taught through an oral method might continue to subvocalize or use inner speech when reading silently (*27*), but they can learn on their own or be taught through sensory feedback mechanisms to suppress subvocalization (*42*). Although a non-oral method of instruction could be used to teach children to read silently from the very beginning of reading instruction (*15*), formation of oral reconstruction or at least recoding subsystems are necessary for oral reading. However, a reader who has attained maturity in both oral and silent reading has not only developed subsystems for both of these types of reading but can minimize or suppress his oral reconstruction and recoding subsystems when reading silently. He also learns to reorganize his mental organization as he shifts from one reading task or purpose to another (*47, 84, 85, 88, 92*).
>
> Peripherally and centrally determined changes in eye-move-

Some critiques of the theory and research based on it (*17, 19, 20, 24, 25, 70, 100, 101*) were evaluated or answered by Singer (*87, 95*).

ment behavior accompany development in reading (*65*). By grade nine, the average individual has attained maturity in functional oculomotor efficiency and accuracy in targeting familiar printed stimuli in reading (*34*). At first grade level, eye-movement behavior on primary grade material consists of two fixations per word, each lasting about seven-tenths of a second, and one regression or backward eye-movement about once for every two words. As children learn to perceive words, associate meaning to them, process information, and formulate appropriate responses, their eye-movement behavior also tends to improve. At the college level, eye-movement behavior is more rhythmic (one regression for every two lines of print), broader in span of perception (one and one-fourth words per fixation), and relatively rapid in pause duration (one quarter second per fixation). The developmental curve of span and pause duration in reading is relatively steep in grades one-four, tends to level off from grades five-ten, has another upward spurt at grade ten, and then levels off again, but rhythmic growth continues all the way to college (*14*).

As individuals progress through the grades, perceptual processes tend to decrease in relative importance while meaning factors tend to increase. Systematic changes also occur in general mental organization of factors underlying speed and power of reading (*44, 48, 52, 53, 81, 88*).

Trends in Research in Reading

In 1964, two trends in research in reading were discerned: 1) a a trend towards more basic research in reading or the explanation of reading phenomena in smaller and smaller units and 2) a trend towards construction of theoretical models to "represent the processes at work in the subsystems or causal chain of events that come to focus in the reading act" (*52*:127). These trends, of course, are interrelated or complementary: researchers can use a model as a guide for determining what variables and relationships need to be studied in greater detail and can hypothesize where more basic units fit into the theoretical structure (*102*). The discovery of more basic units, such as the fractionation of fixation time into stabilizing, seeing, and processing time (*35, 36, 37, 38*), would of course lead to a modification of the structure of a model based on eye-movement behavior. Holmes and Singer (*52*) pointed out that such closely interdependent and mutually directed theory construction is likely to foster creative productivity in a field of study. Essential for the attainment of this ideal relationship between a theoretical model and research is the formulation of a *theory* on which the model is based in such a way that testable hypotheses can be derived from it. Testable hypotheses are not inherent within a theory or model alone, as Sparks and Mitzel (103) and Clymer (*20*) imply, but instead, testable hypotheses result from an interaction between the theory or model and the imaginative, logical, critical, and knowledgeable mind of the researcher. The aim of this review of theoretical models of reading is to summarize a selected set of models and draw implications from them for research and teaching. Of course, other researchers, drawing upon their own frames of reference and theoretical premises, are likely to draw additional implications.

Selected Models

Model of conceptual response to printed words

For one subsystem of reading, instruction could be organized to develop a conceptual response to printed words. A teaching model for such instruction is depicted in Figure 1. The model indicates that the related "materials of thinking," consisting of percepts, images, memories, information and feeling tone, are organized through the process of concept formation and are linked through a linguistic form to a printed word stimulus that represents a class of objects.[2]

The rationale for the model has been drawn from several theoretical formulations. The definition of a concept and concept formation is consistent with Russell's formulation (*76*:117, 248-249):

> Concepts develop out of related perceptual experience. . . ." They are "the means by which a child or adult represents anything to himself and thereby creates a readiness to respond

[2] The original version of this model and its explanation have already been published (*91*). In the present version, the concept of linguistic form (72) has been added to the model.

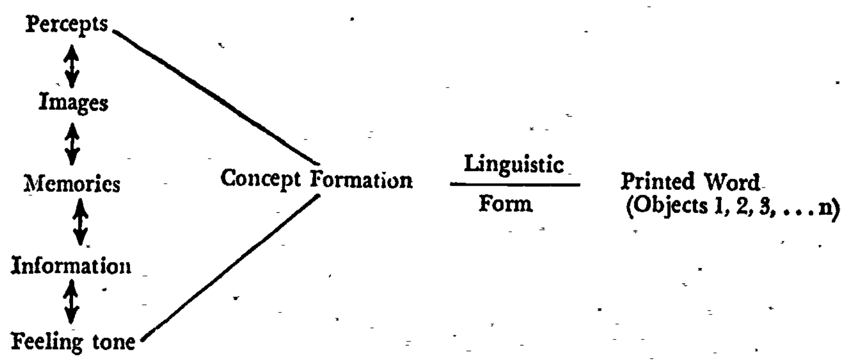

FIGURE 1. A subsystem of related elements mobilized as a conceptualized response to a printed word stimulus that represents a class of objects. (Modified, after Russell, 76.)

> with a particular type of behavior." The process of concept formation involves "discrimination . . . plus generalization or response to common elements in object or situation, the percepts, memories and images are integrated into a concept.

A "linguistic form," as defined by Reed (*72*:849), "is a linking of a unit of meaning to a physical representation in terms of a conventional system such as speech or writing."

A conceptual response in reading can then be defined as an intermodal communication system of ideas, percepts, memories and images which are mobilized in response to value determined purposes of the individual and the stimulus demands of the printed word (*2, 47, 89*).

This model may also be explained in terms of the localization theory of neurology (*68*): engrams are developed in specialized areas of the brain which correspond to various components, such as kinesthetic, auditory and visual images, and feeling tone for words and objects. When a class of objects is presented in close temporal contiguity to printed and spoken words representing the objects, a phase sequence of cell assemblies (*43*) could result in which the associated elements or attributes abstracted from a class of objects communicate with or "teach each other" (*45*). This communicational or transactional system (*22*) yields maximal interfacilitation in response to the printed word.

Implications for teaching

A strategy for developing a conceptual response to printed words can be initiated in the beginning stage of reading development and could be continued with appropriate modifications throughout reading instruction. The objective at the initial stage is merely to present printed and spoken words in close contiguity with each other and their corresponding referent class of objects so that materials of thinking related to a particular class of objects can be associated with each other and with the referent object. A variety of games and rhymes can be devised for this purpose. For example, a kindergarten teacher has children recite a refrain of "Barnyard, barnyard, what's in the barnyard?" as she flips over a picture showing another animal in the barnyard. In this lesson, only the printed word *barnyard* would have to be added to the game to facilitate development of a conceptual response to the printed word.

Another strategy that could be followed at the primary level is to have a class of objects, such as a set of toy cars with the word *car* printed on the side of each car, serve as the instructional objects. The children will manipulate the cars, talk about them, learn something about their characteristics, perhaps trace over the printed word or participate in putting labels on the cars, and discover what is true about all the cars. Through the processes of visual perception and discrimination, manipulation of objects and action on the objects, and tactual-kinesthetic perception of the stimulus features of the printed word with emphasis on the word's left-to-right order, the common elements in each modality could be abstracted and generalized. Then, on a subsequent occasion, the printed word stimulus alone might elicit the conceptualized response representing these experiences. With the original labels removed from the objects, this would provide a test of the attainment of a concept.

As lessons progress, children could develop flexibility in mental organization by practice in switching from one conceptual response to another. For example, two groups of objects could be intermixed which had previously been experienced separately. The printed words representing the objects can be used as a basis for grouping the objects. At successive grade levels, a more appropriate procedure would be followed. For example, a conceptual response to the word *tree* might be developed through Udry's award-winning book (*106*), *A Tree is Nice*. At the high school level, the concept of courage can be classified and enriched through a unit in which students read and interpret a variety of books, all on the theme of *courage*, such as *Profiles in Courage* and *The Red Badge of Courage* (*13*). Thus, as individuals progress through the reading curriculum, they would be stimulated to develop concepts that could be mobilized as mediational responses to printed words (*45*).

Implications for research

The development of such a mediational response system would have several effects on learning to read and on performance in reading. For example, if a conceptual response system for printed words is formed at an early age, the concepts would serve as advance organizers to facilitate subsequent learning and retention (*4*). One hypothesis is that the rate of learning would probably be greater because categorization of stimuli would effectively reduce the perceptual and cognitive load (*79, 89*). Indeed, grouping of stimuli according to categories enhanced transfer in spelling (*31*) and is likely to do so in reading.

Although development of a conceptual response system could and probably does occur to some degree in many pupils without instructional intent or curricular organization for this purpose, an hypothesis to be tested experimentally is that a deliberate instructional strategy would facilitate or accelerate development of a conceptual response system. More specifically stated, the hypothesis is that individuals who had experienced and benefited from a conceptual response strategy are more likely to respond appropriately, within the limits of their stage of mental development (*55, 69*), to a printed word intended to represent a concept than are individuals whose educational experience had been more in the direction of learning to recognize a particular label as representing a particular object. If the conceptual response curriculum is effective, then it is also likely to produce more powerful and more rapid readers. The rationale for the better comprehension is dependent upon the assumption that a higher level of performance in power of reading draws more upon mobilization of conceptual than upon labeling responses. The explanation for the increased rate of reading is that speed of reading depends, in part, not only upon level of thought, but also on flexibility in organizing and reorganizing working systems, including mediational responses. Therefore, curricular experiences in shifting from one conceptual response to another in relation to printed words could augment flexibility and result in an increased rate of reading (*63, 64, 65*).

A conceptual response system is only one subsystem of more comprehensive models for attaining speed and power of reading. One of these models has been constructed at the fourth grade level.

Fourth grade model

The model depicted in Figure 2 was constructed in answer to the statistical question: what are the minimum number of variables which tend to be associated with a maximum degree of individual differences in speed and power of reading?

The resulting model, explained in greater detail elsewhere (*52, 53, 79, 80, 93, 94*), consists of four systems for power of reading and three systems for speed of reading. The systems for power of reading are 1) mental age or reasoning in context, 2) suffixes or morphemic analysis, 3) vocabulary in isolation or word meaning, and 4) matching word sounds or word recognition. The systems for speed of reading are 1) mental age or reasoning in context, 2) auding vocabulary or word meaning, and 3) phrase-perception discrimination or visuomotor perceptual systems.[8]

Each system is associated with related subsystems. For example, in the word meaning system for power of reading, the associated subsystems are mental age, suffixes, and word recognition in context. Word recognition in context, in turn, is associated with prefixes, spelling recognition, and spelling recall. The number next to each predictor variable is its relative weight or contribution to the variance in its associated criterion or subcriterion. All of these systems and

[8] Comparison of this empirically constructed fourth grade model with a model by Ruddell (*75*) representing a logical interrelationship of psycholinguistic research revealed considerable overlap. However, some psycholinguistic subsystems which appear to be missing from the fourth grade model are structural and semantic markers, storage systems for classifying sentences and semantic aspects of words, and syntactical systems (*94*).

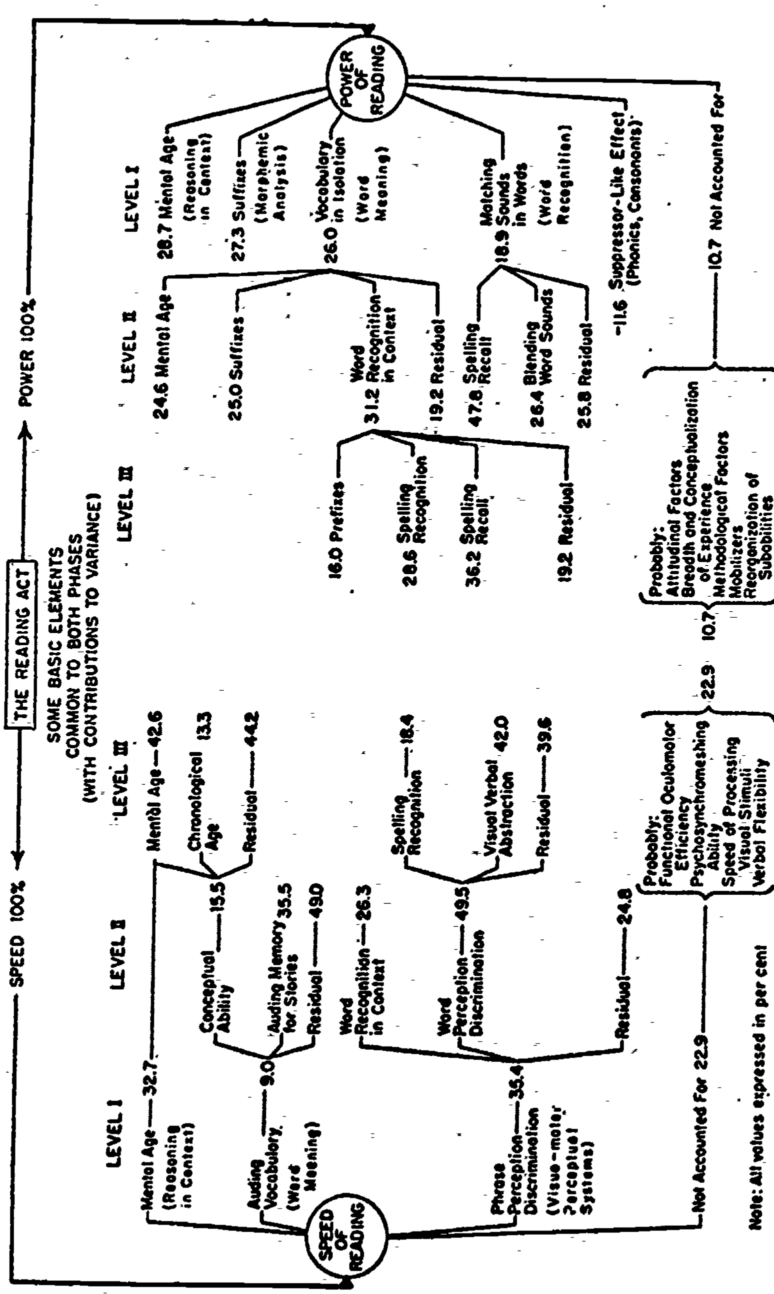

FIGURE 2. Flow chart to show the results of the substrata analysis of speed and power of reading at the fourth grade level.

subsystems are also structurally or functionally associated with each other.

Some factors which might have been depicted in the model, had variables for them been included in the statistical analysis, are listed near the bottom of the model. Among the factors for power of reading are attitudes and values (*2*); breadth and conceptualization of experience (*79*); methodological factors (*1, 10, 16, 93*); mobilizers (*3, 46*); and reorganization of subabilities (*44, 88*). For speed of reading, additional factors could be functional oculomotor efficiency (*34*); psychosynchromeshing ability (*46, 88*); speed of processing visual stimuli (*38*); and verbal flexibility (*79, 88*).

The structure of the fourth grade model is consistent with the definition that reading is an audiovisual verbal processing skill of symbolic reasoning (*53*). Furthermore, the factors shown in the model support the major theoretical premise that reading ability consists of two interrelated components, speed and power of reading. Underlying or associated with each of these components is a functionally organized hierarchy of complexly interwoven systems. These systems are selected and mobilized into a working system of functional communication network in response to the interacting and changing purposes of the reader and demands of the reading task. For example, the model indicates that the factors associated with speed overlap, but are not identical with, those associated with power of reading. Hence a shift from speed to power necessitates a reorganization of systems and subsystems.

The model also suggests that a reader organizes and reorganizes systems and subsystems mobilized for satisfying the changing demands of the stimulus task *within* the purpose of reading for speed or power. For example, in reading along a particular sentence, a reader must retrieve and mobilize systems for recognizing words and phrases, next link the recognized words or phrases to their corresponding meanings, then integrate the accumulated meanings, and subsequently utilize various cognitive processes for inferring, interpreting, and inductively or deductively arriving at conclusions or solutions to problems. Furthermore, it can be inferred from the model that two individuals could obtain the same speed or power of reading but with qualitatively or quantitatively different working systems.

Conditioning the reader's mental performance are his attitudes and values. Whether the reader merely skims, or attains superficial comprehension, or strives for his greatest depth of understanding (*49*) is determined not only by his cognitive but also by his conative and affective systems. Furthermore, influencing his cognitive style in both acquisition of mental systems for reading and for performance in reading are the individual's biological support system (*21, 22*) and his environmental interactions (*23*).[4]

Implications for teaching

Objectives. The model indicates that the objectives of instruction should encompass both speed and power of reading. Since speed and power of reading do have some overlapping factors, improvement in both of these components is likely to ensue from instructional emphasis on their shared factors. However, specific development of each of these components is necessary because the organizational pattern for speed is different from power of reading. Also, quantitative and qualitative differences in the general working systems for these major components of reading necessitate development and practice in mobilizing appropriate working systems for each component. Furthermore, since flexibility in mental organization is likely to facilitate general reading ability, children could benefit from practice in switching from power to speed of reading, and vice versa. Analogous to the procedure for developing accuracy and efficiency in arithmetic (*11*), children might read something first for accuracy or power of reading and then for speed of reading. For example, if an individual is taught to analyze a word into constituent phonemic or morphemic elements, he might subsequently be given practice in recognizing and associating the meaning of the word quickly. This alternation strategy for developing systems and subsystems for speed and power of reading could be instituted in the curriculum at the onset of formal reading instruction.[5]

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[4] Parts of the dynamics of the model agree with the "search model" and other models of reading briefly mentioned and discussed in *The Reading Process* (*57*: 85-115).

[5] The substrata factor theory postulates that speed and power of reading are separate but interrelated components. Although research conducted over forty years ago first established that speed of reading is a separate component of

Curriculum. The model indicates that reading attainment consists of a complex organization of systems and subsystems. The scope of the reading curriculum ought to reflect this complexity by encompassing at least all the educationally modifiable elements depicted in the model, including those suggested as additional factors. All of these educational components also should be incorporated into an hierarchically structured curriculum, projected downward to the primary grades, so that by the fourth grade level the factors depicted in the model could be realized.

Grouping. Grouping for instruction or providing for individual differences should be determined not just according to overall level of performance in power or speed of reading as is the current practice in some, if not most schools, (*5*), but also according to level of performance in *each* system and subsystem. Simply stated: grouping for instruction can be best justified on the basis of diagnosed instructional needs. Tests or interviews (*104*) could be used for this diagnosis.

Diagnosis and evaluation. The model, as a guide for diagnosis and evaluation, sensitizes the teacher to relevant variables and their interrelationships. The te··her can use this frame of reference to observe manifest deficiencies and formulate a diagnostic hypothesis. Appropriate tests can then be administered to determine whether this diagnostic hypothesis is tenable. For example, if an individual has at least normal mental ability, can pronounce words, but does not immediately know the meaning of some words, the next question is whether the individual has a system for morphemic analysis and its level of development in relationship to his other systems and subsystems. If the word can be broken down into meaningful elements, but the individual does not do so, the teacher might administer a test on prefixes, roots, and suffixes (*54*).

For evaluation, the teacher can administer an entire battery of tests to the whole class, then construct class and individual profiles to determine strengths and weaknesses in the curriculum and in

general reading ability (*30*), schools have not systematically taught for nor evaluated attainment of this objective (*85, 96*). Indeed, only recently did Robinson (*73*), acting on the research results of the substrata-factor theory of reading, expand Gray's well-known and influential teaching model by incorporating rate of reading as one of its components.

individuals in the class. When such a battery of tests was administered to a precocious reader, age five and one-half, who could read at the fourth grade level, her pattern of strengths and weaknesses in reading were clearly revealed by the resulting psychographs, depicted in Figures 3 and 4 (*82*).

Thus, the fourth grade model has implications for teaching. Of course, the model is only a first approximation. Further research is likely to lead to the construction of a more comprehensive model

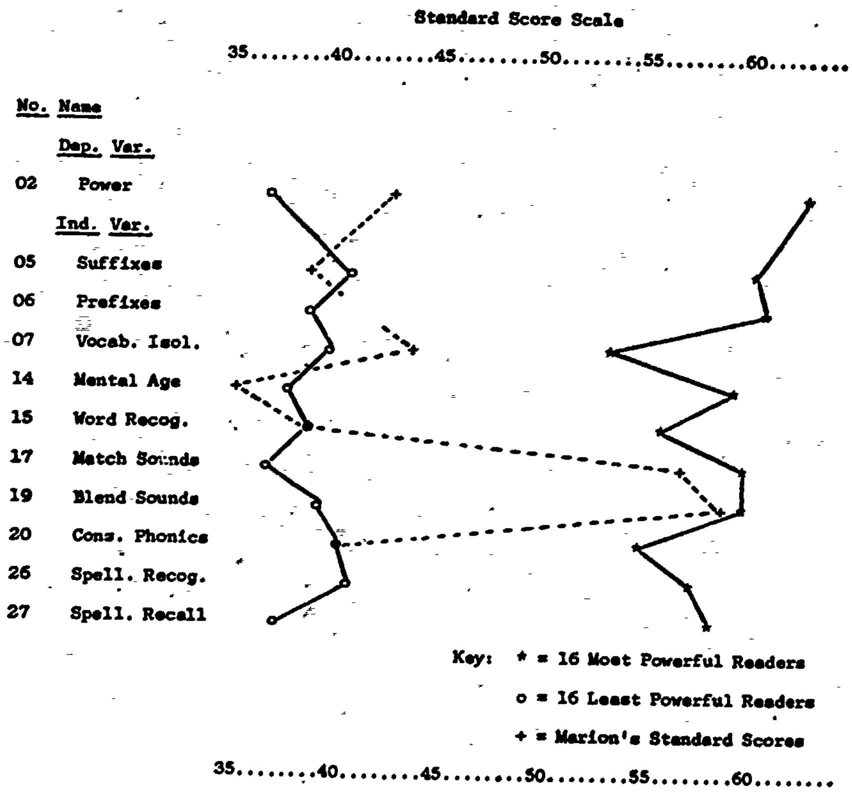

FIGURE 3. Psychograph of selected substrata elements for Power of Reading. The psychograph compared the average standard sources of the upper and lower 27 per cent of 60 fourth graders, separated on the dependent variable, Power of Reading. The groups are compared on variables that underlie Power of Reading at the fourth grade level, as shown in the model, Figure 2. Marion's scores were superimposed on the psychograph to show how her abilities compare with these groups. (Marion did not take the Prefixes or Spelling tests because of time limitations.)

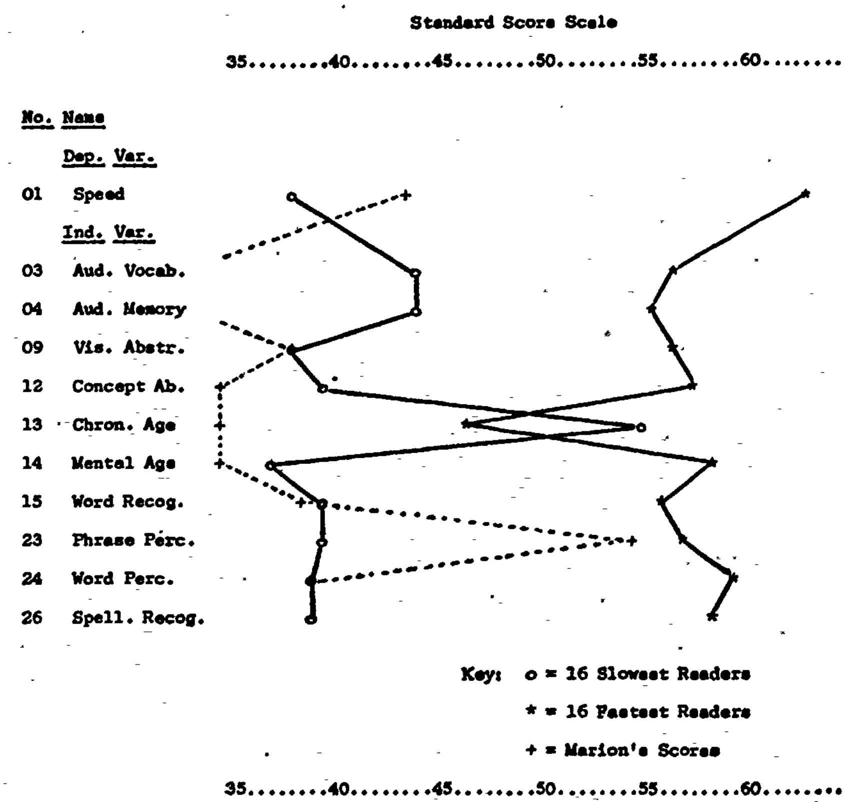

FIGURE 4. Psychograph of selected substrata elements for Speed of Reading. The psychograph compares the average standard scores of the upper and lower 27 per cent of 60 fourth graders, separated on the dependent variable, Speed of Reading. The groups are compared on variables that underlie Speed of Reading at the fourth grade level, as shown in the model, Figure 2. Marion's scores were superimposed on the psychograph to show how her abilities compare with these groups. (Marion did not take the Spelling Test because of time limitations.)

which would have even more implications for teaching. The model also has other research implications.

Research implications

The fourth grade model is a byproduct of confirming the prediction that the major premise of the substrata factor theory of reading could be generalized from the college to the fourth grade level (*79*). Further research would determine whether the scope of the model could, in fact, be expanded through the assessment and statistical analysis of certain perceptual, attitudinal, and psycholinguistic variables (*2, 32, 75*).

A wealth of research hypotheses could be formulated through suppositional thinking in viewing the factors depicted in the model. For example, what if more systematic development were given to morphemic analysis (meaning of prefixes, roots, and suffixes) in grades one to three, would the quantitative level of the factor be increased? Would the group's level of power of reading be accelerated? Or what if instruction in context clues were expanded to incorporate McCullough's more comprehensive list (*66*), would this modify the role played by word recognition in context in the model? Would a grammatical factor, such as semantic or syntactic markers precipitate from a substrata analysis, if systematic instruction in these were included in the curriculum and tests for them constituted part of the comprehensive test battery? The model could thus serve as a cognitive guide for experimental research and for evaluating the effects of experimental instruction.

Since the sample on which the fourth grade model was constructed had been taught by a variety of methods and materials, the model represents the consequence of a general method of instruction (*79, 80*). But, the hypothesis that systematic differences in methods and materials would lead to different models and that these models might be more appropriate for some groups of children than for others also needs to be tested. The first part of the hypothesis could be tested by devising experimental curricula, such as one with emphasis on each segment of the decoding—meaning continuum (*16, 93*). The second part of the hypothesis could be tested by subgrouping children in each curriculum according to their presumed strengths and weaknesses for benefitting from the particular curriculum. A comprehensive battery of tests administered to each curricular group at the end of each grade level would provide data to answer the question of whether differentials in teaching models or stimulus inputs would be reflected in statistically determined models and whether these models would tend to converge or remain significantly different throughout the grades (*93*).

Differential inputs, at least in the primary grades, have produced different psychological models for reading. For example, Buswell (*14*), using an eye-movement camera, compared a phonic method with a content or meaning method. The results indicated that the phonic method tended to promote left to right sequence and word pronunciation, while the meaning method emphasized concern for the content, slower development in word recognition, and rhythmic eye-movement behavior. Agnew (*1*) also found that the phonics-emphasis group was superior to the nonphonics-emphasis group on word recognition and *oral reading*, but on silent reading the two groups were equal. These results suggest that a model for *oral reading* would place more weight on phonics, but a model for *silent reading* would give less weight to phonics ability. However, the hypothesis that these models might converge in later grades has to be tested.[6]

Whether children might benefit more from an auditory or a visual emphasis in input modality depends on whether or not they have a limitation in either modality. Children with certain sensory and perceptual deficiences or modality preferences might not be handicapped in a curriculum that did not tap their weaknesses or nonpreferred modality (*9, 28*).[7] But, even if children do not have developmental lags in perception or other perceptual difficulties in relation to methodological emphases nor encounter a mismatch between stimulus input and modality preference, a particular methodological emphasis might still be detrimental to some children's

[6] Holmes and Singer (*52*) predicted at the third grade level of Durkin's study that her early readers would converge with the control group when both groups had reached the eighth grade. The convergence of these groups may have been a function of the methods of instruction, which were not controlled in Durkin's study. However, the prediction applied only to the criterion used for assessing reading achievement since the two groups could attain the same performance level through different patterns of reading abilities. For example, there could have been persistent differences between the groups in rate or fluency in reading. Since Durkin did not utilize a comprehensive battery of tests and various criteria of reading ability, her data cannot answer these questions.

[7] Although the intent of the *First Grade Study* was to test similar hypotheses, admitted weaknesses in the overall design precluded testing them (*10*). However, some of the individual studies in this group might lend themselves to substrata analysis of their data that would provide at least a tentative answer to the above questions.

reading attainment if the method did not stimulate development of all the necessary components or subsystems for attaining speed and power of reading (*12, 93*).

Whether other known groups, such as slow vs. fast and least vs. most powerful readers, differ significantly in their patterns associated with general reading ability or only in their *rate* of development of these patterns, might also be ascertained. Evidence at the high school level suggests that the patterns of the known groups, although similar in certain subsystems, are sufficiently different to warrant differentiated curricula. Even as early as first grade, a differentiated curriculum is necessary to meet individual differences in age of onset of reading readiness (*97*). During the intermediate grades, the evidence indicates that the structure of the systems associated with speed and power of reading of a representative group undergo not only quantitative, but also qualitative changes, as shown in Figure 5 (*81, 84*). (The model for speed for reading appears as Figure 1 in Singer's article in Part Two of this publication.)

One of these changes provides some support for the hypothesis that there is a kinesthetic-auditory-visual gradient shift accompanying development of general reading ability (*88*). Whether further reorganization occurs in the general working systems or pattern of factors related to power of reading at the junior and senior high school levels is a question that has not yet been answered, although some cross-sectional studies have been reported at these advanced levels.

Model of substrata-factor patterns accompanying development in power of reading

Figure 6 depicts predictors of power of reading at the elementary (*84*), high school (*53*), and college levels (*44*). Since neither test batteries at these levels nor subjects were identical, the following comparison of predictors at these levels can only suggest hypotheses for a longitudinal investigation:

1. During the intermediate grades, word meaning and reasoning in context systems (meaning of affixes, verbal analogies and relationships) tend to increase in their proportion of variance associated with power of reading. But, from the sixth grade through the college level, the quantitative contributions of these systems to power of reading

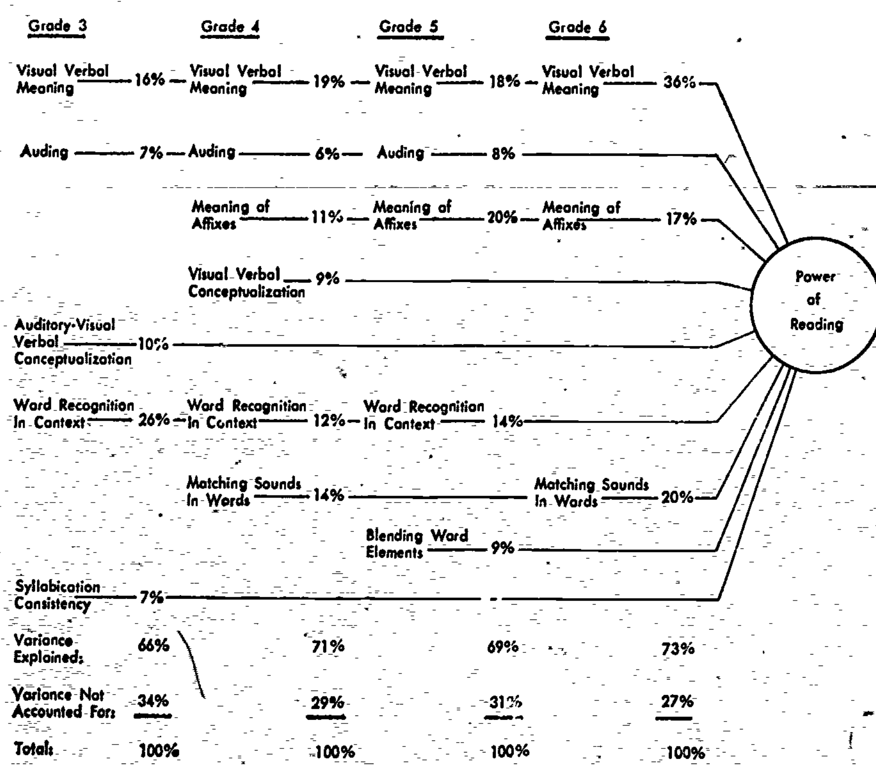

FIGURE 5. Diagrammatic Model of the Substrata-Factors Accompanying Development of Power of Reading in Grades 3 to 6. The model shows for each grade the first level substrata factors and their per cent contributions to variance in Power of Reading. The variance *not* accounted for is probably attributable to Attitudinal Factors, Verbal Flexibility, and Mobilizers. Harry Singer, 1964.

tend to remain constant. At the higher grade levels, they predict about half of individual differences in power of reading. Whether these results reflect rate of maturation or instructional emphasis or some interaction of maturation and instruction would have to be tested via an experimental program at the junior and senior high school levels.

2. Measures of auding were not included at the college level, but were at the elementary and high school level. Although an auding factor did not precipitate at the sixth grade level, it does at the lower grades and at the high school level. At the sixth grade level, auding

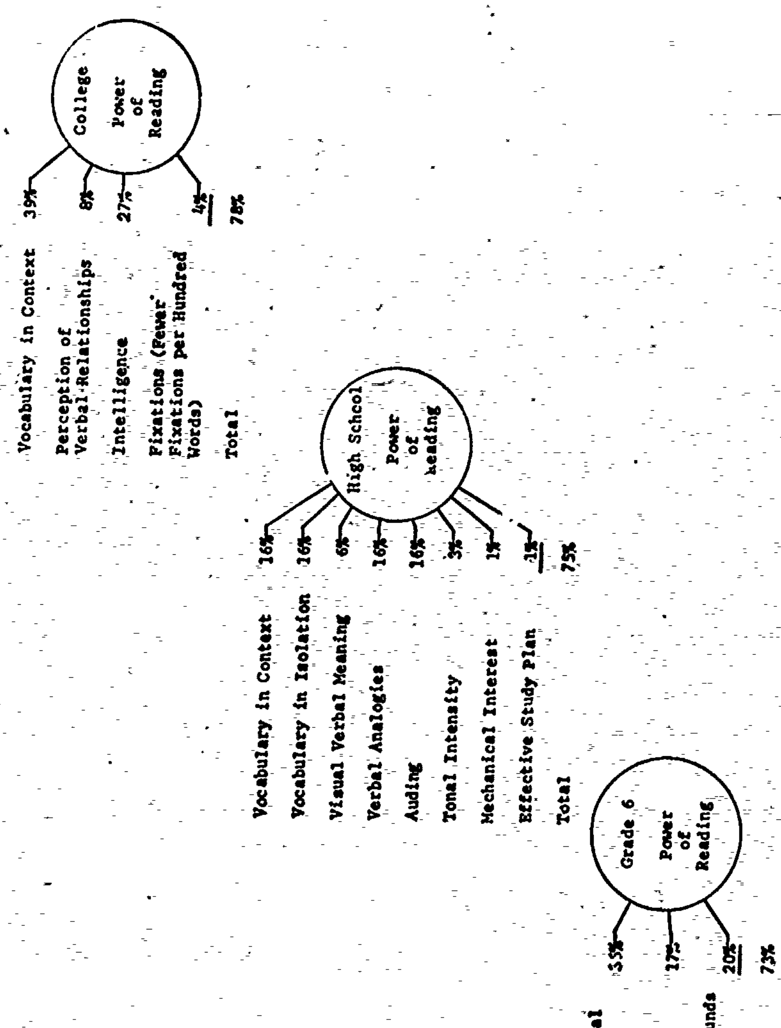

FIGURE 6. First level Substrata Factors and Their Per Cent Contributions to Variance in Power of Reading at the Sixth Grade, High School, and College Levels. Harry Singer, 1964.

seems to shift from an auditory-visual factor at a concrete or associational level to auding at a more abstract level (*81, 92*). This result is consistent with the hypothesis that throughout the developmental continuum reading is an "audiovisual verbal processing sk i: of symbolic reasoning" (*51, 53*).

Although a gradient shift to visual modality dominance probably occurs about the sixth grade level for relatively easy material, when confronted at higher grade levels by difficult materials the reader is likely to mobilize both visual and auditory systems in order to maximize his cues for solving problems in word recognition, word meaning, or reasoning in context (*42, 88, 92*).

3. A system of phoneme-grapheme relationship, such as "matching sounds in words," does not precipitate after the sixth grade level as a first level predictor for power of reading, even though variables for tapping this system had been included in the test battery at the high school and college levels. However, readers at these advanced levels logically must go through some process of word recognition. The interpretation for this apparent paradox must be that a word recognition system, as such, does not precipitate at the first level of analysis because at the advanced levels of reading individual differences in power of reading are primarily attributable to factors other than word recognition.

Implications for teaching

The corresponding implications for teaching are the following:

1. Emphasis, in general, in teaching and evaluation of reading ability should reflect the relative magnitude of the contributions to variance of the systems associated with power of reading. Therefore, approximately half of the curricular time beyond the sixth grade could justifiably be devoted to development of word meaning and reasoning in context. Of course the teacher must adapt the curriculum to the wide range of individual differences that exist in each classroom.

Although direct teaching of vocabulary and affixes is likely to develop an individual's mental dictionary, a broad educational curriculum would contribute to this goal and would also tend to develop other appropriate subsystems and processes, such as retrieval and integration of stored information. Included in such instruction should be the meaning and use of structural and semantic markers (*75, 94*).

2. Mobilization of auditory processes into an individual's working system is a function of his interacting purposes and the difficulty of the materials. This mobilization is likely to occur when the perceived reading task is difficult. Teachers, aware of this dynamic process, could structure reading assignments appropriately. If teachers try to develop silent reading with a minimum of auditory processes or subvocal speech, they should use relatively easy materials and only require a surface level response because difficult materials and a purpose of reading for depth of understanding are likely to mobilize *both* visual and auditory systems. Alternation of difficulty of materials and purposes would probably develop necessary versatility in mobilization of these systems.

3. Although certain subsystems for word recognition continue to improve throughout the developmental continuum (*53, 105*), the word recognition system is, in general, well developed by the sixth grade level. Curricular emphasis at the advanced levels of instruction should therefore be on word meaning and reasoning in context systems. Of course, instruction in word recognition will still be necessary for those individuals who have not yet developed an adequate word recognition system.

Implications for research

Present knowledge of the development of reading ability is based essentially on cross-sectional studies. Although these studies provide some information on development of reading ability, they must still be followed by a longitudinal investigation. However, only a few longitudinal studies of reading, limited in scope or duration, have been reported. These have been studies of functional oculomotor efficiency (*34*) and other aspects of eye-movement behavior (*35*), acquisition of a particular methodological approach to reading (*67*), early readers (*26*), and the effect of various methodological emphases in the primary grades (*74*).

What is very much needed in the field of reading is a longitudinal investigation of reading development that encompasses each domain related to reading achievement. Perhaps such an investigation will arrive at a conclusion similar to Bayley's on the growth of intelligence (*7, 8*:807): "intelligence . . . appears to be a dynamic succession of developing functions with the more advanced and complex functions in the hierarchy depending on the prior maturing of the earlier, simple ones."

Also, the relationship of stages in development of logical thinking (*55, 69*) to acquisition and performance in various systems and subsystems of reading behavior should be investigated. For example,

READING

Figure 7 not included due to copyright restrictions

FIGURE 7. A learning structure for the basic skills of reading. (From *The Conditions of Learning* by Robert M. Gagné. Copyright © 1965 by Holt, Rinehart and Winston, Inc. Reprinted by permission of Holt, Rinehart and Winston, Inc.)

Piaget's stages of mental development may explain the change in factor patterns that occur at the sixth grade level: the average sixth grader may be passing from the concrete to the more abstract, formal stage of mental development.

Until comprehensive longitudinal data are adduced on the empirical development of the hierarchical structure associated with speed and power of reading, the curriculum constructor must fill in the gaps in knowledge with a curriculum based both upon empirical data and logical analysis. Figure 7 depicts an outline of a logically determined hierarchial structure for reading (*29*) which has not yet been developed into a complete teaching model. Objectives for such a teaching model may be based upon the comprehensive set of categories constructed by Spache (*99*). Categories were formulated for word recognition, word meaning, and reasoning in context, corresponding to all the cells in the semantic layer of Guilford's model (*41*) of intelligence. All the operations of cognition, memory, divergent thinking, convergent thinking and evaluation and all the products of intelligence, consisting of units, classes, relations, systems, transformations, and implication are represented in these objectives for reading. These objectives are shown in charts in Figures 8a, 8b and 8c.

Spache's categories can also be used for selection of a test battery to evaluate and plot in a longitudinal study the hierarchical development of systems and subsystems associated with attainment of speed and power of reading. A by-product of this investigation would be the construction of a comprehensive developmental model of reading.[8]

Interrelationship Among Types of Models

Models of teaching, skills and abilities, and processes involved in reading are interrelated. Depicting these interrelationships is the

[8] Comprehension objectives similar to Spache's, but corresponding to Bloom's taxonomy of cognitive and affective dimensions, have been formulated by Barrett (*6*). Although both sets are logical formulations, Spache's does have some empirically-based rationale. However, both sets of objectives ought to be considered in the formulation of an hierarchically structured, comprehensive curriculum in reading.

Mental Processes	*Unit*	*Class*	*Relations*	*Systems*	*Transformations*
Cognition (recognition of information)	Recognition of printed word as such	Recognition of difference among letters, words and numbers	Recognition by word form and letter details, as *little*	Recognition of phonic characteristics, i.e. initial and final sounds	Recognition of word endings (plurals, or roots and affixes)
Memory (retention of information)	Recall of specific word forms, e.g. own first name house number	Recall of random words, letters and numbers in isolation (reading signs)	Recall by word form and details (sight vocabulary)	Recall of complete word by combined clues, e.g. initial sound, sentence pattern and form	Recall of word endings (*s, ed, ing*) root or affix
Divergent Production (logical, creative ideas)	Neologisms, word form errors	Recognition by distinctive detail as *g* in *dog*; capital letters	Recognition by base word within larger, compound words	Spontaneous phonic and structural generalizations	Experiments with derived and base words
Convergent Production (conclusions, inductive thinking)	Recognition by pictorial clues, shape of sign, etc.	Recognition by sheer length, as *grandmother*; or by unusual shape, as *elephant*	Recognition by sentence pattern, word groups	Recognition by word families, common syllables, roots, etc.	Recognition of derived words by base plus ending, or root plus affixes
Evaluation (critical thinking)	Comparisons of differences and similarities in gross form	Discrimination of words, numbers, letters	Discrimination by form, details and sentence pattern	Discrimination by form, details and phonic elements and sentence pattern	Discrimination of base and derived words by endings, letter sounds, sentence pattern, root and affixes

[1] Figures 8a, 8b, and 8c are reprinted from *Toward Better Reading* by George Spache, Champaign, Ill.: Garrard Publishing Co., 1963. By permission of the author.

FIGURE 8a. Reading Behaviors in Symbolic Content (Words, Letters)[1]

Mental Processes	*Unit*	*Class*	*Relations*	*Systems*	*Transformations*	*Implications*
Cognition (recognition of information)	Recognition that printed word has meaning	Recognition of word function—naming, action, descriptive, pronominal, connective	Recognition of word associations and relationships, e.g. synonyms, onomatopoeia, alliteration, rhyme	Recognition of implicit comparison in hierarchies of words (temporal, spatial, intensity)	Recognition of inherent meaning in roots, affixes and inflectional forms.	Recognition of word connotations, figures of speech and presence of tone and mood.
Memory (retention of information)	Recall specific word meanings (denotations)	Recalling specific meaning thru recognition of function, e.g., this word is a thing	Recall the associated word (synonym, etc.) and thus recall meaning of given word.	Recall of base word and meaning, recall of other degrees in the hierarchy, e.g. recognized *strongest* through *strong*.	Recall of meaning of base word or of root and affixes.	Recall of specific connotations and meanings of figures of speech.
Divergent (logical, creative ideas)	Secure meaning from context by inference, guess	Recognizing examples of unusual or new usage, e.g., *Mae West*	Using mnemonics to recall meaning	Using trend of hierarchy to recognize comparison and thus derive meaning for given word.	Recognizing words containing new, or assimilated, condensed or related affixes and roots. Discriminating differences in meaning due to variants.	Free association to connotations, i.e. daydreaming or imagery; recognizing new figures of speech, new connotations, allegories.
Convergent (conclusions, inductive thinking)	Meaning from context by sentence structure (appositive, explanation, contrast, definition)	Relating specific meaning to antecedent, to accent and contextual clues to function of the word	Try associated word (synonym, etc.) in context and thus derive meaning intended for given word.	Given a group of words, formulates a tentative hierarchy.	Use of structural analysis as clues to meanings; dictionary study of derivation.	Using connotation, tone and figurative language to interpret context.
Evaluation (critical thinking)	Critical reaction to author's choice of words	Reacting to author's usage, to use of slang, colloquialisms, etc.	Discriminating differences among synonyms and antonyms; recognizing irony and sarcasm.	Reacting critically to shades of meaning, to exaggeration, hyperbole.	Reacting critically to shades of meaning imparted by variations in affixes.	Detection of author's use of emotionally-toned words, analysis of figurative language, tone or mood.

FIGURE 8b. Reading Behaviors in Semantic Content of Words

Mental Processes	*Unit*	*Class*	*Relations*	*Systems*	*Transformations*	*Implications*
Cognition (recognition of information)	Recognition that word has meaning	Recognition of sentence as complete thought	Recognition of paragraph meaning (literal idea of paragraph)	Recognition of types of relationships within structure of paragraph	Underline key words of paragraph	Recognize that there are implications in author's main idea
Memory (retention of information)	Recall specific word meanings	Recall of thoughts of sentence (reverberations)	Comprehend main idea as summation of sentences (reverberation)	Summarize facts of paragraph in own words with due attention to structure	Combine recall with own associations	Choose possible implications from given alternates
Divergent Production (logical, creative ideas)	Meaning from context by inference	Selecting implied meaning of sentence	Choosing implied main idea	Analyze author's reasons for structure	Construct rebus of paragraph; offer new titles for paragraph	Amplify author's implications and ideas in free association
Convergent Production (conclusions, inductive thinking)	Meaning from structure of context (i.e. appositive sentence)	Combining ideas into literal meaning of sentence	Evolving main idea as extension of topic sentence	Categorize structure of paragraph; outline it	Choose among alternate titles or statements of main idea	Suggest future applications of author's ideas
Evaluation (critical thinking)	Acceptance or rejection of author's diction	Acceptance or rejection of meaning of sentence, as fact-opinion	Acceptance or rejection of main idea as fact or opinion; check author's sources; compare with own experiences and beliefs	Look for fallacies in logic, appeals to reader's emotions, overgeneralizations, omissions, distortions	Identify author's viewpoint and purpose; compare with other viewpoints; explore the ultimate outcomes of acceptance of author's viewpoint	Check author's background as basis for viewpoint; react to author's value judgments; examine author's basic assumptions and inferences from these

FIGURE 8c. Reading Behaviors in Semantic Content (Meanings, Ideas)

sequential scheme constructed by Strang (*104*). This scheme is shown in Figure 9.

FIGURE 9. The diagram indicates the interrelationships among the individual (O), the classroom reading situation (S) the individual's responses to the situation (R), the resulting memory traces (T) and the individual's perception (P) of the next situation. (Reprinted from "The Reading Process and Its Ramifications." In *Invitational Addresses*, 1965. Newark, Delaware: International Reading Association, 1965, 49-74. By permission of the author and the publisher.)

The individual student is represented by *O* and consists of a psychological model of the products, prerequisites and processes within the reader. Included in this model are physical, physiological, mental, attitudinal, knowledge, self-concept, desire to read—in short, all those interacting systems and subsystems within the individual that function between stimulus input and response output. Instruction is next concerned with *S* or the classroom situation, its decor, learning atmosphere, and types of reading material, which mutually interact with *O*. The resultant of this interaction is *R*, the student's responses to the situation. This dynamic interaction leaves a trace, *T*, which is stored within an individual's nervous system. This trace then influences the individual's perception, *P*, of the next situation, which completes the cycle.

Summary

After a review of the literature on models of reading development, several were selected for more detailed presentation and for drawing implications for teaching and research. These models covered the developmental range from kindergarten to the college level.

All of the empirical models selected for detailed presentation are byproducts of research to test hypotheses of the substrata-factor theory of reading. They provide some cross-sectional evidence on psychological factors associated with development of speed and power of reading. Although this cross-sectional evidence tends to support the hypothesis that the structure of skills and abilities associated with speed and power of reading is hierarchically developed and organized, a longitudinal study is necessary to fill in the developmental gaps and to reveal individual patterns of reading development.

If a longitudinal investigation is undertaken, important in such an investigation would be the formulation and utilization of a teaching model that is based upon a theory of the hierarchical structure of learning (*29*) and a comprehensive set of objectives, such as those constructed by Spache (*99*) and Barrett (*6*). In such an investigation we would seek to construct a comprehensive pattern of the "common routes to maturity around which individuals vary," determine how these common routes interact with the personality of the individual, his environmental influences, and his biological support systems. If we can also ascertain whether or not variations in educational procedures have durable effects upon the development, structure, and functioning of these common routes, then we would be in a position to construct a comprehensive theory along the lines outlined by Strang (*104*). This theory would then serve as a cognitive map for improving development of speed and power of reading.

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Reactions to Theoretical Models of Reading: Implications for Teaching and Research

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IT IS A GREAT PLEASURE to contribute to a publication dedicated to the late Jack A. Holmes. Although we worked on opposite sides of the nation we had for years managed to visit at various professional meetings once or twice each year. I miss these occasions and I miss Jack Holmes.

The word *model* now is appearing more frequently in educational literature. It has been used with increasing frequency by Singer in the past few years. The word *model* has a good ring; it has good semantic overtones. Yet the practice of building models can be nonproductive. Sometimes one becomes so involved with the task of constructing the model that we confuse the model with theory, or forget that the model must be tested if it is to be of value. Singer provides a genuine service to others in supplying a rather comprehensive bibliography of papers on models as applied to reading. Careful examination of these works, however, will demonstrate their inadequacies and limitations for either explicating the reading process or for providing a basis for experimentation. It is hoped that Singer or someone else might expand this review section in the near future, for the models described serve best to tell us what reading is not, rather than what reading is.

If we are to remove model making from the domain of speculation or game playing, we obviously must provide bases for testing experimentally the models we construct. Some logical tests can be employed first, and, secondly, we can develop experiments for seeing how the terms of the model correspond to the concepts and other constructs of the phenomenon being studied. Having stated a few cautions concerning models and model making, let us examine the models presented by Singer.

Figure 1 in Singer's paper is titled "A subsystem of related elements mobilized as a conceptual response to a printed word stimulus that represents a class of objects." In explaining this teaching model for instruction, Singer states, "The model indicates that the related materials of thinking consisting of percepts, images, memories, information and feeling tone, are organized through the process of concept formation and are linked through a linguistic form to a printed word stimulus that represents a class of objects." It is difficult to see how this model is representative of a teaching model in the usual classroom sense. The flow chart presented in Figure 1, however, may be representative of conceptual response to printed words, but it unfortunately fails to explicate reading behavior simply because it substitutes unknown terms of a higher order of abstraction for the unknown terms of lesser abstraction traditionally used by reading specialists. Terms such as *percepts, images, memories, information, feeling tone* and *concept formation* are highly abstract, often nonoperationally defined, and suspect to many psychologists. Every printed word and linguistic form is difficult to deal with operationally. The model as presented by Singer not only fails to clarify the reading act, but also one wonders how Singer is able to leap from the frying pan of ambiguity to the fire of the means of teaching it. (See "Implications for Teaching.")

In an early report Holmes and Singer (1961) provided an elaborate definition of reading. "Reading is an audiovisual verbal processing—skill of symbolic reasoning, substained by the interfacilitation of an intricate hierarchy of substrata factors that have been mobilized as a psychological working system and pressed into service in accordance with the purposes of the reader." This definition is sufficiently complex to do honor to the often voiced belief that reading is a complex process. In spite of their definition, however, Holmes and Singer have continued to treat reading behavior as if two dimensions, speed and power, fully explain its nature and parameters. In this paper Singer, for example, undertakes to show differences in the factor structures that occur in reading behavior at various grade levels. It is helpful to have this data substantiate what has been long suspected: that reading is somewhat different at different age levels. However, the differences reported may be due to a number of variables. Reading tests vary at different grade levels. Children think differently, have different amounts of knowledge to mobilize and apply to problems, and have different language abilities at various stages of development as shown by the work of Piaget and others. It seems dubious that speed and power as separate dimensions adequately describes all types of reading at all stages of development. One also might question the degree to which speed and power in reading are correlated, either because certain traits such as reasoning, intelligence, or language function in both domains or because the dichotomy employed is not so well defined as it might be. Examination of the factors comprising speed of reading and power of reading, as shown by Singer's figures, reveals a surprising amount of commonality. Certainly Singer's charts reveal one problem of factor analytic studies. In factor analysis it is possible to add parameters as desired by simply adding more measures. The degree to which any of the charts presented by Singer actually represents reading behavior will only be determined when empirical evidence is obtained by conducting carefully controlled experiments.

Keeping in mind the factor patterns shown by Singer for power and speed of reading at various grade levels, let us describe various types of reading that might occur at each level. The question to be answered here is "Do we think the same factor patterns are mobilized and functioning for each type of reading?"

- $Reading_1$ is the type of reading an individual does when he looks at a STOP sign or a sign over a theatre door marked EXIT.
- $Reading_2$ is the type of reading an individual does when he glances through the newspaper to see what is happening to his favorite comic strip characters.
- $Reading_3$ is the type of reading that is narrative, literary, fun. This is described as independent reading level by reading pedagogy.
- $Reading_4$ is the type of reading an individual does when the ideas are complex, when many unfamiliar concepts and terms of an abstract nature are encountered.

It is somewhat naive to think that speed and power (if they are significant dimensions) function to the degree shown by the models presented by Singer. (More types of reading obviously should be shown above.) One also could raise similar questions concerning the relationship of these dimensions to the substrata factor patterns of superior, average, and inferior readers at various levels of development. Again, one wonders whether speed and power and their substrata factors function in such reading behaviors as oral reading, skimming, and scanning. So far we can only speculate about these questions. Singer, however, provides a basis for careful examination.

Despite the apparent inadequacies of the models presented, however, Singer deserves a note of thanks. Here is a man, like his mentor the late Jack A. Holmes, who dares to theorize and to share his ideas. He has addressed himself to explicating the reading process. It is unfortunate that more of our young reading specialists do not take this path.

Much of the substrata theory still remains to be tested.

PART TWO

The Substrata-Factor Theory of Reading: Some Experimental Evidence[1]

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IN THIS PAPER I intend to do three things: I will (1) pose a crucial question; (2) give an over-view of the Substrata-Factor Theory and relate it to this question and (3) illustrate the power of the Theory by reporting some insights and experimental findings from our own laboratories.

As experts in the fields of education, psychology, and reading, you are all aware that reading is a much more complex ability than many of our critics would seem to believe. *But our scientific understanding of the reading process depends upon our answers to the basic question: Just how complex is this ability we call reading, what are its dimensions, and how do they operate?*

In 1942, May Lazar (*1*) expressed the notion that the reasons for reading failure must be sought in a constellation of causes and that the most constructive approach that could be taken would be to investigate these causes in their interdependence, in order to find out, if possible, which carry the most weight. Unhappily, she was forced to conclude that at this time no clear-cut and definite method existed for specifically isolating the most significant elements from the combination of many. What the Substrata-Factor Theory really does, then, is to take seriously this basic notion of Lazar's and, lifting it out of the diagnostic context in which it was originally embedded, generalize and formalize it into a precise, premised statement of theory.

In essence, the Substrata-Factor Theory (2) holds that, normally, reading is an audio-visual verbal-processing-skill of symbolic reasoning (3), sustained by the interfacilitations of an intricate hierarchy of

[1] Reprinted from *New Frontiers in Reading,* Proceedings of the Fifth Annual Conference of the International Reading Association. New York: Scholastic Magazines, 1960.

substrata factors that have been mobilized as a psychological working-system and pressed into service in accordance with the purposes of the reader.

From the Theory three complementary models have been developed. Space precludes my describing in detail the neurological *(4)* or statistical (*5*) models; however, I will refer to them whenever such a reference would seem to help clarify my explanation of the psychological model (*6*).

Obviously, of first importance for the theory are the *substrata factors.* They are thought of as neurological subsystems of brain cell-assemblies, containing various kinds of information; such as, memories for shapes, sounds, and meanings of words and word parts, as well as memories for vicarious and experiential material, conceptualizations, and meaningful relationships stored as substantive verbal units in phrases, idioms, sentences, etc. Such neurological subsystems of brain cell-assemblies gain an interfacilitation, in Hebb's (*7*) sense, by firing in phase. By this means, appropriate, but diverse, subsets of information, learned under different circumstances at different times and, therefore, stored in different parts of the brain are brought simultaneously into awareness when triggered by appropriate symbols on the printed page. These substrata factors are tied together in a working-system, and as their interfacilitation in the working-system increases, the efficiency of the child's reading also increases. Here is an explanation, then, of what may take place when the child learns to read better, by reading. Such diverse substrata factors initially become associated together in a particular working-system by the psychocatalytic action of what the Theory hypothesizes as mobilizers.

Mobilizers (*8, 9*) are psychologically defined in terms of deep-seated value systems, the fundamental ideas that the individual holds of himself, and his developing relationship to his environment. As conative tendencies, with or without conscious awareness, mobilizers function to select from one's repertoire of subabilities those which will maximize one's chances of solving a specific problem in particular, and forwarding the realization of self-fulfillment in general. Mobilizers must play their major roles as the fundamental driving value systems from whence spring the many and specific attitudes and anxieties* a person holds toward the purpose and worth (a) of life and death, (b) of the social and physical nature of the universe, and (c) of the self's expanding personality. Consequent patterns of behavior, of course, are directed by such value-attitudes. Neurologically, mobilizers may be thought of as controlling influences, electro-chemical biases, in the brain's scanning-search mechanisms which govern those cell-assemblies which shall be selected and momentarily tied into a particular neural pattern of communication.

A working-system may be described as a dynamic set of subabilities which have been mobilized for the purpose of solving a particular problem. Neurologically, a working-system is conceived of as a nerve-net pattern in the brain that functionally links together the various substrata factors that have been mobilized into a workable communications system.

The Theory ascribes great importance to the logical order and substantive content of the material stored in each of the substrata factors and to the relative efficiency of a total working-system. Some interesting ways of looking at both intra- and inter-individual likenesses and differences follow from this premise. For instance, we hypothesize that an individual will solve the same problem at different times in his life by using different working-systems. Moreover, different individuals may perform the same task to an equal degree of success by drawing upon different sets of subabilities. In other words, we hypothesize that there is more than one way to solve an intellectual problem.

Such exciting hypotheses are, at Berkeley, presently being put to the acid test of experimentation under the auspices of a contract from the United States Office of Education** and a grant from the Carnegie Corporation of New York.*** In the U.S. study we are

* This writer believes that without values there can be no anxieties. Furthermore, other things remaining constant, the intensity of an anxiety is directly proportional to the strength of the value threatened.

** This research is being pursued under contract with the United States Office of Education, Department of Health, Education, and Welfare.

*** These experiments are being supported by a three-year grant from the Carnegie Corporation of New York.

concerned with discovering, at the high school level, what substrata factors are utilized by different known-groups (boys *vs.* girls, brights *vs.* dulls, powerful readers *vs.* non-powerful readers, etc.) in order to achieve success in reading. While our analysis on this particular hypothesis has not yet been completed, we have enough evidence to safely state that we have discovered that the factors contributing to relative success in reading within a known-group of poor readers are somewhat different from those which underlie relative success within a known-group of good readers.

In the Carnegie Project, on the other hand, we are searching for the important substrata factor changes which take place in the child as he progresses through school. The Theory postulates that the pattern of substrata factors in a child's reading hierarchy will undergo a *gradient shift*, or orderly change, as he advances through the grades. As a child increases his proficiency over a succession of newly learned subskills, the substrata factor patterns which underlie his developing ability to read will also change. Furthermore, this reorganization in the structure of the hierarchy will reflect the impact of the interaction of the psychoeducational factors of learning, the biochemical and neurophysiological factors of growth and development, the sequential organization of the material studied, and the method by which the child has been taught.

This hypothetical construct broadens our explanation of individual differences. Two children, for instance, may read quite differently not only because one child has more and better information stored in this or that particular substrata factor, but also because, for reading, one has a working-system that is superior to that of the other.

What a child knows depends upon the repertoire of information stored in his cell-assemblies; but how he thinks, how he reasons with what he knows, depends first upon the nature and number of his genetically determined neuro-configurations and, second, upon the nature of the functional-configurations or working-systems into which he can efficiently organize his mental repertoire of information. It would seem, then, that a child's reasoning process is related to, and for pedagogical purposes determined by, the way in which facts, concepts, attitudes, abilities, etc., are psychologically superimposed on his basic neuro-configurations.

Other things being equal, then, individual differences in the ability to reason about what is being read (that is, to mentally manipulate the inflow of new ideas so that they bear a meaningful relationship to what one has already learned) depends not only upon the essential nature of the stored information, but more importantly, upon the *associative logic of the conceptualizing activity-of-perception* stimulated within the brain, by the meaningfulness of the sequential input at the time of *presentation* and *reception.*

We, as teachers, I hasten to add, have always acted as if we had intuitively appreciated this notion. In fact, it is what we have always thought of as the very essence of good teaching. What, then, has the Theory added; what is new in what I have said? Obviously, it is the explanation! We now have an explanation of how reasoning in reading works, and this rationale should help us to better understand and justify our teaching procedures. Perchance, this theoretical insight will lend an even greater significance to the tremendous effort and teacher-hours we expend every year trying to make things clear and logical to our students.

The point I wish to drive home is this, the careful selection of meaningful material, the logic of our explanations, the continuity of our theme in the classroom lesson, the unit, and the total curriculum are important not only because they foster clarity and understanding at the time of presentation, but because the logic-and-fact of the sequential input is the essential element in teaching that leads the child *himself* to develop those habits of cortical association which determines not only the nature and efficiency of recall, but also the degrees of freedom or versatility a child may have for reorganizing his working-systems later on when, in fact, reorganization is necessary and desirable, if the process of symbolic reasoning is to be both logical and creative—that is, if it is to maximize creativity in the transfer of training process.

The content, sequence, and scope of our reading readiness, developmental, and creative reading programs, then, merit our best efforts; but what shall we select as the core of our programs? For at least a partial answer to this question as well as by way of illustrating the several elements of our Theory, let us turn our attention to an experiment I did in 1948 (10).

The major hypothesis we were interested in testing stated that the general reading ability of college students is a composite of speed and power of reading, and that underlying each component is a multiplicity of related and measurable factors. The investigation was designed to discover, if possible, the relationship between speed and power of reading and some forty subabilities categorized under the headings of intelligence, linguistic abilities, oculomotor abilities, and personality traits.

The psychograph in Figure 1 diagrammatically summarizes the mean comparative scores made by the 22 most powerful and 24 least powerful college students in my total working sample of 126. All scores are in standardized form and may be compared across the board test for test. Notice that for the criterion, *power of reading*, the two known-groups are separated by a tremendous gap. The mean of the least powerful is at the seventh percentile; whereas, the mean of the most powerful readers is at the ninety-third percentile. Although not so greatly differentiated, the two groups, nevertheless, show large and significant differences in the intellectual, linguistic, perceptual, and oculomotor areas. I was not able to find significant differences for these two groups in the personality traits tested.

My toughest problem, however, was the very same one that confronted Lazar; that is, there existed no clear-cut and definite method for specifically isolating the most significant elements from the combination of many. Hence, I was forced to try to develop a new statistical technique. This I was able to do by modifying and extending the Wherry-Doolittle multiple correlation technique to yield substrata factors. This substrata analysis, as the Wherry-Doolittle-Holmes model is now called, yields successive sets of sub-variables, gives each set a definite place in a complex hierarchy of subabilities, and finally calculates the significant contribution which each of the subabilities in the hierarchy makes to the variance of the criterion.

By using this new statistical technique, the proper experimental design, a working sample of 126 college students, and a check-sample of 94 college students, I was able to select out of the 37 independent variables listed in Figure 1 only those which made a direct or an indirect, yet statistically significant and "independent" contribution to the variance of the criteria, speed, and/or power of reading.

One starts the analysis by selecting the most valid predictor of

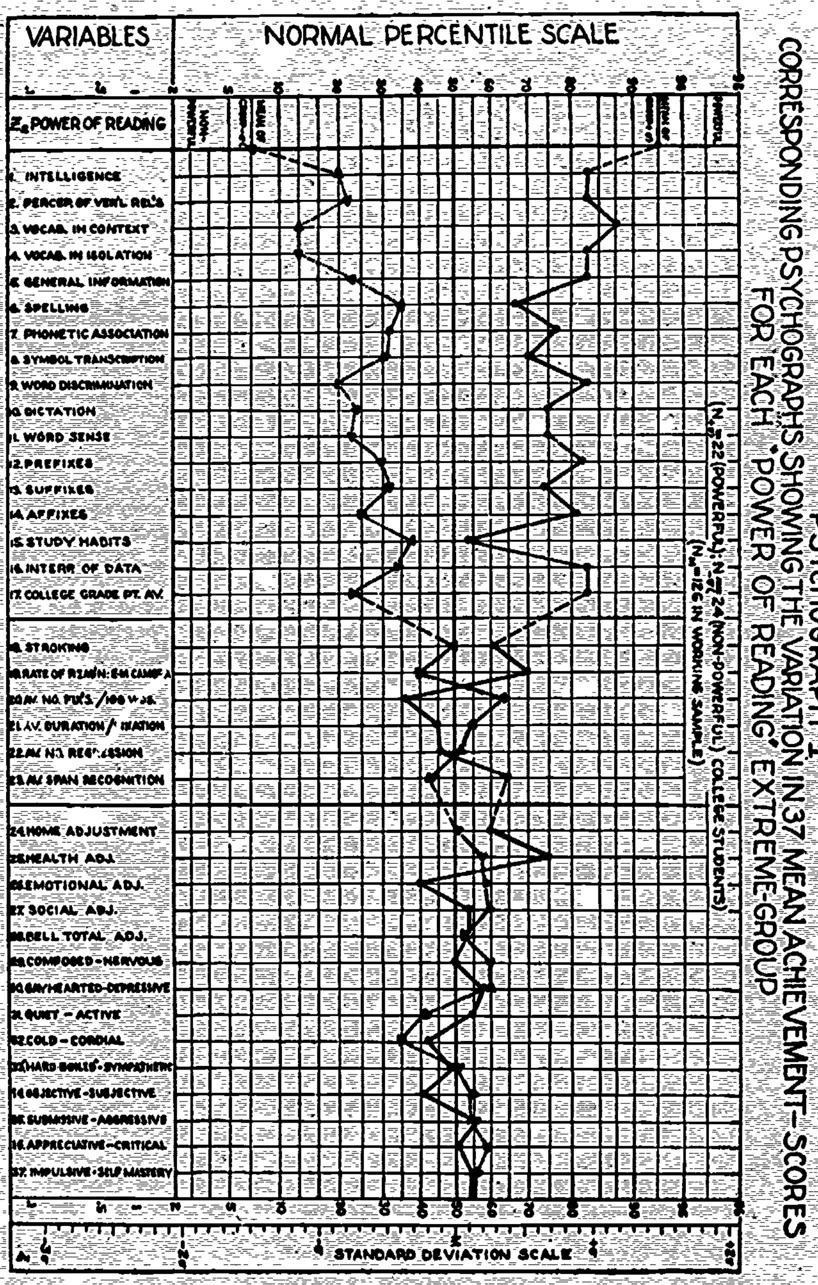
PSYCHOGRAPH I
CORRESPONDING PSYCHOGRAPHS SHOWING THE VARIATION IN 37 MEAN ACHIEVEMENT-SCORES FOR EACH "POWER OF READING" EXTREME-GROUP
VARIABLES
NORMAL PERCENTILE SCALE
POWER OF READING
1. INTELLIGENCE
2. PERCEP. OF VERL. REL'S
3. VOCAB. IN CONTEXT
4. VOCAB. IN ISOLATION
5. GENERAL INFORMATION
6. SPELLING
7. PHONETIC ASSOCIATION
8. SYMBOL TRANSCRIPTION
9. WORD DISCRIMINATION
10. DICTATION
11. WORD SENSE
12. PREFIXES
13. SUFFIXES
14. AFFIXES
15. STUDY HABITS
16. INTERP. OF DATA
17. COLLEGE GRADE PT. AV.
18. STROKING
24. HOME ADJUSTMENT
25. HEALTH ADJ.
26. EMOTIONAL ADJ.
27. SOCIAL ADJ.
28. BELL TOTAL ADJ.
29. COMPOSED - NERVOUS
31. QUIET - ACTIVE
32. COLD - CORDIAL
34. OBJECTIVE - SUBJECTIVE
35. SUBMISSIVE - AGGRESSIVE
36. APPRECIATIVE - CRITICAL
37. IMPULSIVE - SELF MASTERY
STANDARD DEVIATION SCALE

Figure 1

the criterion, power of reading. And then, by partialing out the explainable variance that can be accounted for by this first selected test, the method analytically searches for and selects the next most important predictor. Now, the variance attributed to these *two* tests is partialed out, and again one searches for and selects the next most valid predictor test in the battery. This systematic search continues until the Wherry Shrinkage Formula stops the analysis. At this point we have selected, at the primary level, that team of tests which most efficiently explains the variance in the power criterion. The question now asked and answered by the substrata analysis is what are the predictor variables which underlie each of the three tests which we have selected to predict power? To find out, the method outlined above is now repeated using each predictor-test in our first order team as a subcriterion. As indicated in Figure 2, this process is continued until a point of diminishing returns has been reached.

As promised, I will not dwell on the statistical model, but go straight to the results, which are shown in the *flow-sheet* in Figure 2. It may be noted that out of the thirty-seven variables referred to, the flow-sheet depicts only those that the substrata analysis selected, out of the master matrix of intercorrelations, as the variables which significantly contribute to the variance of speed and/or power of reading. By way of example, we may point out how the chart may be read. Entering into the third order, just left of center, we find phonetics; and, as indicated by the lines of the working-system, we conclude that the knowledge of phonetics is important to speed of reading, because, along with vocabulary-in-context and span of recognition, it enters into the constellation of subabilities that make up word sense. Word sense, then, augmented by intelligence, spelling, and vocabulary-in-context, makes a contribution as a substrata factor underlying the skill which we measure as word discrimination. Finally, on the highest level, word discrimination, word sense, and span of recognition become integrated, with some other abilities not tested for in this particular study, to culminate in what we measure as speed of reading, *per se*.

The other side of the *flow-sheet* indicates the working-system of the substrata factors which function together to form what we measure as *power of reading*. Again starting with phonetics, we see

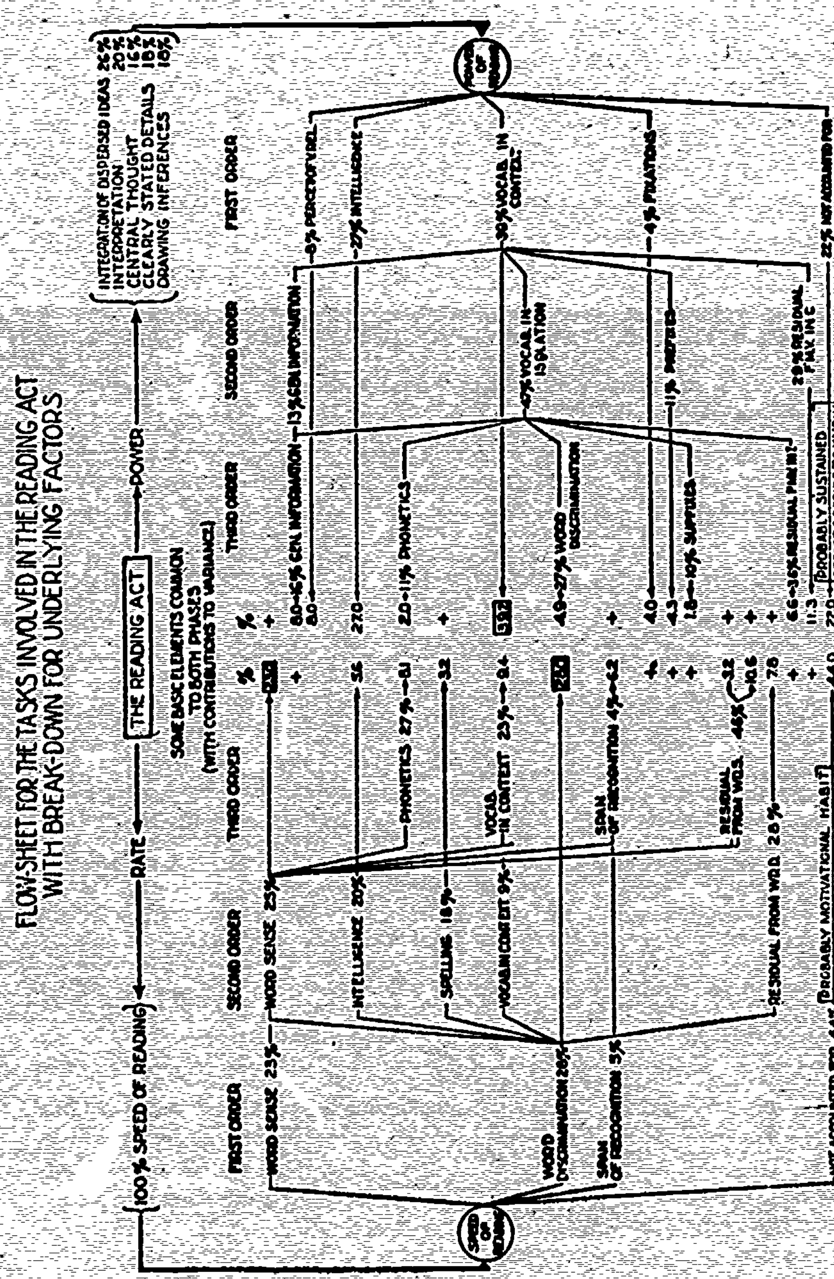
FLOW-SHEET FOR THE TASKS INVOLVED IN THE READING ACT
WITH BREAK-DOWN FOR UNDERLYING FACTORS
100% SPEED OF READING
RATE
THE READING ACT
POWER
SOME BASIC ELEMENTS COMMON TO BOTH PHASES (WITH CONTRIBUTIONS TO VARIANCE)
INTEGRATION OF DISPERSED IDEAS
INTERPRETATION
CENTRAL THOUGHT
CLEARLY STATED DETAILS
DRAWING INFERENCES
FIRST ORDER
SECOND ORDER
THIRD ORDER

Figure 2

that it is important to power of reading, because, along with general information, word discrimination, and suffixes, it enters into a constellation of subabilities to form vocabulary-in-isolation. Vocabulary-in-isolation in its turn combines with general information and prefixes and some other abilities not tested for in this particular study to function as vocabulary-in-context. And finally, vocabulary-in-context becomes integrated with perception of verbal relations, intelligence, and the reciprocal of the number of eye-movement fixations to culminate in what we assess as the ability to read with power. Instead of explaining speed and power of reading in terms of the original thirty-seven, we now are able to explain reading by the interaction of these thirteen crucial variables.

From this paper, two major conclusions may be drawn: first, that the premise upon which we begin our experimental work has been substantiated, and therefore we are justified in formalizing the hypothesis into a generalized theory from which other hypotheses may be deduced and tested; second, that although at first the Theory appears complex, the experiment and statistical analysis do delineate certain important dimensions and bestow upon these an organization, the reasonableness of which, I believe, helps to increase our basic understanding of the nature and dynamics of the reading process.

You perhaps have already noted to yourself that if the Theory holds for reading, why will it not hold for other learning or performance situations as well; we believe it will!

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A Developmental Model for Speed of Reading in Grades Three Through Six[1]

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THE MAJOR developmental hypothesis of the substrata-factor theory of reading (Holmes, 1953; Holmes, 1954; Singer, 1960; Holmes & Singer, 1961; Davis, 1964) states that as an individual learns to read, he sequentially develops a hierarchically organized mental structure of interrelated neuropsychological subsystems. In response to the changing purposes of the reader and the demands of the task-stimuli, these subsystems are organized and reorganized or mobilized into a variety of working systems for attaining speed and power of reading. As a function of maturation, instruction, experience, and mediation, an individual's subsystems improve. Consequently, he can mobilize increasingly more effective working systems. However, improvement in speed and power of reading results not only from changes in the magnitude of substrata-factors which comprise an individual's subsystems, but also from the way in which his subsystems are organized. According to this hypothesis, two individuals could have quantitatively identical subsystems, but one individual might still read better or more rapidly than the other because of a superior integration or a more mature organization of his subsystems.

Although the combination of subsystems that can be organized into a working system for attaining speed and power of reading may vary from individual to individual, at least at the high school level, known groups of individuals—such as boys vs. girls or fast vs. slow readers—if they are to read at all, must mobilize certain neces-

[1] This paper is a revision of an invited address before the National Council of Teachers of English, Cleveland, Ohio, November 25-27, 1964. The research reported herein was supported through the Cooperative Research Program of the Office of Education, U.S. Department of Health, Education, and Welfare, Cooperative Research Project No. 2011. Reprinted from *Reading Research Quarterly*, 1, 1965, 29-49.

sary subsystems, whether these subsystems draw upon strengths or weaknesses in their substrata factor repertoire. However, the working systems of known-groups of individuals, according to their unique patterns of strengths and weaknesses, vary quantitatively and qualitatively around this common structure (Holmes & Singer, 1961, 1964).

This evidence at the high school level is consistent with the hypothesis that there is for the average reader at each grade level a common structure or general working system for attaining speed and power of reading. Moreover, it would seem that this common structure would undergo systematic changes as individuals, in general, develop towards maturity in speed and power of reading. The purpose of this study, therefore, was to test this developmental hypothesis by determining whether substrata-factors at successively higher grade levels have systematic changes in magnitude and/or organizational position concomitant with improvement in speed of reading.[2]

The problem may be restated in terms that are more meaningful to the classroom teacher. In grades three through six, the average scores of pupils on speed and power of reading, plus many other subabilities, increase each year (Singer 1964). Pupils within these grades, however, vary widely not only in speed and power of reading, but also in a multitude of interrelated subabilities, such as phonics, knowledge of affixes, vocabulary, conceptual abilities, and many other variables which teachers instructionally emphasize in the belief that development of such subabilities will effect improvement in speed and power of reading.[3] If teachers knew *a*] which of the multitude of subabilities constitute a parsimonious set of factors that are, in fact, related to speed and power of reading at each grade level, and *b*] which of this set of factors have concomitant changes that are associated with improvement in speed and power of reading, they could use this knowledge as a guide for more precise developmental instruction (Singer, 1962). Teachers would still have to provide for individual differences in reading, but the factors in the model would draw their attention to relevant sources of individual differences in development of speed and power of reading. Then, by concentrating

[2] A developmental model for Power of Reading has been reported elsewhere (Singer, 1964).

[3] In this study, Speed of Reading was assessed at all grade levels by a seven minute subtest of the Gates Reading Survey (Gates, 1953).

general instruction on these relevant factors, teachers theoretically could more effectively and efficiently develop pupils into faster and better readers. Consequently, a practical outcome of this study is to provide teachers and curriculum makers with a statistically-determined model from which guide lines that are consistent with the substrata-factor theory of reading could be drawn for planning developmental instruction in speed and power of reading in grades three through six.

Experimental Design

The developmental hypothesis was tested by administering a selected battery of scales which had precipitated as predictors of speed and power of reading in previous investigations at the college (Holmes, 1954), high school (Holmes and Singer, 1961),[4] or elementary school level (Singer, 1962). These tests, which could be categorized as measures of mental abilities, listening comprehension, linguistic meaning, word recognition, and visual and auditory perception, were selected after a comprehensive review of the literature (Holmes, 1954; Singer, 1960; Holmes & Singer, 1961)[5] These tests with modified names are listed in Table 1.

Personality, interests, and motivation variables were not included because factors representing these domains either had not precipitated from the substrata analysis in previous studies, or tests for these domains were not psychometrically suitable for administration in grades three through six. However, personality, interest, and motivational domains are related to speed of reading under certain conditions (McDonald, 1960) and for some known-groups (Holmes, 1961; Laycock, 1962).

Sample

The tests were given to a total of 927 pupils in six schools located in a middle-class socio-economic district in Alvord, Cali-

[4] An abridged version of this report will be published by the U. S. Office of Education (Holmes & Singer, in press).

[5] The tests were chosen from the batteries of Durrell and Sullivan (1937), Gates (1953, 1958), Holmes (1962), Kwalwasser and Dykema (1930), Singer (1963), Thurstone and Thurstone (1954), and Van Wagenen (1953).

TABLE 1

TEST BATTERY AND MODIFIED TEST NAMES

Test battery	*Modified test name*
A. Gates Reading Survey	
1. Speed of reading	Speed of Reading
2. Level of comprehension	Power of Reading
B. Thurstone Primary Mental Abilities	
3. Words	Visual Verbal Meaning
4. Pictures	Auditory Picture Meaning
5. Space	Spatial Relations
6. Word grouping	Visual Verbal Conceptualization
7. Figure grouping	Reasoning with Visual Figures
8. Perception	Speed of Visual Perception
C. Van Wagenen-Dvorak Silent Reading	
9. Range of information	Range of Information
D. Durrell-Sullivan Reading Capacity	
10. Word and paragraph meaning	Auding
E. Singer Language Perception Tests	
11. Auding conceptual ability	Auditory Verbal Conceptualization
12. Meaning of affixes	Meaning of Affixes
13. Word recognition in context	Word Recognition in Context
14. Matching word sounds	Matching Sounds in Words
15. Blending word elements	Blending Word Elements
16. Phonics	Phonics
17. Syllabication	Syllabication
18. Auditory verbal abstraction	Auditory Verbal Abstraction
19. Spelling recognition	Spelling Recognition
20. Speed of word perception	Speed of Word Perception
21. Recognition of affixes and roots	Recognition of Affixes and Roots
22. Word reversals	Word Reversals
F. Holmes Language Perception Tests	
23. Visual verbal abstraction	Visual Verbal Abstraction
24. Dot-Figure ground configuration	Dot-Figure Ground Configuration
25. Cue-Symbol closure	Cue-Symbol Closure
G. K-D-H Musical Aptitudes	
26. Pitch discrimination	Pitch Discrimination
27. Rhythm discrimination	Rhythm Discrimination
28. Tonal intensity discriminaton	Tonal Intensity Discrimination

fornia.[6] As shown in Table 2, the sample appears to be representative of the general population of pupils in grades six through six because the mean scores at each grade level on chronological age,

[6] The writer wishes to express his appreciation to the Alvord Unified Sc[illegible]ol District, to the Riverside County Superintendent of Schools Office, and t[illegible] research staff at the University of California, Riverside, for participating [illegible] cooperating in this research project.

Primary Mental Abilities I.Q., and Gates *Reading Survey* Speed of Reading and Level of Comprehension or Power of Reading do not differ markedly from standardized test norms.

TABLE 2

COMPARISON OF CERTAIN SAMPLE MEANS WITH STANDARDIZED TEST NORMS

Grade	Variable	Sample size	Sample mean	Standardized test norms
3	Chronological age	223	9.0	9.0
	PMA Intelligence Quotient		101	100
	Gates Speed of Reading		15.4	14.2
	Gates Level of Comprehension		9.6	13.1
4	Chronological age	283	9.9	10.0
	PMA Intelligence Quotient		102	100
	Gates Speed of Reading		19.9	18.7
	Gates Level of Comprehension		15.6	18.0
5	Chronological age	262	10.9	11.0
	PMA Intelligence Quotient		99	100
	Gates Speed of Reading		22.1	23.5
	Gates Level of Comprehension		19.5	24.0
6	Chronological age	159	12.0	12.0
	PMA Intelligence Quotient		97	100
	Gates Speed of Reading		28.9	27.9
	Gates Level of Comprehension		23.3	26.6

Although a selective migrational factor may be present in the California school population, its influence, if any, was not detectable in this study. In fact, because of the mobility of the sample, the results of this study cannot be attributed to any particular method of instruction or to any one set of reading materials. Instead, the results of this study must be related to a *general* method of instruction and to a *general* set of teaching materials since many of the pupils have had at least some of their reading instruction in schools located throughout the U.S. Consequently, they have been exposed to a wide variety of instructional techniques and materials.

Psychometric characteristics of the tests

The data for the mean scores and standard deviations on each variable for grades three through six are given in Table 3. All the tests for differences between means for adjacent grades in this table are significant at least at the five per cent level. These results indicate that all the scales can adequately measure development in reading in grades three through six.

TABLE 3

RAW SCORE MEANS AND STANDARD DEVIATIONS, GRADES THREE THROUGH SIX

No.	Name	Means Gr. 3	Gr. 4	Gr. 5	Gr. 6	Standard deviations Gr. 3	Gr. 4	Gr. 5	Gr. 6
	Dependent variables								
01	Speed of reading	15.4	19.9	22.1	28.9	6.9	7.6	8.5	11.4
02	Power of reading	9.6	15.6	19.5	23.3	6.9	8.1	8.9	9.4
	Independent variables								
03	Visual verbal meaning	12.9	18.4	22.7	27.1	6.0	7.2	7.5	7.2
04	Auditory picture meaning	15.4	19.7	22.7	26.1	4.2	5.1	5.4	6.3
05	Spatial relations	14.3	15.8	17.4	18.4	4.4	4.3	4.0	3.9
06	Visual verbal conceptualization	13.3	17.1	18.6	20.2	5.2	4.8	4.5	4.3
07	Reasoning with visual figures	15.3	18.0	19.3	20.4	4.9	4.2	3.6	3.4
08	Speed of visual perception	17.6	23.4	24.8	29.9	6.9	7.8	8.5	7.8
09	Range of information	16.9	20.4	24.0	26.9	4.7	5.1	5.4	5.6
10	Auding	70.1	84.4	92.2	97.0	14.6	15.4	13.3	13.9
11	Auditory verbal conceptualization	4.9	6.5	7.3	7.8	3.2	2.9	2.7	3.0
12	Meaning of affixes	16.7	23.1	28.1	34.0	6.8	8.8	9.6	10.1
13	Word recognition in context	30.9	41.1	44.3	48.9	14.8	13.8	13.3	11.8
14	Matching sounds in words	28.7	39.6	44.1	49.2	14.9	15.2	14.0	12.0
15	Blending word elements	26.1	31.9	33.3	35.5	8.8	8.0	7.6	7.5
16	Phonics	14.9	21.9	26.9	30.9	8.7	12.3	12.2	12.7
17	Syllabication	3.2	5.0	6.1	7.5	2.5	3.2	3.7	3.6
18	Auditory verbal abstraction	10.8	14.1	15.2	17.5	6.5	6.2	5.9	5.5
19	Spelling recognition	29.4	38.0	42.8	49.7	10.8	11.8	11.7	11.9
20	Speed of word perception	27.8	36.8	43.2	52.9	9.4	13.1	12.6	15.6
21	Recognition of affixes and roots	18.1	25.4	30.1	35.2	9.3	9.9	9.4	8.6
22	Word reversals	8.1	11.5	14.6	18.2	5.8	6.6	7.2	8.9
23	Visual verbal abstraction	9.6	15.0	19.5	22.5	6.1	7.1	8.7	8.4
24	Dot-figure ground configuration	47.9	51.5	54.5	58.9	10.5	11.5	11.3	11.0
25	Cue-symbol closure	22.9	26.2	30.1	34.9	7.9	8.6	9.1	9.5
26	Pitch discrimination	15.4	17.0	18.6	20.3	4.3	5.6	5.0	5.2
27	Rhythm discrimination	15.0	16.1	17.2	18.5	3.4	3.1	2.7	2.7
28	Total intensity discrimination	13.0	14.6	15.9	16.7	4.3	4.0	3.0	3.0

Such development may be attributable to a comprehensive instructional program interacting with a general linear rate of mental development and some degree of intercortical facilitation (Singer, 1964). Moreover, these mean increments indicate that the quantitative part of the hypothesis tested in this study should be confirmed: development in speed of reading in the average reader is accompanied by increases in the magnitude of substrata-factors.

The reliabilities of the tests are listed in Table 4. These reliabilities are split-half corrected by Spearman-Brown Prophecy formula for the untimed tests and parallel scale reliabilities for the timed tests.

Table 4 also shows the concurrent validity coefficients of the experimentally independent variables with Speed of Reading. These coefficients vary gradually from a correlation of —.05 for Tonal Intensity Discrimination at the third grade to .74 for Visual Verbal

TABLE 4

TEST BATTERY RELIABILITY AND CONCURRENT VALIDITY COEFFICIENTS FOR SPEED OF READING, GRADES THREE THROUGH SIX

No.	Name	Reliability Coefficients[a]				Validity Coefficients for Speed of Reading			
		Gr. 3 N = 50	Gr. 4 N = 50	Gr. 5 N = 50	Gr. 6 N = 50	Gr. 3 N = 223	Gr. 4 N = 283	Gr. 5 N = 262	Gr. 6 N = 159
	Dependent Variables								
01	Speed of reading	.96	.88	.91	.89	—	—	—	—
02	Power of reading[b]	.84	.89	.88	.90	.43	.60	.61	.72
	Independent variables								
03	Visual verbal meaning	.90	.91	.94	.93	.53	.63	.64	.74
04	Auditory picture meaning	.66	.70	.88	.89	.26	.46	.47	.60
05	Spatial relations	.82	.83	.84	.74	.18	.09	.13	.27
06	Visual verbal conceptualization	.84	.79	.85	.78	.40	.49	.49	.56
07	Reasoning with visual figures	.80	.84	.63	.59	.16	.17	.15	.39
08	Speed of visual perception	.88	.94	.93	.91	.26	.28	.31	.39
09	Range of information	.81	.73	.77	.81	.30	.48	.52	.61
10	Auding	.88	.92	.91	.92	.27	.42	.38	.57
11	Auditory verbal conceptualization	.77	.76	.82	.90	.43	.41	.45	.51
12	Meaning of affixes	.65	.87	.89	.92	.45	.64	.63	.74
13	Word recognition in context	.95	.93	.93	.96	.44	.52	.57	.60
14	Matching sounds in words	.95	.96	.95	.97	.49	.55	.61	.68
15	Blending word elements	.88	.85	.80	.93	.33	.51	.52	.61
16	Phonics	.86	.96	.93	.96	.37	.53	.50	.61
17	Syllabication	.74	.83	.74	.88	.38	.48	.39	.53
18	Auditory verbal abstraction	.91	.90	.86	.85	.35	.45	.35	.59
19	Spelling recognition	.91	.90	.92	.95	.55	.63	.66	.73
20	Speed of word perception	.87	.80	.84	.80	.58	.58	.55	.66
21	Recognition of affixes and roots	.89	.89	.88	.89	.47	.40	.37	.54
22	Word reversals	.64	.73	.71	.82	.15	.33	.47	.59
23	Visual verbal abstraction	.85	.81	.81	.82	.45	.45	.42	.47
24	Dot-figure ground configuration	.73	.75	.53	.60	.22	.22	.27	.31
25	Cue-symbol closure	.71	.65	.68	.56	.17	.27	.24	.36
26	Pitch discrimination	.44	.73	.65	.67	.17	.24	.16	.25
27	Rhythm discrimination	.79	.64	.64	.61	−.02	.19	.16	.14
28	Tonal intensity discrimination	.62	.82	.81	.50	−.05	.20	.24	.33

[a] A random sample of 25 boys and 25 girls from each grade level was used in the reliability study.

[b] Power of reading was omitted from the matrix when predicting Speed of Reading.

Meaning at the sixth grade. This finely graduated array of validity coefficients attests to the wide variety of functions measured by the test battery and to the necessity for higher-order statistical methods of analysis to determine the minimum number of variables in a linear prediction equation that would tend to yield a maximum prediction of Speed of Reading.

Because a multiple regression equation assumes rectiline ity in the bivariate relationship between each predictor in the regression equation with the criterion measure, both rectilinear and curvilinear coefficients were computed between each variable and Speed of Reading at each grade level. A chi-square test for each resulting pair of bivariate relationships revealed no significant differences.[7] Therefore, the standard error of estimate for each regression equation in this study will be uniform throughout the range of prediction (Mosier, 1951).

In summary, the experimental design consists of *a*] the selection of a battery of reliable and valid tests for predicting speed of reading, *b*] administration of this battery to representative samples of pupils in grades three through six, and *c*] construction at each grade level of a statistically-determined model of substrata-factors for predicting speed of reading. The basic assumption of this experimental design is that these statistically-determined models, related according to grade level sequence, constitute a developmental model of an average individual's general working system for attaining Speed of Reading in grades three through six.

Analysis of the data

Substrata analysis was used to analyze each of the correlation matrices.[8] This analysis consists of an extension (Holmes, 1948, 1954) and modification (Singer, 1960; Holmes & Singer, 1961) of the Wherry-Doolittle Multiple Test Selection Technique (Wherry, 1947). This technique tends to select the minimum number of variables from a correlation matrix that yields a maximal prediction of a criterion. The resulting sub-matrix is next inverted to obtain a multiple regression equation, and the components of this equation are corrected for "shrinkage" or chance sampling factors. The per

[7] Computations were performed on the IBM 7090 Computer at the University of California, Berkeley, by means of RSCAT Program written by M. Maruyama for the Carnegie-Holmes Reading Project.

[8] Correlation matrices for each grade level appear in the final report (Singer, 1965).

cent contribution made by each predictor to the variance of the criterion is then computed from this multiple regression equation.

Holmes extended the technique to analyze the variance of each predictor that could be psychoeducationally analyzed from the remaining pool of predictors by eliminating the major criterion and finding which of the remaining variables in the correlation matrix are substrata-factors for each subcriterion. Subsequent modifications led to:

1] the use of an F-test to determine the number of significant variables to select at any one level, and
2] the development of simple structure in the working-system by systematically eliminating a variable from subsequent predictor matrices once it had been selected. This was in accordance with the methodological assumption that this systematic elimination permitted the analysis to proceed from the more complex to the more elemental substrata levels.[9]

The substrata analysis was then carried out to several levels to obtain a best estimate of the pattern of abilities that underlie Speed of Reading for the *average* individual. However, only the first level predictors from each grade were utilized in the construction of the developmental model in order to emphasize the scope and sequence of substrata-factors that accompany improvement in Speed of Reading for the third to sixth grade reader.[10] These first level models, therefore, are simply the results of the Wherry-Doolittle Technique, modified only by use of an F-test.

Results

The results of the Wherry-Doolittle Analysis for grades three through six appear in Table 5. The table shows the order of selection

[9] A detailed presentation of the theory, assumptions, and statistics, written by Professor Holmes, appears elsewhere in this issue. Mr. Price Stiffler modified the substrata analysis program for the IBM 7090 Computer at the University of California, Berkeley, and assisted in all statistical analysis for this investigation.

[10] A paper on developmental model for Power of Reading was read in an invited main address at the National Reading Conference, Dallas, December 3-5, 1964 (Singer, 1964). A final report to the U.S. Office of Education on the complete project was due July 31, 1965.

TABLE 5

RESULTS OF THE LEVEL 1 WHERRY-DOOLITTLE MULTIPLE SELECTION TECHNIQUE FOR PREDICTING SPEED OF READING, GRADES THREE THROUGH SIX

Grade	Pred. Seq.	Substrata-factor names	Variance increment (V^2/Z)	Computation of shrunken R: K^2	$\frac{N-1}{N-m-1}$	$\overline{K}^2$	$\overline{R}^2$	$\overline{R}$
3	1	Speed of word perception	.3407	.6593	1.0045	.6623	.3377	.5811
	2	Visual verbal meaning	.0763	.5830	1.0091	.5883	.4117	.6416
	3	Dot-figure ground config.	.0256	.5575	1.0137	.5651	.4349	.6595
	4	Recog. of affixes and roots	.0178	.5396	1.0183	.5495	.4505	.6712
	5	Word reversals	.0188	.5209	1.0230	.5329	.4671	.6835
4	1	Meaning of affixes	.4113	.5887	1.0036	.5908	.4092	.6397
	2	Speed of word perception	.0976	.4911	1.0071	.4946	.5054	.7109
	3	Spelling recognition	.0286	.4625	1.0108	.4674	.5326	.7298
	4	Auditory picture meaning	.0141	.4483	1.0144	.4548	.5452	.7384
	5	Spatial relations	.0185	.4299	1.0181	.4376	.5624	.7499
5	1	Spelling recognition	.4423	.5577	1.0038	.5598	.4402	.6635
	2	Speed of word perception	.0677	.4900	1.0077	.4937	.5063	.7115
	3	Visual verbal meaning	.0574	.4326	1.0116	.4376	.5624	.7499
	4	Auditory verbal abstraction	.0113	.4212	1.0156	.4278	.5722	.7565
	5	Visual verbal abstraction	.0162	.4050	1.0195	.4129	.5871	.7662
	6	Meaning of affixes	.0107	.3943	1.0235	.4036	.5964	.7723
6	1	Visual verbal meaning	.5471	.4529	1.0064	.4558	.5442	.7377
	2	Speed of word perception	.0996	.3533	1.0128	.3579	.6421	.8013
	3	Auditory picture meaning	.0327	.3206	1.0194	.3268	.6732	.8205
	4	Spelling recognition	.0187	.3019	1.0260	.3098	.6902	.8308

of predictors and the cumulative multiple prediction, corrected for shrinkage, of Speed of Reading. In the Wherry shrinkage formula

$$\overline{R} = \sqrt{1 - K^2 (N - 1/N - m - 1)}$$

in which $\overline{R}$ is the "shrunken multiple correlation coefficient, the coefficient from which chance error has been removed" (Wherry, 1931; 1947, p. 438).

The correlation matrix of the selected predictors and the criterion variable, Speed of Reading, for each grade level is then inverted to obtain the beta weights and the multiple correlation (R). The weights for each predictor and its zero-order correlation with Speed of Reading, prorated for shrinkage ($\overline{R}^2/R^2$), constitute the components of the regression equation for predicting Speed of Reading. In the general regression formula

$$\overline{R}^2 = \overline{\beta_{01} r_{01}} + \overline{\beta_{02} r_{02}} + \overline{\beta_{03} r_{03}} + \ldots \overline{\beta_{0n} r_{0n}}$$

where

$\overline{R}^2$ = the predicted variance, adjusted for shrinkage

$\bar{\beta}$ = a beta weight, computed from the inverse of the selected matrix, corrected for shrinkage

$\bar{r}$ = a zero order correlation of the predictor with the criterion measure, Speed of Reading, corrected for shrinkage.

The last computational step is to multiply each component of the regression equation by 100 to obtain the percent contribution to variance for each predictor. Table 6 shows the data for the regression equations for each grade level and the contributions to variance, corrected for shrinkage, for each predictor of Speed of Reading.

TABLE 6

REGRESSION EQUATION DATA AND PER CENT CONTRIBUTIONS TO VARIANCE IN SPEED OF READING FOR GRADES THREE THROUGH SIX

Grade	Substrata-factor name	Beta weight	Zero-order correlation with speed of reading	Per cent contribution to variance in speed of reading, corrected for shrinkage
3	Speed of word perception	0.40	.5837	22.81
	Visual verbal meaning	0.28	.5347	14.34
	Dot-figure ground configuration	0.14	.2219	2.93
	Recog. of affixes and roots	0.19	.4763	9.00
	Word reversals	−0.15	.1594	−2.37
	Sum			46.71%
4	Meaning of affixes	0.30	.6413	19.05
	Speed of word perception	0.28	.5822	15.96
	Spelling recognition	0.24	.6367	14.96
	Auditory picture meaning	0.17	.4639	7.65
	Spatial relations	−0.15	.0970	−1.39
	Sum			56.24%
5	Spelling recognition	0.24	.6651	15.57
	Speed of word perception	0.25	.5586	13.52
	Visual verbal meaning	0.31	.6425	19.69
	Auditory verbal abstraction	−0.18	.3594	−6.21
	Visual verbal abstraction	0.15	.4290	6.21
	Meaning of affixes	0.17	.6346	10.86
	Sum			59.64%
6	Visual verbal meaning	0.24	.7397	17.54
	Speed of word perception	0.29	.6667	19.34
	Auditory picture meaning	0.25	.6072	14.83
	Spelling recognition	0.24	.7305	17.31
	Sum			69.02%

The regression equation for each grade level can be visually represented as a set of predictors for Speed of Reading. These predictors are shown in Figure 1 as a diagrammatic model of the development of Speed of Reading in grades three throught six.

Developmental Model for Speed of Reading

The model reveals 1] the Level 1 substrata-factors which accounted for variance in Speed of Reading in grades three through six, and 2] the developmental changes in substrata-factors that accompany improvement in Speed of Reading from grade to grade. In the left hand column of each figure are the substrata-factors or predictors for grade three, followed in successive columns by the predictors for grades four, five, and six. Adjacent to each predictor is its percent contribution to the variance in Speed of Reading for the particular grade level. At the bottom of each column is the variance in Speed of Reading that was not accounted for, and which must be attributable to variables other than those used in the construction of the model, such as functional oculomotor efficiency (Gilbert, 1953), flexibility (Laycock, 1958), speed of processing visual stimuli (Gilbert, 1959), mobilizers (Holmes, 1959), and biological support system (Davis, 1964).

Interpretation of the model

Figure 1 shows that at the third grade level, 47 percent of the variance in Speed of Reading was accounted for by the following five factors: Speed of Word Perception, 23 percent; Visual Verbal Meaning, 14 percent; Recognition of Affixes and Roots, 9 percent; Dot-Figure Ground Configuration, 3 percent; and Word Reversals, —2 percent. Speed of Word Perception, the ability to recognize words and phrases quickly, is a compound measure of speed and span of word recognition. Visual Verbal Meaning measures the ability to recognize a word and match it with a synonym. Recognition of Affixes and Roots is a test of ability to perceive commonly recurring and *meaningful* components of words. Dot-Figure Ground Configuration involves the ability to perceive quickly and accurately a letter or number embedded in a cloud of dots. Word Reversals, designed to assess perceptual control over word perception, require rapid recognition of a multiple choice word spelled backwards, such as "time" and "emit."[11] Therefore, at this grade level individual differences in Speed of Reading are dependent largely upon speed, control, and accuracy of visual perception of printed stimuli and to a lesser extent upon knowledge of word meanings and concepts they represent.

At the fourth grade level five variables accounted for 57 percent of the variance in Speed of Reading: Speed of Word Perception, 16 percent; Auditory Picture Meaning, 8 percent; Meaning of Affixes, 19 percent; Spelling Recognition, 15 percent; and Spatial Relations, —1 percent. Auditory Picture Meaning consists of associating a heard word with a picture or attaining at least a concrete level of word meaning. The ability to select a particular phrase that contains the meaning of a prefix or suffix attached to a given word was measured by Meaning of Affixes. Spelling Recognition is a multiple-choice type of spelling test that may be categorized as a visual word recognition ability, and perhaps assesses visual memory images for words. The interesting result at this grade is the increase in variance accounted for by word meaning factors; this increment is part of a developmental trend which continues through grade six.

At the fifth grade level, the following six variables accounted for 61 percent of the variance in Speed of Reading: Speed of Word Perception, 14 percent; Visual Verbal Meaning, 20 percent; Meaning of Affixes, 11 percent; Spelling Recognition, 16 percent; Visual Verbal Abstraction, 6 percent; and Auditory Verbal Abstraction, —6 percent. The factors which precipitated at the fifth grade include two additional factors: Visual Verbal Abstraction, the ability to perceive the same stimulus word when embedded among varying letters, is analogous to the abstraction of a root word that has been perceived in several, somewhat different words; Auditory Verbal Abstraction is a similar ability for phonic elements, but in the fifth grade matrix has a suppressor-like effect, perhaps augmenting the contribution of

[11] The small, negative contributions to variance made by Word Reversals at grade three, Spatial Relations at grade four, and Auditory Verbal Abstraction at grade five are interpreted as meaning that these factors act as statistical suppressor-like purifiers. As such, they augment the combined contributions to variance which the other predictors make to Speed of Reading (Lubin, 1957; Holmes, 1959).

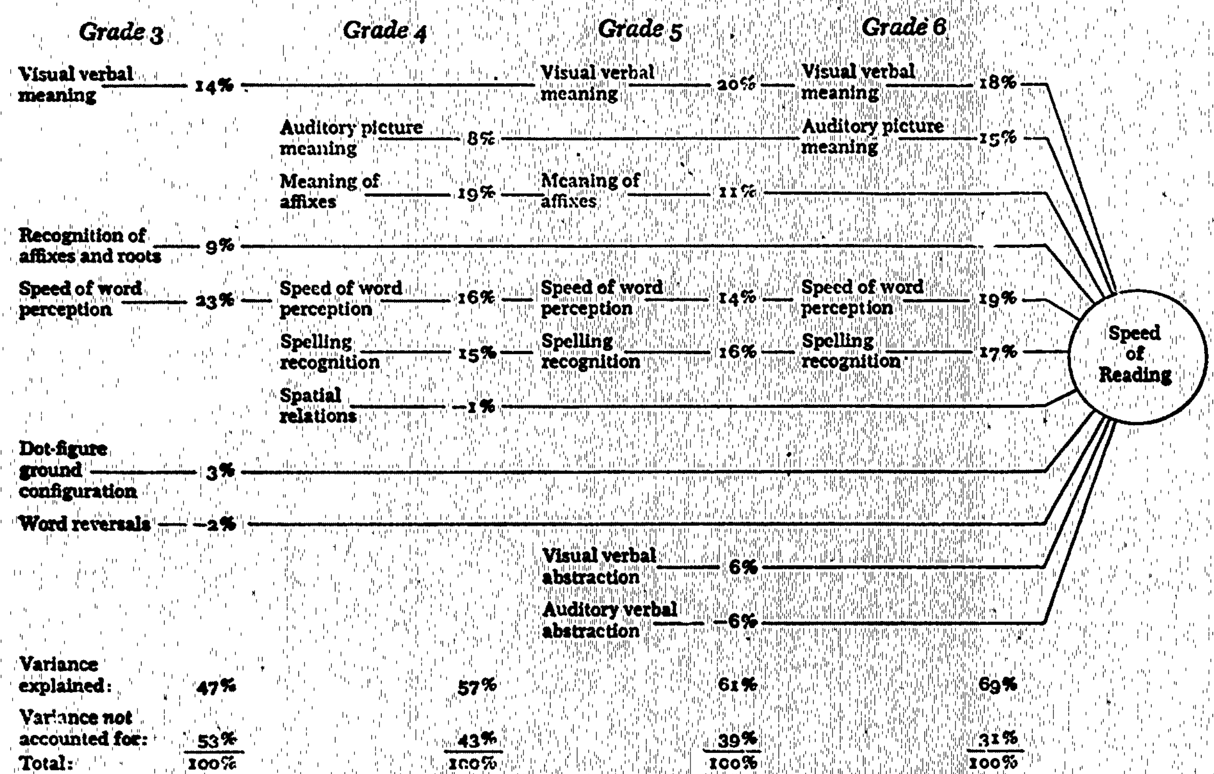

FIGURE 1. Diagrammatic model of the substrata factors accompanying development of Speed for Reading in grades three to six. The model shows for each grade the first level substrata factors and their per cent contribution to variance in Speed of Reading. The variance *not* accounted for is probably attributable to Functional Oculomotor Efficiency, Speed of Processing Visual Stimuli, Mobilizers, Biological Support System, and Verbal Flexibility.

the other factors by suppressing phonic elements with the result that the working system is then composed of more purely visual components. In other words, to the extent that the individual has to attend to auditory elements, his Speed of Reading is slowed down.

Only four factors accounted for 69 percent of the variance in Speed of Reading at the sixth grade. The fact that fewer factors accounted for more of the variance at this grade than at the preceding grade level suggests that a more efficient integration has occurred in the substrata factor organization for speed of reading. Another change is that 33 percent or almost half of the accounted for variance in Speed of Reading was distributed between two kinds of vocabulary factors: Visual Verbal Meaning, 18 percent; and Auditory Picture Meaning, 15 percent. Hence, both range and variety of vocabulary abilities are increasingly important in accounting for individual differences in development of Speed of Reading. The other two factors are Speed of Word Perception, 19 percent, and Spelling Recognition, 17 percent. These factors deal with speed and span of word perception and visual memory images for words.

The faster reader can mobilize, when necessary, all the factors at the previous grade levels, but at the sixth grade level his range and variety of vocabulary abilities, coupled with his speed and span of word perception and visual memory images for words give him his superiority. He can not only take in more words at once and process then more rapidly, but he can also mobilize the necessary word meanings, whether at the concrete or abstract levels and through the visual or auditory modalities, more adequately than the slower reader.

Trends in the developmental model for speed of reading

Four developmental trends can be discerned or inferred from the developmental model for Speed of Reading:

1] A gradual change occurs in substrata-factor organization from a predominance of variance attributable to such visual perceptual abilities at the third grade level as Speed of Word Perception, Recognition of Affixes and Roots, and Dot-Figure Ground Configuration to a more equitable distribution of variance among visual perceptual and word meaning factors at the sixth grade level.

2] Although several auditory variables were in the matrix, only visual factors tended to precipitate in accounting for variance in Speed of Reading in grades three to six. Even when Auditory Verbal Abstraction (a factor logically classified as auditory) did emerge in grade five, it had a suppressor-like effect. Perhaps this indicated that when the auditory elements in the other selected tests are suppressed, the organization of substrata-factors that are more visual in their modality can then function with greater efficiency.

3] A developmental integration of substrata-factors can be inferred from the theory and was empirically demonstrated by substrata analysis at the second and third substrata levels (Singer, 1965b). For example, Recognition of Affixes and Roots accounts directly for some of the variance in Speed of Reading at the third grade level, but only indirectly through other factors at higher grade levels. More specifically, as shown in Figure 2, Recognition of Affixes and Roots precipitates in the third grade as a first level substrata factor. At the fourth and fifth levels, Recognition of Affixes and Roots contributes through Phonics, a second level substrata-factor, to variance in Meaning of Affixes, which makes a direct contribution to variance in Speed of Reading. Finally, at the sixth grade level, Meaning of Affixes, as a second level substrata factor, contributes to variance in Visual Verbal Meaning, which as a first level substrata-factor accounts directly for some of the variance in Speed of Reading.

4] Speed and Span of Word Perception and Verbal Meaning Factors precipitate at each grade level and were integrated at least by the third grade level. Consequently, they have to be considered as necessary factors in the developmental working system for attaining Speed of Reading in grades three through six.

Some implications of the model for the reading curriculum

The model gives curriculum makers an overview of the scope and sequence of factors which provide for individual differences in Speed of Reading in grades three to six. The model can, therefore, be used as a cognitive guide for planning and evaluating development of Speed in Reading. The general implication is that instructional emphasis upon the appropriate factors may promote improvement in this major reading ability. Although a broadly organized instructional program is required, it is clear that other factors—to the extent that they are modifiable—should also be included since not

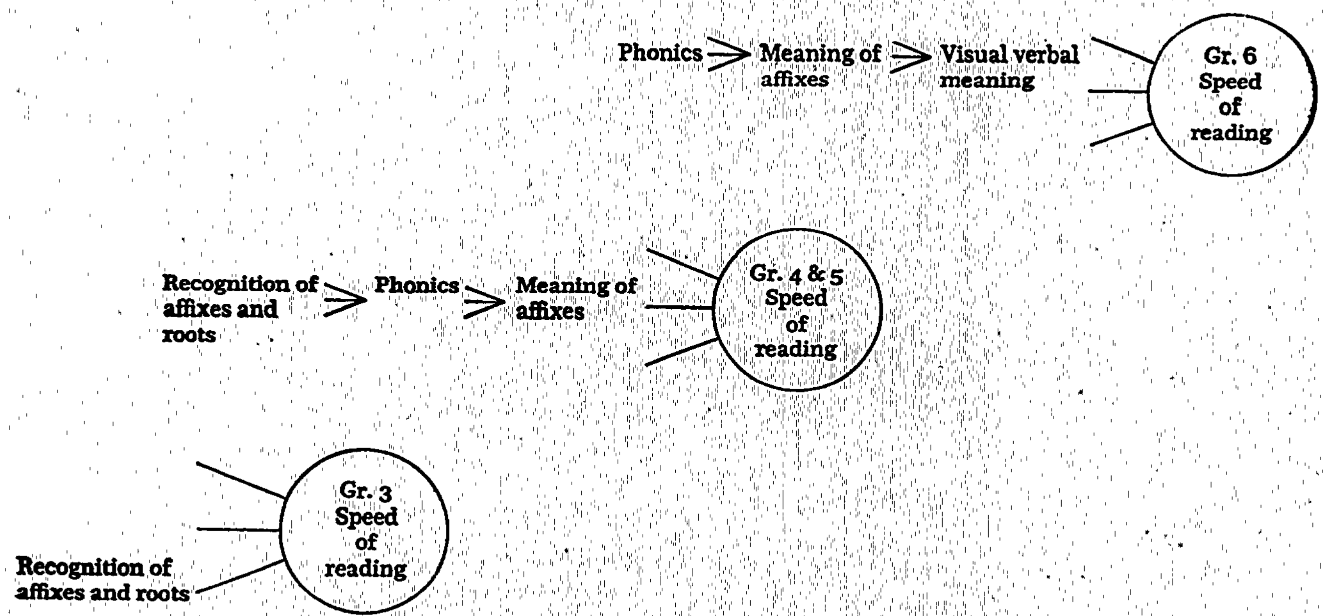

FIGURE 2. Developmental integration of one subsystem for speed of reading in grades three through six The figure shows that Recognition of Affixes and Roots accounts *directly* for some of the variance in Speed of Reading at the third grade level, but only *indirectly* through other factors at higher grade levels.

all the variance was accounted for at any grade level. These factors may reside in the attitudinal, motivational, verbal flexibility, and biological domains.

Because there are some factors common to the developmental working systems for Speed *and* Power of Reading, instructional emphasis upon these common factors contributes to the development of both working systems (Holmes, 1954; Singer, 1962). But, individuals also need to mobilize some different subsystems as they shift from Speed to Power of Reading, and vice-versa. Perhaps these subsystems may be developed more effectively by alternating instruction from accuracy to speed of response. For example, after an individual has been taught by an analytical method to arrive at an accurate recognition of a word, he can be given practice in a variety of ways for perceiving the word accurately *and* quickly. An individual could, therefore, learn to be *effective and efficient* in solving his reading tasks. Analogous to the rate, accuracy, and processes necessary for mature development in arithmetic (Brownell, 1961), an individual by alternately developing subsystems necessary for speed and power of reading could make progress towards maturity in both reading components. Thus, the curriculum would emphasize the necessary subsystems in the context of appropriate purposes in order to promote individuals' developments of speed and power of reading to their highest potential.

Summary and Conclusions

The major developmental hypothesis of the substrata-factor theory of reading was tested by administering a selected battery of variables to approximately 250 pupils in each grade, three through six. Substrata analyses of the resulting correlation matrices confirmed the statistically-formulated hypothesis that quantitative and organizational changes in substrata factors are, in fact, associated with development in Speed of Reading. A theoretical model, constructed to depict these substrata-factor changes, also revealed the following developmental trends: *a*] The general working system for attaining Speed of Reading undergoes a developmental shift from a predominance of visual perceptual abilities at the third grade to a more equitable organization of visual perceptual and word meaning factors at the sixth grade level. *b*] Throughout grades three through six, when substrata-factors that are more visual in their modality are mobilized, the working system for attaining Speed of Reading can function with greater efficiency. *c*] Because Speed and Span of Word Perception and Verbal Meaning Factors precipitated at each grade level as first level predictors of Speed of Reading, they must be considered as necessary factors in the general working system for attaining Speed of Reading. Some specific implications of these findings for the reading curriculum were stated.

Although the empirical results of this study alone contribute to the field of reading because of their practical implications for the understanding and teaching of reading, the fact that a hypothesis was confirmed means that the theory from which the hypothesis was derived has also gained further support (Singer, 1965a). Consequently, the theory can now be utilized with even greater confidence than previously as an explanation of the development of general reading ability and as a theoretical guide in the teaching of reading (Singer, 1962, 1965c).

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A Theory of Language, Speech, and Writing[1]

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RECENT AWARENESS that the science of linguistics may be of considerable relevance to research in elementary reading instruction could produce very unfortunate effects if linguistics should be misunderstood as giving wholehearted support to phonic methods of teaching reading. It is true that during the thirties, forties, and fifties of this century most linguists emphasized the primary nature of speech and the secondary nature of writing. A few were incautious enough to state that writing is merely a secondary representation or identification of speech. Many non-specialists, in their efforts to apply the findings of linguistics to the accomplishment of practical ends concluded that speech *is* the language. It will be demonstrated shortly that these more extreme positions about the primacy of speech over writing are patently absurd.

Linguistic statements, like other scientific statements, have to be understood in terms of the historical context that produced them. During most of the nineteenth century and until about 1925, the primary interest of linguists was in historical linguistics and in the reconstruction of prehistoric stages of descendant languages. This interest naturally led investigators to the written records of earlier periods as their primary source of information. Around 1925 several new interests combined to shift attention for writing to speech. Among these were interest in recording and analyzing the very large number of unwritten languages in the world, interest in more accurate descriptions of modern languages that have systems of written

[1] This paper was presented at an International Reading Association Conference on Linguistics and Reading held in Detroit, May 1965, and published in Brother Leonard Courtney (Ed.), Highlights of the Pre-Convention Institutes, Institute VI, *Linguistics and Reading*. Newark, Delaware: International Reading Association, 1966, pp. 4-25. The first part of the paper was also published in *Elementary English* 42, December 1965, 845-851. The second part of the paper was delivered at the Annual Convention of the National Council of Teachers of English, Boston, November, 1965.

representation, and interest in the comparison of dialects of living languages. All of these interests fostered the development of phonetics and structural linguistics as more exact sciences. It was entirely natural that linguists would seek, during this period, to make supportable generalizations about the primacy of speech over writing. It was observed, for example, that even in historical linguistics it is necessary to interpret written records in terms of speech sounds before a systematic description of the historical development of the language can be given.

Although all the linguistic interests of recent decades have continued to the present day, it has come to be recognized increasingly since the late fifties that phonologically based grammars are incapable of producing adequate analyses of syntax. All of the newer theories of grammar, including the transformational, have in common the procedure from syntax to speech and writing rather than the other way around. And, as soon as one views speech and writing as the end products of grammar rather than as the starting point for grammatical analysis, it is inevitable that he will view the relationship of speech and writing to one another in a new light.

The Primacy of Speech Redefined

Speech is certainly primary and writing secondary in at least the following respects: (1) Speech in some form is probably more than a half million years old; writing is no more than one percent this age. (2) Every contemporary human society has one or more languages, but of the thousands of such now in existence, a large majority have no accepted system of writing. (3) The experience of individuals with unimpaired hearing, nervous systems, and vocal organs, who grow up in a society that has a system of writing, parallels the experience of the race, in that speech is acquired first and largely without conscious effort, whereas understanding of the writing system comes much later as a result of extended and intensive study. (4) In societies that have writing all normal adults have a working command of the spoken language, but only a minority have a comparable command of the written language.

These statements might be summarized by saying that speech generally enjoys a chronological primacy over writing. But it is interesting to note that even this chronological primacy is not a necessary condition in the relationship of speech to writing. One who is totally deaf may be expected to learn to read and write before he learns to speak. Indeed, he may grow up as a deaf mute—one who never learns to speak and is thus exactly comparable to the adult illiterate, who never learns to read and write. In the very interesting case of Helen Keller, who was rendered deaf and blind by scarlet fever before she was two years old, the primary system of representing the English language was a tactile system, in which symbols identifying language are formed by the fingers of one person in contact with the hand of another. Braille became the secondary system, comparable in function to reading and writing for most people, and speech, which Miss Keller never acquired perfectly, was merely a tertiary system for repı senting English.

In short, the observed relationships between speech and writing will not justify our saying that speech *is* the language or that writing is merely a secondary representation of speech. If speech *were* the language, then deaf mutes would be people who have never learned a language—in spite of the obvious fact that some of them read and write English, others German, others French, and so forth. We should also be at a loss to explain how skilled readers can, within a given period of time, identify through reading, a string of linguistic forms that cannot possibly be uttered by the most rapid speaker in a comparable period of time.

The Limits of Phonemic-Graphemic Correspondence Reappraised

It is also easy to prove, in terms that would satisfy the most exact physical scientist or mathematician, that neither writing nor speech is a direct representation of the other. No set of rules of phoneme-grapheme correspondence, however numerous or complicated, can tell us how to pronounce all graphic configurations or how to spell all spoken forms. As an example of the former impossibility, consider <read> or <lead>. To read the first of these, we need to know whether it consists of verb + present, or verb + past. To read the second, we need to know whether it is a verb, or a noun. As an example of the other kind of impossibility, consider a homophone like /red/. One cannot write this correctly unless he knows it to be adjective or, alternatively, verb + past.

The Whole Word Fallacy in Reading

I have devoted so much time to refutation of what I shall call the phonic fallacy, because I believe that linguistics is popularly understood to support it. However, it would be most unfortunate indeed if the preceding remarks were understood to give aid and comfort to supporters of what I shall call the "whole word fallacy." This position is more ridiculous and more dangerous by far than the phonic fallacy. It is more ridiculous, because it is based on a more fundamental misunderstanding of the interrelations between language, speech, and writing than is phonics. It is more dangerous because it has been used for a longer period as one of the methods of the basal readers, which have been employed in the vast majority of instances in teaching American school children to read.

Reading and Understanding

In its most extreme, or, shall I say, crudest, form, the whole word position is that the English system of writing represents whole words which are conceived of, not as linguistic forms, but as something called "meanings." Reading, then, is viewed as a process of identifying meanings from their written representations. If this hypothesis were valid, a child confronted with a string of graphic configurations like <The dog ate the meat.> could demonstrate his ability to read by uttering "The canine quadruped devoured the flesh," or some other suitable paraphrase. Obviously, if our hypothetical child were able to perform such feats consistently, we should be forced to conclude that he could read, but, at the same time, we should also have to say that he had not directly demonstrated his ability to read, but rather his ability to understand written English—a more complicated skill that is based on the ability to read. In fact, the only adequate response to <dog>, if one is to demonstrate that he can read it, is to identify the linguistic form it represents by producing the conventional sign for it in some other system of representation—as, for example, by uttering the syllable /dɔ:g/.

The whole word fallacy, then, is based on a confusion between reading and understanding. Reading is the identification of linguistic forms from strings of written configurations that represent them, as evidenced by producing the conventional signs for the *same* linguistic forms in some other system of representation. Understanding a passage of writing is the identification of the meaning of the linguistic forms that have been identified from the writing, as evidenced by producing, in any system of representation, the conventional signs for *different* linguistic forms that will be judged by native users of the language to have the same meaning. Anyone who has learned to read can read many sentences whose meanings are almost completely unknown to him. I shall now do so: "The theory of functions of a complex variable deals with the differentiability of complex functions, analytic continuation, the residue theorem, and conformal mapping." In reading this sentence, I had no difficulty whatever in identifying all the linguistic forms—both the words and the syntactic structures—but I would find it impossible to produce a paraphrase that would be remotely satisfactory to a mathematician. That is, I *read* this sentence but I don't understand it.

Before turning to more specific matters, I should like to clear up two possible misunderstandings that may derive from my effort to distinguish between reading and understanding. First, let me say that I think that understanding is of vital importance. If one assumes, as I do, that any normal or above average child should be able to learn to read within two years, then most of the reading that he does from the third grade to the end of his formal education and beyond ought to have as its purpose the improvement of his understanding. But I also believe that to introduce this second goal before he has learned to read can only confuse him and delay his progress in learning to read.

Second, there may be those who challenge the notion that different linguistic forms are judged by native users of the language to have the same meaning. Isn't it true, they may ask, that two formally different statements never have the same meaning? This objection may be categorically disposed of: No, it is not true. If it were true, human communication would be impossible. Consider the case of a college student who is asked on an examination to discuss the meaning of Hamlet's third soliloquy or any other passage from literature. If the objection expressed above were valid, the only correct answer to the question would be a verbatim and letter-perfect quotation of the passage. Consideration of this and similar examples may lead to the formulation of a revised and weaker hypothesis to the effect that, although two formally different statements always have different meanings, there is a wide range of variation in the degree of difference between statements. Although I believe in the validity of the qualification, its attachment to the false generalization will not enable us to account for examples of the type cited above, because, even though some paraphrases of Hamlet's third soliloquy might be judged superior to others, all paraphrases would still be judged inferior to a verbatim quotation. In short, I believe that the correct hypothesis about meaning is that some formally different statements have the same meaning, whereas, among those that do not, there is a wide range of variation in the degree of difference in meaning. Only with some such assumption can we continue to grade examinations.

Probably some of you agree with my conclusions about the inadequacy of both the phonic and the whole word methods of teaching elementary reading, but would hasten to point out that these are only two among a number of methods of reading instruction employed in the basal readers. I am sorry to say that this argument reminds me of Stephen Leacock's description of an upright woman who raised her daughter according to the best Christian principles, then taught her Mohammedanism to make sure. The phonic and the whole word methods are contradictory. If one is right, the other must be wrong. To use both is to spend at least part of one's time teaching wrongly, so as to mislead and confuse the learner. If, as I hope I have demonstrated, both methods are based on fallacious theories, to use the two methods is to spend all of one's time teaching wrongly. What is needed at the outset is a better theory of the interrelationship of writing and speech.

Linguistic Forms Variously Represented in Different Symbol Systems

In the theory I have been seeking to develop, the term *linguistic form* is of critical importance. It is certainly not original to me, having been used at least as early as in Bloomfield's *Language* in 1933. Bloomfield defined linguistic forms as the grammatical units of language, consisting of morphemes (the smallest meaningful units) and what he called taxemes of order, selection (primarily of form classes and constructions), phonetic modification (by which the form of morphemes is modified when they enter into combination with other morphemes), and modulation (*i.e.,* intonation). Probably no linguist today would analyze grammar in strict Bloomfieldian terms. Phonetic modification, for example, would be analyzed not as part of the grammar itself, but as part of the transition from language to speech, known as morphophonemics; and modulation would have to be defined abstractly enough to permit its actualization as either intonation or punctuation. The significance of Bloomfield's analysis, however, lies not in such details but in the recognition of a linguistic, or grammatical, level, of which phonemic and graphemic representations make up no part. In the discussions that have raged over Bloomfield's chapter on "Meaning," the placement of that chapter in the total book has been generally overlooked. It comes immediately after the chapters devoted to phonetics and phonemics and immediately before the chapter devoted to morphology. Moreover, although many Bloomfieldians have sought to avoid meaning altogether in their linguistic analyses, Bloomfield is explicit on the point that meaning, regardless of how resistant it may prove to analysis, is an indispensable feature of every linguistic form.

A linguistic form, then, is a linking of a unit of meaning to a physical representation in terms of a conventional system such as speech or writing. Although some linguists have preferred to think of linguistic forms as physical units that signify meanings that are themselves non-linguistic, and others have thought of linguistic forms as semantic units that are identified by nonlinguistic physical configurations, I am of the opinion that it is preferable to think of linguistic forms as simultaneously having semantic and physical features, neither of which is paramount. This may be explained by the analogy of a coin, on which "heads" represents the meaning, "tails" the physical representation. It would be absurd to speak of either side of the coin as the "real" coin, in contrast to the other face which is merely a secondary concomitant. To improve the analogy, we might imagine a country in which several national banks are authorized to strike coins. There is a prescribed national standard for the size, weight, and metallic content of each denomination of coin, but each bank may place its own design on the two faces, so long as these are always the same for the denomination struck by one bank and different for different denominations. We actually have something like this system, since the designs on our coins are changed from time to time. In any event, without laboring the analogy further, the variant designs on the obverse face of a given denomination would correspond to the variant meanings that may be associated with a given linguistic form, whereas the variant designs on the reverse face would correspond to variant representations of the same linguistic form in speech, writing, Braille, *etc.* Correct association of a written symbol with a spoken symbol is accomplished through identification of the linguistic form rather than the meaning, in the same way that, shown a coin with a picture of Monticello on it, one would know that there are other coins of the same value—nickels—that bear a corresponding picture of a buffalo. No knowledge would be required of what appears on the opposite face of either coin, although the ordinary user of American coins would presumably have such knowledge.

Further clarification of the concept, linguistic form, may be secured by comparing it to a related but different concept, commonly termed the "nonsense syllable." I must first comment on the singular ineptness with which these units have been named. The term *syllable* suggests that they are phonological units of a particular length, yet they may equally well be graphic configurations, and their length may range from less than a syllable to many syllables. The term *nonsense* indicates that they are devoid of meaning, but anyone who has encountered "burbled" or "snicker-snack" in "Jabberwocky" knows that this is not true. A better term than *nonsense syllable* might be *pseudo linguistic form,* since the term is meant to cover graphic or phonological configurations or sometimes graphic *and* phonological forms that are associated with one another, all of which are likely to be assigned to a common area of meaning by native users of the language, but have in common the fact that they do not represent any current linguistic form in a given language. Many non-English graphic configurations like <gough> do not correspond to anything in speech, since they have no linguistic form to serve as intermediary. We may imagine <gough> to be pronounced /gu:/, /gau/, /gɔ:f/, /gɔf/, *etc.,* indifferently, on the analogy of *through,* *bough, cough,* and *tough.* Likewise, many non-English phonological configurations like /fo:t/ have no graphic correspondent forms. We may think of /fo:t/ as beginning with <f> or <ph>, with its vowel spelled <o . . . e>, <oa>, and so forth. Furthermore, the semantic feature of a pseudo linguistic form is usually much less precise than that of a true linguistic form. It seems likely that many forms which finally attain linguistic status pass through a transitional stage as pseudo linguistic forms.

Linguistic Forms Regularly Represented in Any Given Symbol System

If both writing and speech are actualizations of linguistic forms and if neither is a representation of the other, just where does this leave us as regards the teaching of reading? In order to proceed, we need to take into account two apparently contradictory characteristics of representational systems: they are always absolutely regular and absolutely arbitrary in terms of the units represented. We are familiar with statements, that have often been ridiculed by linguists, to the effect that English is not a phonetic language. If this statement has any meaning at all, it should mean that the linguistic forms of English are not consistently represented in speech by phonological symbols. Given the knowledge that there is a linguistic form in English that means "canine quadruped," I might sometimes represent it as /hɔ:rs/, sometimes as /nó:sən/, and sometimes as /mú:n/. If this kind of irregularity existed, spoken communication in English would clearly be impossible. Parallel to the statement that English is not a phonetic language is the often-heard allegation that the English system of writing is highly irregular. Once again, if this statement were at all meaningful, it should mean that the linguistic forms of English are not consistently represented by graphic symbols. I might represent the linguistic form that means "canine quadruped" as <horse>, <notion>, or <moon>, as the spirit moved me. If this kind of irregularity existed, written communication in English would be impossible. In short, where the question of regularity is concerned, the only hypothesis that makes sense with reference to English speech and English writing is that both are absolutely regular representations of the English language. It does not follow that either is a regular representation of the other, although, as will be pointed out as soon as we have considered the arbitrariness of representational systems, since English writing is alphabetic, there is a degree of correlation between spoken and written symbols for the same linguistic forms.

Linguistic Forms and Learning to Speak and to Read

Readers of linguistic literature during the last forty years are probably more familiar with the concept that representational systems are arbitrary than that they are regular. There is nothing intrinsic in the linguistic form that means "canine quadruped" that makes it essential for me to pronounce it /dɔ:g/ and spell it <dog>. Except for the arbitrary conventions of English, I might always pronounce it /mu:n/ and spell it <tab>. It follows that the learning of linguistic forms, which, I must remind you, consist of the linking of a meaning or meanings with an arbitrary but wholly regular representational configuration, must at first consist of laborious trial-and-error imitation and memorization. This is what normal children do at the stage of learning to speak their native language, or what deaf children do in learning to read their native language. Gradually the child comes to recognize certain regularities within the grammatical system and the representational system—that, for example, there are a limited number of different sounds in speech and that they occur only in certain patterns. From this point on, his progress in learning improves, because he can call into play higher mental faculties than mere imitation and memorization.

The position of one who has already learned the grammar of a language through one of its representational systems and then turns to learning a second representational system for the same language he has been learning is quite different from the situation described above. The normal child who has learned to speak English and is proceeding to the study of reading and writing is in this second position. He can begin to learn to associate graphic configuration with linguistic forms that he already knows. Only after he has learned to read and write his own stock of linguistic forms should he be encouraged to make use of reading to learn further linguistic forms.

How can the construction of reading materials take advantage of the fact that the child is already a native speaker of English? In the briefest possible terms, a set of rules can be devised, ordered from the most specific rules, that account for single morphemes, to the most general rules, such that, given the spelling of English morphemes, their spoken representations may be arrived at. The list of rules will be long, and it is not necessarily being urged that all or even any of these rules should be taught to the child. It is urged, however, that elementary reading materials should be structured in terms of the rules. This principle does not prescribe any particular structure: Two organizations, of which one is the exact reverse of the other, might both be structured in terms of the rules. Once the rules have been set forth, however, it will be the responsibility of psychologists and classroom teachers to determine which organization, deriving from the rules, is most conducive to learning. On this question, the linguist, as linguist, cannot be expected to have a valid opinion.

Linguistic Forms and Other Units of Language

If we are to come to a better understanding of the complex relationship between speech and writing, we need to characterize as accurately as possible those particular linguistic forms that are actualized as English sounds and English letters. The *phoneme* of descriptive linguistics is entirely inappropriate for this purpose. Insofar as it may be useful at all, it is as a unit of speech rather than of language. Phonemes must bear a direct relationship to the sounds that one speaker of English utters, and they cannot, by their very nature, account for the morphological structure of his language or for the relationships between his speech and that of other speakers of the language, including that of speakers of other dialects. *Graphemes,* as units of writing rather than of language, are also inappropriate for similar reasons.

Let us consider, first, how morphological structure is a factor in the determination of linguistic forms and therefore affects the relationship between speech and writing. The words *metal, rebel, civil, Mongol,* and *cherub* have the same vowel phoneme in their second syllables in most, if not all dialects of English. Yet in English spelling the vowel of these second syllables is represented by five different letters. If we try to describe this situation in terms of direct phoneme-grapheme correspondence, we shall need five rules—one each to explain the spelling of the unstressed vowel in each of these words. There are undoubtedly thousands of English words that present comparable problems, so that the student of English reading who follows strictly the method of phoneme-grapheme correspondence will have to memorize the spelling of thousands of apparently isolated examples. If, however, we consider the following words that are derived from those in the original list—*metallic, rebellion, civilian, Mongolian,* and *cherubic*—it is obvious that they contain five different vowels that are in a consistent relationship with the spelling. If we assume that *metal,* for example, consists of the same linguistic forms (which would generally be called *morphophonemes*), regardless of whether *metal* has /ə/ in its second syllable when it occurs alone or /æ/ in its second syllable when it occurs as part of *metallic,* we shall be in a position to account relatively simply for the spelling of the unstressed vowels in these and thousands of other words. In terms of practical applications of this principle it is suggested that, wherever other considerations (such as unfamiliarity of the derived form) do not militate against it, the longer derived form ought to be taught first, to exemplify the basis for the spelling, before the shorter base form is taught.

Consider, next, such pairs of words as *defy, defies; rely, relied,* and any number of other words that are spelled with <y> in final position, but <ie> in medial position. In such cases it is clear that English *pronunciation* signals the linguistic identity of the forms /difáy/ and /riláy/, even though these forms are spelled differently as bases and as part of derived forms in conventional English writing. The method of phoneme-grapheme correspondence, which cannot take account of the morphological identity involved, will require the memorization of long lists of words in which <ie> spells the diphthong /ay/ of *defies* rather than the vowel /i:/ of *relieve.* Recognition of a linguistic form (in this case a *morphographeme*) that occurs in *defy, rely,* and derived words that contain these and similar elements would obviate this difficulty. The practical application of this principle would be to teach base forms like *defy* and *rely* first; then to teach a simple rule by which derivatives are formed from such bases, rather than attempting to teach derivatives as independent, unrelated forms. The correct procedure has always been followed by reasonably intelligent teachers, but it is important to observe that it is an outright contradiction of the method of phoneme-grapheme correspondence.

From what has been noted up to this point, it should be obvious that the linguistic forms that are represented in English speech and writing consist in part of morphophonemes that are different from the phonemes employed by most, if not all, speakers in certain words, and in part of morphographemes that are different from the graphemes employed in conventional English spelling in certain words. It remains to consider how dialect difference is a factor in the determination of linguistic forms and therefore affects the relationship between speech and writing.

Let us consider three examples, presented first in their written form: 1) <cant>, meaning "to tilt or slant," or, alternatively, "a jargon," 2) <can't>, the contraction of *can* and *not,* and 3) <Kant>, the German philosopher. The first is pronounced /kænt/ in most dialects of English and America; the second is pronounced /kænt/ in the majority of American dialects, but /ka:nt/ in Standard Southern British and a few American dialects; in the third form, these vowels are reversed for many speakers, so that the pronunciation /ka:nt/ prevails in America, but /kænt/ is the only pronunciation given by Daniel Jones for Standard Southern British. Clearly there is a linguistic difference among these three forms, and English writing represents this fact by employing three different spellings for the forms. In the commonest varieties of British and American speech, however, only two different pronunciations are employed, Britain equating forms 1 and 3, America equating forms 1 and 2. English writing spells all three forms differently, in order to show that they contain three different *diaphonemes.* Diaphonemic spelling enables an American reader to associate the "broad *a*" pronunciation with <Kant>, and the British reader to associate it with <can't>.

The opposite of this situation may be illustrated by the forms pronounced /wayz/, /sayz/, and /ayz/ (that is, the verb-forming suffix.) The first and second are spelled <wise> and <size> on both sides of the Atlantic. The verbal suffix is spelled <ize> in America, but <ise> in England. The *pronunciation* of the suffix in both countries reflects the linguistic identity of the form, and the different spellings are a matter of variation in written dialects. All three forms contain the same *diagrapheme*, as indicated by their pronunciations.

We can now say that the linguistic forms that are represented in English speech and writing consist in part of diaphonemes that are different from the phonemes employed by some speakers in some words and different from the phonemes employed by other speakers in other words, and in part of diagraphemes that are different from the graphemes employed in conventional English spelling in certain words. Combining this conclusion with the one previously reached, we might say that English spelling is "dia-morpho-grapho-phonemic," but we cannot say that the linguistic forms represented in speech and writing are "diamorphographophonemes," or the like. Actually the linguistic forms represented in speech and writing include some diaphonemes, some diagraphemes, some morphophonemes, some morphographemes, and, in all those cases that linguists have thus far emphasized, where there is a one-for-one correspondence between phoneme, linguistic form, and grapheme, some mere graphophonemes. We need a name for the class of which these various "emes" are members, and we cannot continue to call it merely "linguistic form," because there are many other linguistic forms, such as "noun," that are not represented directly by phonemes and graphemes. Under these circumstances, I shall venture to coin a new term, *linguon*, to signify the smallest linguistic unit, such as actualized by phonemes in speech and by graphemes in writing. The term is formed on the analogy of *proton, electron, neutron*, etc. in physical science, and is similar to such terms as *phonon, morphon, lexon*, and *semon*, that are used in stratificational grammar.

The abstract nature of such a concept as "the English language" cannot be overemphasized here. Just as one cannot meaningfully say, "I drive the American automobile," so he ought to recognize that when he says, "I speak the English language," he is employing an oversimplified statement to express some such notion as, "I employ a system of speech that is derivable by a list of rules from an abstract structure known as the English language." In terms of the analogy, a given dialect is like a particular make of automobile, say Buick, and my idiolect is perhaps analogous to a particular 1949

Buick sedan I once drove. If we wish to discuss the American automobile in the abstract, we may employ such terms as battery, spark-plugs, brakes, etc., each of which may be thought of as analogous to morphophoneme, diagrapheme, etc. Linguons, in these terms, correspond to automobile *parts*, without reference to the make of car or the function of the part.

I should like to test the linguon hypothesis against a particularly recalcitrant body of data: words that contain one of the linguons[2] //a://, //ɔ://, or //ɔ//. These words are spelled with <a> <au(gh)>, <aw>, <o>, or <ough>, and pronounced with three, two, or one low back vowel phoneme in different dialects, with considerable variation, in America at least, in the incidence of these phonemes in different words. In order to make the body of data more manageable, only monosyllables containing no more than one post-vocalic consonant have been studied. Such an arbitrary restriction may, of course, either simplify or complicate the rules that must be adduced to account for sound-to-spelling correspondences. Any theory of these correspondences must, ultimately, account for all the data.

It may be asked how one can determine what linguons a word contains, since linguons are often not identical to English graphemes or to the phonemes employed in a particular idiolect. This is a particular instance of the general question, how does one formulate a hypothesis, to which the answer is that no one knows. In this particular case, one would, of course, assemble the words under study in their graphic representations along with their principal pronunciations as indicated in dictionaries, linguistic atlases, and other available sources. He would then postulate the linguon constituency of each word in a manner that seemed likely to permit the statement of linguon-phoneme and linguon-grapheme correspondences in terms of the smallest number of rules. One can never be certain that he has found the best formulation—only that one particular formulation is better than another. Thus, it might seem natural to suppose that the words *for, nor, Thor, tor,* and *war* contain the linguon //ɔ://, since all are pronounced with /ɔ:/ in dialects that have this phoneme. If we postulate this linguon in these words, however, we shall require

[2] Linguons will be written between double virgules.

the following rules to convert the linguon into the proper phonemes and graphemes:

(1) //ɔ:// → /ɔ:/[8]
(2) //ɔ:// → <a> [w__r]
(3) //ɔ:// → <o> [__r]

Of these rules, (1) is required for other words with //ɔ://, and so its statement here does not represent any addition to the required set of rules. Rules (2) and (3), however, are not needed for any other words, and may be described as due to our decision to assign //ɔ:// to the words in question. If we had postulated //ɔ// in *for, nor, Thor, tor,* and *war,* we should have needed the following rules to convert the linguon into the proper phonemes and graphemes:

(4) //ɔ// → /ɔ:/ [__r]
(5) //ɔ// → <o>

Rule (5) is required for other words with //ɔ//, but rule (4) is necessitated by the assignment of //ɔ// to the words in question. Thus, we see that it will be better to assume that *for, nor, Thor, tor,* and *war* contain //ɔ// rather than //ɔ://, because to do so will enable us to convert linguons into the proper phonemes and graphemes with one fewer special rule.

Some 225 monosyllabic words containing no more than one postvocalic consonant phoneme, but containing one of the three vowel linguons in question have been studied. Of these 16 contain //a://, including *ma, pa, calm, palm, par, tar,* and ten other words with postvocalic *r*. Another 131 contain //ɔ//, including *pop, top* (and 11 others with postvocalic *p*), *pot, tot,* (and 12 others with postvocalic *t*), *botch, notch, Scotch, cock, bock* (and 10 others with postvocalic *k*), *cob, bob* (and 10 others with postvocalic *b*), *pod, Tod* (and 8 others with postvocalic *d*), *dodge, lodge, hodge-podge, tog, cog* (and 7 others with postvocalic *g*), *Tom bomb, Don, John* (and 5 others with postvocalic *n*), *Poll, doll* (and 3 others with postvocalic *l*), *tong, bong* (and 8 others with postvocalic *ng*), *doff, golf, scoff, off,*

[8] Rule (1) should be read, "The linguon long open *o* is actualized as the phoneme long open *o*; rule (2) as, "The linguon long open *o* is actualized as the grapheme *a* in the environment following the linguon *w* and preceding the linguon *r*."

Goth, moth, wroth, toss, boss, (and 3 others with postvocalic *s*), posh, *bosh, josh, gosh, of, Oz, tor, nor, for,* and *Thor; watt, squat, watch, squad, wan, wash, squash, was,* and *war.* The remaining 78 contain //ɔ://, including *taught, caught, naught, aught, Maugham,* and *Vaughan; ought, bought* (and 4 others with postvocalic *t*), *Sauk, auk, baud, daub, Maude, Paul, maul, Saul, pause,* and *gauze; hawk, pawed, cawed* (and 6 others with postvocalic *d*); *pawn, dawn* (and 4 others with postvocalic *n*), *shawl, yawl, awl, paws, taws* (and 6 others with postvocalic *z*), *(Bryn) Mawr, paw, taw* (and 12 others with final //ɔ://); *talk, chalk,* (and 3 others with postvocalic k), *tall, call* (and 8 others with postvocalic *l*).

It is found that 21 rules are needed to convert the vowel linguons of these words into their correct English graphemes. Of these 21 rules; 18 relate to the linguon //ɔ://, two relate to //ɔ//, and one relates to //a://. The rules follow:

(1, 2)	//ɔ:// → <au>	[*taught, caught*]
(3)	//ɔ:// → <ou>	[—X +][4]
(4)	//ɔ:// → <au>	[—X]
(5)	//ɔ:// → <awe>	[*awe*]
(6-10)	//ɔ:// → <aw>	[*shawl, yawl, awl, Mawr, hawk*]
(11, 12)	//ɔ:// → <aw>	[— +, —n]
(13-16)	//ɔ:// → <au>	[*Paul, maul, Saul, haul*]
(17)	//ɔ:// → <a>	[—l]
(18)	//ɔ:// → <au>	
(19)	//ɔ // → <a>	[w—]
(20)	//ɔ // → <o>	
(21)	//a:// → <a>	

These are ordered rules, which is to say that they must be applied largely in the order in which they have just been presented. Specifically, rules (1-4) must be applied in that order with reference to one another and must precede rule (18). Rule (5) must precede rules (6-12) and rule (18). Rules (6-10) must precede rules (7-18). Rules (11-12) must precede rule (18). Rules (13-16) must precede rules (17-18). Rule (17) must precede rule (18), and, finally, rule (19) must precede rule (20).

[4] //X// is a linguon represented by <gh> and /Ø/ (*i.e.,* "zero"). //+// is a linguon representing morpheme boundary.

Turning to the conversion of these vowel linguons into the phonemes of my idiolect, I find that 20 rules are needed. Since I have only two vowel phonemes, /a:/ and /ɔ:/, in this phonetic area, I need only two rules for //a:// and one rule for //ɔ://. Seventeen rules are required, however, to explain which words with //ɔ// are pronounced with /a:/, which with /ɔ:/.

(1) //a:// → /ɔ:/ [— +]
(2-7) //ɔ // → /a:/ [*doff, Goth, posh, bosh, josh, gosh*]
(8-15) //ɔ // → /ɔ:/ [*mock, dog, log, fog, hog, gone, on, golf*]
(16-18) //ɔ // → /ɔ:/ [—r, —ng, —F][5]
(19) //ɔ // → /a:/
(20) //– // → /– /[6]

The number of rules necessary to make these conversions is due in part to the mixed character of my idiolect. The rules make clear something that I had not previously known: In words that I learned in my native dialect area, rules (16-19) plus one additional rule (18a)—//ɔ// → /ɔ:/ [—g]—will account for all of these //ɔ// words except *mock, gone, on,* and *golf.* My pronunciation of *mock* is probably a folk-etymological back formation from *mawkish,* and *golf* could probably be accounted for in a study that includes rules for consonant linguons by a rule that deletes //l// in certain phonetic environments, after which *golf* is accounted for by rule (18). Only *gone* and *on* seem to have been anomalies in my native dialect. Thus, if the effects of dialect mixture are eliminated, only 7 rather than 17 rules are required to account for //ɔ// in my native dialect. Standard Southern British and similar dialects of American English would require only rules (16, 20). Northern Middle West dialects in which //ɔ// becomes /ɔ:/ before //r//, otherwise /a:/, would require only rules (16, 19, 20). Dialects like those of Western Pennsylvania and some parts of the Far West, that have only one low back vowel phoneme, would require only three rules, probably of the form, (1) //a:// → /ɔ/, (2) //ɔ:// → /ɔ/, plus rule (20) from above.

Only nine rules are needed to convert the vowel letters of these words into the correct linguons:

[5] //F// represents any voiceless fricative.

[6] This rule is to be read, "Replace linguons with phonemes."

(1) <ou> → //ɔ://
(2) <o> → //ɔ //
(3) <au> → //ɔ://
(4) <aw> → //ɔ://
(5, 6) <a> → //ɔ:// [—lk, —ll]
(7, 8) <a> → //ɔ // [w—, qu—]
(9) <a> → //a://

It should be noted that, in a system that converts consonant graphemes into linguons, rule (8) will be unnecessary, since <qu> will already have been converted into //kw//.

Fifteen rules are needed to convert the vowel phonemes of my idiolect into the linguons of English in these words:

(1, 2) /ɔ:/ → //a:// [*ma, pa*]
(3-6) /ɔ:/ → //ɔ // [*mock, gone, on, golf*]
(7) /ɔ:/ → //ɔ:// [(*Bryn*) *Mawr*]
(8-11) /ɔ:/ → //ɔ // [—g, —ng, —r, —F]
(12) /ɔ:/ → //ɔ://
(13, 14) /a:/ → //a:// [—r, —lm]
(15) /a:/ → //ɔ //

Rule (3) is necessitated by the mixed nature of my idiolect, and rule (6) would not be required in a study that included rules for consonants, since it would come under rule (11) after the deletion of /l/. Standard British English would require only rule (7), rule (10), and a rule of the form /—/ → //—// to indicate the same relationships. The simplest form of Northern Middlewest dialect would require rules (7), (10), and (12-15)—a total of six rules. Dialects like that of Western Pennsylvania would require a much longer list of rules, that will not be specified here, in order to sort the one phoneme /ɔ/ into three linguons.

It remains to inquire about the relative difficulty of converting writing to language to speech in these words, on the one hand, as opposed to converting speech to language to writing on the other. The following table indicates the number of rules required to perform these operations in the case of my idiolect, of my native South Midland dialect, of the simplest Northern Middlewest dialect, and of Standard Southern British:

	Graph. to Ling.		Ling. to Phon.		Graph. to Phon.	Phon. to Ling.		Ling. to Graph.		Phon. to Graph.
Reed	9	+	20	=	29	15	+	21	=	36
S. Midl.	9	+	10	=	19	13	+	21	=	34
N. Midw.	9	+	6	=	15	6	+	21	=	27
British	9	+	2	=	11	3	+	21	=	24

Column 3 is the total of columns 1 and 2, and column 6 is the total of columns 4 and 5. It will be observed that the two total columns indicate that it is always easier to move from writing to speech than it is from speech to writing. The differences are greatest for the relatively "pure" dialects. Since elementary school children ordinarily have much less dialect mixture than adults, the figures for the pure dialects assume increased importance. Of course, we cannot know at this stage of our research whether these relationships will hold when a larger segment of the language is studied.

Superficially these figures suggest the intuitive reaction that it is easier to learn to read than to write. This interpretation will hold, however, only in the normal situation of a subject who knows the spoken language and is trying to learn the written language. If we assume a formerly deaf person who can read and write and is trying to learn the system of English speech, the same figures suggest that it is easier to learn to speak than to comprehend spoken English. One is reminded of Abe Burrows' statement, "I speak French, but I don't understand it."

In conclusion, what has been presented here is what I take to be a set of facts about the relations of speech and writing to a small segment of the English language. What the implications of these facts may be for the organization of reading materials and for classroom procedures in reading instruction will have to be hypothesized by psychologists and reading experts and tested in the laboratory and the classroom. These are not matters upon which linguists may safely pontificate.

Psycholinguistic Implications for a Systems of Communication Model[1]

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THE ROLE of psycholinguistics in studying language skills learning is undoubtedly more powerful than either that of linguistics or psychology considered separately. Although the linguist has offered a description of language competency through possible systems for describing and generating sentences and the psychologist has pursued learning theory from various viewpoints, the psycholinguist is interested in exploring the psychological reality of linguistic descriptions. In brief, the viewpoint of the psycholinguist as described by Miller is that of accepting "a more realistic conception of what language is" (*3*). A major goal of the psycholinguist which may be realized in the distant future is the development of a theory or theories of language performance.

The relationship between psycholinguistics and reading instruction is apparent if one views the former discipline as developing an understanding and explanation of language processing and the latter as having its central focus on the enhancement of the ability to decode and comprehend language. This relationship is even more obvious as one considers the definition of reading as a complex psycholinguistic behavior which consists of decoding written language units, processing the resulting language counterparts through structural and semantic dimensions, and interpreting the deep structure data relative to an individual's established objectives.

A central problem, however, in attempting to relate the findings of linguistics and psycholinguistics to the language skill of reading is ironically that of communication. The many dimensions

[1] Reprinted from *Psycholinguistics and the Teaching of Reading*, Kenneth S. Goodman and James T. Fleming, editors. Newark, Delaware: International Reading Association, 1969, 61-78.

of these two disciplines have caused the reading specialist and reading researcher to ask how the multitude of individual components are related to one another and in turn to language skills development. The purpose of this discussion is to provide an overview of selected linguistic and psycholinguistic variables related to decoding and comprehending language, to briefly examine their psychological reality, and in summation to incorporate these variables into a systems of communication model.

Transformational and semantic theories have proposed that language may be viewed on several levels. The first level is considered to be the surface structure and encompasses morphemic and synactic structures which are realized in the form of the graphemic, morphographemic, phonemic, and morphophonemic systems. It is at this level that reading instruction considers the decoding process. The second level consists of structural and semantic readings which make provision for processing language for interpretation. The various transformational and rewrite rules and the structural reading, as well as an individual's mental dictionary of semantic readings, are considered to be incorporated into this level.

The third and least-understood level consists of the deep structure of language where it is hypothesized that the syntactic and semantic components of the language are integrated for language interpretation and stored in memory. This article will initially examine the decoding process, representing one dimension of the surface structure level. Next, the comprehension process encompassing the syntactic dimension of surface structure, the structural and semantic readings, and the deep structure will be considered. A minor emphasis will be given to the role of affective mobilizers and cognitive strategies in language processing. And finally, a systems of communication model will be presented to summarize the discussion relative to reading and language skills processing.

The Decoding Process

One of the central tasks of early reading instruction is that of discovering the nature of the correlation between printed units and their oral counterparts. Instructional approaches have placed varying degrees of emphasis on a variety of decoding units. These include careful control of "regularities" and "irregularities" in grapheme-phoneme correspondences, notably vowels; spelling sound units which are related to an intermediate level unit known as the morphophoneme; and a phonologically based unit known as the vocalic-center group which closely approximates the syllable and in certain instances the smallest significant meaningful language unit or morpheme.

Most reading programs place some degree of emphasis on these various units at some point in the program although the exact structure and sequencing of these units may not always be obvious. Nevertheless, decoding skills have been taught successfully by placing special emphasis on one or a combination of these units. Perhaps a more scientific statement would be that children have learned to decode while being instructed through these various approaches. The latter statement leaves open the possibility that in some manner children are independently able to arrive at an optimal decoding unit depending upon their own cognitive strategy and the particular decoding approach used. But the key question at this point asks what research evidence is available to support a particular perceptual unit or units leading to decoding skill development in reading instruction. Parallel questions not considered in this discussion ask if a variety of units should be considered in the instructional program, at what point in a developmental sequence should they be introduced for maximum utilization, and is there any relationship between specific linguistic units and learner characteristics.

Grapheme-phoneme correspondences. The recommendation that initial words be introduced on the basis of grouped grapheme-phoneme consistencies has been proposed by Soffietti (*47*), Fries (*12*), Smith (*49*), Hall (*20*), and Bloomfield (*4*). These individuals have expressed the opinion that the inconsistencies of the English orthography place a limitation on the acquisition of sound-symbol correspondences as presently developed in widely used reading textbooks. Although the results have been inconsistent in investigations varying the degree of emphasis on sound-symbol correspondences and related generalizations, some early studies have revealed superior results for phonic emphasis at early grade levels, particularly in word recognition (*3, 26, 48*). More recently the work of Hayes (*22*), Ruddell (*40*), Hahn (*19*), Tanzer and Alpert (*51*), Mazurkiewicz (*29*), and Downing (*9*) have lent support to the value of greater consistency in the introduction of sound-letter correspondences. Additionally, the consistent replication of research findings discussed by Chall (*6*) also supports the logical expectation that an approach to decoding which helps the child grasp the nature of the English writing code would be of value.

From the standpoint of information transfer the research by Samuels and Jeffrey (*43*) emphasizes the value of sound-letter correspondence units. In their research psuedo letters were designed to represent English phonemes and kindergarten subjects were taught to decode on the basis of sound-letter correspondences and on the basis of "whole words." The findings indicated that subjects taught by the first method were more effective in transferring their skills to "new words" than were those subjects taught by the second method. The emphasis on individual correspondences appears to provide a lower error rate and more effective decoding skill than does attention to word identification based on single featues.

In a later study the same researchers (*23*) replicated aspects of the above study with similar findings. However, they attributed their results in part to one aspect of the experimental treatment which taught the subjects to blend phonemes represented by the psuedo letters into words. These findings are similar to those of Silberman (*44*) in that subjects were unable to transfer correspondence information to new words unless they had received phonic-blend instruction. The findings may be interpreted to suggest that sound blending places the phonemes in a natural sound-unit context constituting a more elaborated decoding unit which is of value in transferring sound-letter correspondence information to new letter patterns and words.

Morphographemic-morphophonemic correspondences. If a decoding program is to account for the nature of the English writing system, it is necessary to consider spelling units or letter patterns which provide for prediction of sound correspondences beyond the grapheme-phoneme correspondence level. Venezky (52), Wardhaugh (*53*), and Reed (*38*) have discussed this concern with reference to the morphophoneme. This unit represents an intermediate unit between the phoneme and morpheme and may be thought of as a sound-spelling pattern unit or morphophonemic-morphographemic system. For example, in considering the words "extr*e*me" and "ex tr*e*mity" one might point to the second *e* grapheme and note that there is little regularity in its representation of a given sound. However, when one considers these two words on the morphophonemic level, a very regular pattern is immediately obvious. In the alternations extr*e*me-extr*e*mity, obsc*e*ne-obsc*e*nity, supr*e*me-supr*e*mity, one observes a consistent shift in the sound value (/iy/ to /i/) with the addition of the suffix *-ity*. Although some reading programs have developed a few alternations—such as that found in the final *e* marker (sit /i/, site /ay/)—very little consideration has been given to detailed study and research in this area.

Venezky has emphasized that a distinction needs to be made between spelling-sound patterns based on the spelling system and those based on phonological habits. In the first case children probably need to be taught the generalization that the letter *c* represents /s/ when followed by *e, i,* or *y* (e.g., city/sitiy/) and represents /k/ otherwise (e.g., cat/kæt/). However, the generalization that final consonant *s* is pronounced as /z/ following voiced sounds (e.g., dog*s* /z/), as /ə z/ after /s, z, š, ž, č, ǰ/ (e.g., buzze*s* /ə z/) and as /s/ in all other contexts (e.g., hop*s* /s/) is phonological in nature. For this reason the native speaker will automatically produce this change and there would seem to be little need to teach it.

An intensive research effort is needed to examine the contribution of the value of morphophonemic generalizations for reading instruction. One basic question might explore the possible advantage of near simultaneous introduction of contrasting letter patterns representing different but consistent vowel values (e.g., bat, bate), in contrast to sequencing grapheme-phoneme correspondences on the basis of "consistent" vowel correspondences (e.g., bat, mat), as is the case in many recently published reading programs. The research by Levin and Watson (*28*), although limited in scope, has demonstrated possible value in establishing a "set for diversity" in decoding and may be interpreted to lend some support to the former consideration.

Vocalic-center group, morpheme. Hansen and Rodgers (*21*) have posited that a linguistic unit identified as the vocalic-center group provides for high transfer value in decoding. This unit defined as "a vowel nucleus with 0-3 preceding and 0-4 following consonants" (*39*) is phonologically rather than semantically based. In most cases, however, this unit would parallel that of the syllable as defined by the lexicographer. The rationale for considering such a unit is that phonological segmentation is of greater significance than morphological segmentation for the early reader. Rodgers has reported one experiment in which children were asked to repeat disyllabic words (e.g., toas-ter) and bimorphemic words (e.g., toast-er) after the investigator. Their errors were found to favor redivision along the syllabic or phonological rather than along morphological breaks. It should be pointed out, however, that many words classified along phonological boundaries (e.g., quick-ly) will also be classified in an identical fashion along morphological boundaries (e.g., quick-ly).

Other research, notably that of Gibson and her colleagues (*14*), has explored the presence of a higher order unit formed by grapheme-phoneme correspondences. This research has demonstrated that children in the early stages of reading have developed higher-order generalizations which provide for decoding pseudolinguistic letter patterns following English spelling expectancies. The children appeared to perceive regularities in sound-letter correspondences and transfer these to decoding unfamiliar trigrams even though taught by what the researchers refer to as the "whole word" approach.

Additional work by Gibson, et al. (*13*), has demonstrated that adult subjects perceive pseudolinguistic trigrams more easily when they follow English spelling generalizations or pronounceable units (e.g., *BIF*) than when they are less pronounceable (e.g., *IBF*) or more meaningful (e.g., *FBI*). Because the task of the reader is that of decoding written letter patterns and transferring them into oral counterparts, pronounceable letter combinations would seem to be of significant value. On the other hand, meaningful trigrams, such as *FBI*, require the reader to work with three units rather than one. It was noted that the latter type of trigram was more easily recalled than the pronounceable unit. The ease in recall of the meaningful unit was attributed to known and exhaustible storage categories while the pronounceable trigram syllables would call for an extremely large number of categories and be more difficult to retrieve. The researchers concluded that pronounceability was the better grouping principle for reading. This conclusion lends support to the validity of the previously discussed vocalic-center group and in certain instances the corresponding morpheme.

At this point the discussion has considered several decoding units and their psychological real value for developing decoding skills. It would appear that the following units are psychologically real decoding units as used by early readers: grapheme-phoneme correspondences; morphographemic-morphophonemic patterns; and vocalic-center groups and in some cases corresponding morphemes. Upon initial examination the above units appear to be mutually exclusive. This condition may not be so obvious, however, when operationalized in the instructional program. The great majority of linguistically influenced programs which attempt to control for sound-letter correspondences do not teach correspondences in isolation. For the most part, this learning is accomplished through initial consonant substitution, final consonant substitution, and vowel substitution contrasts. For example, the matrix in Figure 1 accounts for emphasis on initial consonants b/b/ and m/m/ in context; medial vowels a/æ/ and i/i/ in context; mrophophonemic pattern contrast with a vowel shift from /æ/ to /ey/; and utilizes the vocalic-center groups and corresponding morphemes.

FIGURE 1. Commonalities In Decoding Units

	-at	*-ate*	*-it*
b-	bat	bate	bit
m-	mat	mate	mit

This example greatly oversimplifies the discussion but serves to illustrate the operational economy which is possible in teaching various decoding generalizations. Most programs, however, attempt to place specific emphasis on a particular unit of analysis by controlling letter-sound relationships with substitution of correspondences in initial, medial, and final positions.

It is thus possible to view the decoding process as establishing an understanding of the relationship between grapheme-phoneme correspondences, which form the larger morphographeme and morphophoneme units which, in operational form, can in turn formulate the pronunciation of the vocalic-center group and, in some instances, the corresponding morpheme.

The Comprehension Process

In examining the process of comprehension the two general areas of relational meaning and lexical meaning are of primary concern. With the former, one is concerned with the importance of structural relationships in sentences; and with the latter, the importance of semantic considerations realized through denotative and connotative meanings and nonlinguistic signs.

Research related to the comprehension process has been prompted by the extensive sentence knowledge which the English speaker possesses. For example, he can recognize grammatical from nongrammatical sentences, *The car struck the tree* versus *The struck tree the car;* comprehend different sentences having the same constituent structures, *John is eager to please* versus *John is easy to please;* identify ambiguous sentences with identical surface structure, *They are frying chickens* versus *They are frying chickens;* and understand sentences with similar meaning but possessing different surface structures, *The girl struck the robber* versus *The robber was struck by the girl.* Additionally, the English speaker can comprehend as well as generate a phenomenally large number of novel sentences. These facts alone suggest that language production and comprehension must be characterized by a rule governing nature. But what evidence is present which will provide for the validation of language generalizations proposed by language scholars?

Relational meaning—surface structure. Recent psycholinguistic research has sought to explore the psychological reality of surface structure constituents or the way in which language patterns tend to "chunk" into syntactic categories. Glanzer (*16*) has shown that pseudosyllable-word-pseudosyllable patterns are more easily learned when the connecting word is a function word (e.g., *of, and*) than when it is a content word (e.g., *food*). This finding supports the view that the resulting constituent group is a more natural word group and thus more easily processed.

The work of Johnson (*24*) dealing with a paired associate learning task has shown that adult subjects make a larger number of recall errors between phrases (e.g., *The valiant canary . . . ate the mangy cat.*) than within phrases (e.g., *The . . . valiant . . . canary,* etc.). This finding suggests that phrases may operate as psychologically real units. The experiment of Fodor and Bever (*11*) also supports this contention. In their investigation, a clicking noise of brief duration was made as a sentence was read. Regardless of the placement of the click (e.g., during a word occurring immediately before or after a phrase boundary), the subjects indicated that the click occurred at the phrase boundary. Thus their conclusion supports the viewpoint that perceptual units correspond to sentence constituents as designated by the linguist.

The recent work of Ammon (*1*) has revealed that third grade and adult subjects require more time to process and respond to phrases. Suci et al (*50*) reported similar findings, thus providing additional support for sentence constituents as meaningful processing units.

Relational meaning—deep structure. The transformational theory has proposed that sentences are processed from the surface structure level to an underlying or deep structure for comprehension purposes. This deep structure is realized through transformational and rewrite rules and is then integrated with the semantic component to convey meaning.

The work of Miller (32) has demonstrated that when subjects are asked to transform sentences from one form into another (e.g., active affirmative to passive or active affirmative to passive negative), a positive relationship is present between transformation time and the complexity of the transformation. This finding supports the contention that transformations possess psychological reality in that the greater the number of transformations the greater is the distance between the surface and deep structure of a sentence.

Mehler (*30*) has shown that after subjects have been asked to memorize a series of complex sentences varying in grammatical type, they tend to recall the sentence but in a simpler grammatical form. For example, a sentence in the passive may be recalled in its active form. These findings suggest that a recoding of the sentence has occurred and that the semantic form is maintained but the deep syntactic marker indicating the passive form has been forgotten.

The role of transformations in sentence comprehension has also been demonstrated in the research of Gough (*18*) and Slobin (*46*). These researchers have shown that sentence comprehension varies in increasing difficulty (speed in determining truth value of sentence) in the following order—active affirmative, passive, negative, and passive negative. Thus, the available evidence does give support to the reality of deep sentence structure. Additional support will be derived from the discussion of short- and long-term memory presented later in this paper.

Lexical meaning. It should be obvious at this point that this discussion of surface and deep structure has placed little emphasis on the role of lexical meaning. Some evidence is present in the previously discussed work of Gough (*18*) and Slobin (*46*) to suggest the importance of this language component. It is of interest to note, for example, that passive sentences were comprehended with greater ease than negative sentences even though the former are thought to be syntactically more complex. This unexpected finding may be attributed in part to the semantic difference between the passive and the negative and to the semantic similarity between the passive and the active. In instances requiring a true or false determination, negative sentences seem to be difficult to comprehend. Slobin has emphasized that not only is syntax important in comprehending sentences but semantic considerations must also be accounted for. His research has shown that the differentiation in difficulty between active and passive can largely be eliminated by clarifying the role of nouns in the subject and object positions. This clarification can be accomplished by reducing the possibility of semantic reversibility(e.g., Reversible: The *girl* struck the *boy*. The *boy* was struck by the *girl*. Nonreversible: The *boy* picked the apple. The *apple* was picked by the *boy*.) Such findings suggest that much more is involved in sentence understanding than relational meaning.

One would expect structure words o play an important role in narrowing possible semantic alternatives in the sequence of a sentence context. For example, the word *the* not only cues a noun which follows but may also clarify or emphasize the semantic nature of the noun (e.g., *The* dog was in our yard versus *Some* dog was in our yard). Miller (*32*) and Miller et al (*34*), demonstrated that words in context following a similar grammatical pattern are perceived more accurately than when in isolation. These findings suggest that the contextual constraint serves to narrow the possible range of appropriate words. Additional support for the importance of context in narrowing semantic possibilities is found in the research of Goodman (*17*). He has shown that although children may be unable to decode words in isolation, they deal successfully with the same words in a running context. Research by Ruddell (*41*) has shown that reading comprehension of fourth grade children is significantly higher on passages utilizing basic high-frequency patterns of their oral language structure in contrast to passages using low-frequency and more-elaborated construction. These findings may be interpreted to support the importance of contextual associations which provide sufficient delimiting information to enable a child to determine the semantic role of a word and further to recognize and comprehend it in the sentence.

The importance of the connotative dimension of word meaning obtains support from the research by Samuels (*42*). Fifth and sixth grade subjects were found to perform significantly higher in comprehending a reading passage containing words of high association value than a control group reading a passage containing low association value words.

Although effort is being made in developing a semantic theory which parallels the previously discussed deep structure, progress has been understandably slow because of the extremely complex nature of relating the semantic and structural components. Katz and Fodor (*25*) have characterized the form of a semantic theory as linguistic description minus grammar. They have postulated that a semantic component in language serves to assign meaning to each sentence through semantic markers. For example, semanticists have constructed semantic categories such as object—nonobject, animate—inanimate, human—nonhuman, and male—female. A semantic marker (*37*) such as *male* represents the content of words like *man, boy,* or *father* in contrast to words like *car, truth,* and *girl.* In some respects this approach resembles the game of 20 questions which provides for narrowing the definition of the meaning under consideration. A sequence of such semantic markers constituting the dictionary would thus provide a semantic reading and define the conceptual content of words. By then utilizing a set of projection rules, the readings of lexical items would be integrated with the grammatical relationships as indicated by the deep structure to derive the semantic characterizations of sentence constituents. Postal (*37*) expresses the view that such characterizations will explain semantic properties such as tence context. To use an example from Katz and Fodor, the sentence "The bill is large," can mean a sizeable debt or the unusual size of a bird's beak. To know that the sentence is ambiguous is only a first step toward the understanding of its meaning. The meaning difficulty is resolved in a larger verbal context such as "Oh, I see you bought a new dress," or "My, what an unusual bird." The ambiguity may also be accounted for in a nonlinguistic fashion if one is purchasing clothing at a store or visiting a zoo. To describe rules, however, which will define the larger verbal context and nonlinguistic meaning represents an enormous task for the psycholinguistic researcher.

Short- and long-term memory. The importance of memory in language processing is also of significant concern as one considers surface and deep structure. Miller and Chomsky (*35*) have proposed that a short- and long-term memory are operative in language processing. It is further proposed that the limited short-term memory deals with the less complex surface structure of sentences while the long-term memory handles the more involved, deep structure of sentences.

Miller (*32*) has demonstrated that subjects have great difficulty in processing sentences containing self-embedded structures (e.g., The rat that the cat that the dog worried killed ate the malt, etc.) in contrast to right-recursive sentences (e.g., This is the dog that worried the cat that killed the rat that ate the malt, etc.) Because the deep structure of these sentences is identical, Miller attributes this variation in difficulty to the heavy demand placed on the short-term memory by the surface structure of the self-embedded sentence.

It would thus seem logical that because of the limited short-term memory (*33*), a deep language structure and a long-term memory component are essential for information processing over running discourse. The previously cited work of Mehler may be interpreted to support this viewpoint in that complex sentences presented to subjects were recalled in a simpler form. It would thus seem that after a sentence is processed in the deep structure, the underlying

show similarities and differences, but all point to a selective, tentative, anticipatory process quite unlike the process of precise, sequential identification commonly assumed.

Let's take a closer look now at the components the reader manipulates in this psycholinguistic guessing game.

At any point in time, of course, the reader has available to him and brings to his reading the sum total of his experience and his language and thought development. This self-evident fact needs to be stated because what appears to be intuitive in any guessing is actually the result of knowledge so well learned that the process of its application requires little conscious effort. Most language use has reached this automatic, intuitive level. Most of us are quite unable to describe the use we make of grammar in encoding and decoding speech, yet all language users demonstrate a high degree of skill and mastery over the syntax of language even in our humblest and most informal uses of speech.

Chomsky (*3*) has suggested this model of sentence production by speakers of a language:

Semantic Deep Surface

→ transformations *phonological*

meaning is retained with little regard for the structure. It would also appear that the deep underlying structure is basic to comprehending sentences.

Affective and Cognitive Dimensions

Affective mobilizers. A system of communication must in some manner account for an individual's interests, attitudes, and values which become operationalized as his objectives and goals. As an individual confronts a verbal task, his motivation reflected in his persistence and drive is extremely important. This viewpoint is supported by Durkin's research (*8*) which has identified the preschool reader as an individual who is serious and persistent, possesses the ability to concentrate, and is of a curious nature. In a study of achieving and nonachieving elementary school readers, Kress (*27*) has reported that the former group demonstrated more initiative in exhausting solutions and was found to persist in problem solving under changing conditions. The research of Piekarz (*36*) has indicated that the high-level reader, in contrast to the inferior reader, provides significantly more responses in interpreting a reading passage, a trait thus indicating greater involvement and participation. The high-level reader is also more objective and impersonal in synthesizing information sought. The research of Athey (*2*) has demonstrated the importance of value systems as mobilizers for reading at the junior high school level.

One would also expect life objectives to influence an individual's store of concepts and in turn his semantic dimension of language processing. The reality of this view is reflected in functional varieties of language. The lexicon of the organic chemist varies markedly from that of the newscaster, and both in turn differ from that of the farm laborer.

The affective mobilizers operationalized as the objectives and goals of the individual would thus be expected to influence language processing at the surface-structure level, through the structural and semantic readings, and at the deep-structure level.

Cognitive strategies. As an individual participates in the communication act, he is constantly required to perceive and organize experiences. He must develop a symbol-processing system which will provide for conceptualization of experience. Bruner et al. (*5*) have shown that a cognitive strategy is of basic importance to the conceptualization process. Kress (*27*) concluded from a concept formation study of elementary school children that achieving readers were superior to nonachievers in versatility and flexibility, ability to draw inferences from relevant clues, and ability to shift set when new standards were introduced. From an extensive review of research on conceptualization, Singer (*45*) concluded that an important dimension in comprehending language consists of changing, modifying, and reorganizing a previously formed concept.

Thus the cognitive strategy of an individual is considered to be operationalized as a process of evaluating the adequacy of information, data gathering, hypothesis building, organizing and synthesizing data, and hypothesis testing. Additionally, the utilization of these factors must be guided by a constant awareness of the need to shift one's strategy to account for other approaches to problem solutions.

A Systems of Communication Model

Although care must be exercised in attributing psychological reality to a competence model or linguistic description, the research presented in this discussion lends some degree of support to the reality of surface structure, language processing through structural and semantic readings, deep structure, short- and long-term memory, and the importance of affective mobilizers and cognitive strategies. Thus, in a limited degree, evidence is present to suggest the general nature of a model of performance.

The language model in Figure 2 has been formulated in order to integrate the previous discussion and express relationships between the various psycholinguistic factors involved in the communication process. On the extreme left of the model the basic communication skills are identified. The rectangular line encloses a hypothetical representation of the systems involved in encoding and production processes of speech or writing and the decoding and comprehension processes of listening or reading.

Near the bottom of the rectangle, the affective mobilizers and the cognitive strategies are noted. The mobilizers represent indi-

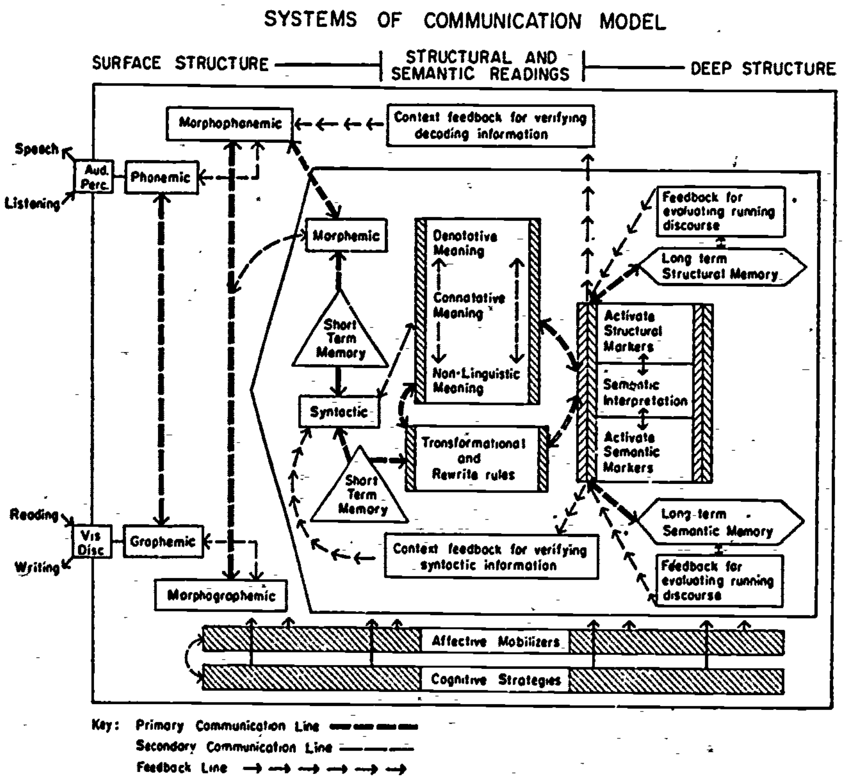

FIGURE 2. Systems of Communication Model

vidual interests, attitudes, and values and become operationalized as goals and objectives in the communication setting. The strategies represent an individual's approach to the language-processing task as determined in part by his objectives. The vertical arrows are entered at key parts of the model from the affective and cognitive dimensions and indicate that during language processing the reader is constantly interacting with each phase of the communication model. These aspects of the model would enable the individual to shift his attention, for example, to the structural aspects of a sentence in order to obtain added relational data to determine the specific semantic dimension of a given word.

The model becomes more meaningful as the act of reading is traced through the various dimensions. In the early stages of reading, the child encounters the English writing system. The objective of the instructional program is to help him understand the nature of the code. This objective may be accomplished by establishing the relationship between the graphemic and morphographemic systems and the phonemic and morphophonemic systems, respectively. The development of cognitive strategies should lead the child to examine alternatives to decoding words. For example, after an unsuccessful attempt to utilize the grapheme-phoneme relationships in decoding, it may be necessary to examine clues at the morphographemic-morphophonemic level or to utilize the context feed-back from the interpretation derived from the deep structure of the sentence. The more advanced reader may move directly from the morphographemic level through the morphophonemic system to the morphemic level or directly from the morphographemic level to the morpheme with a minimal use of the morphophonemic system (*10*).

The organized sound patterns directly involve the morphemic system. At this point the short-term memory is effected, and the syntactic system begins to "chunk" the language units through the constituent structures for transformational and rewriting purpos. Following the transformation and rewriting of the sentence in its most basic form, the semantic aspect of the model is encountered, and the meaning of the various morphemes are considered through a semantic reading utilizing the denotative, connotative, and nonlinguistic dictionary components. The semantic and structural meanings are then meshed through the semantic interpretation or projection rules, and the meaning is established. Simultaneously, the appropriate semantic markers and structural markers are attached, and the semantic and structural contexts are placed in long-term memory. If at the point of semantic projection some difficulty is encountered and the sentence appears to be ambiguous, the reader may return to the morphophonemic level or the syntactic level to verity the surface structure realization for a specific morpheme or constituent structure, respectively.

As a new sentence appears in the running context, the communication is processed in the same fashion. Previous information, which has been stored in the long-term semantic and structural memories, is available for mobilization to the semantic-interpretation level to aid in evaluating the running discourse relative to the objectives established by the reader.

Just as one has examined the act of reading which involves the factors inside the rectangular line, one could proceed through the model in a similar fashion for the decoding and comprehension processes of listening. The encoding and productive processes of writing and speech can be examined by starting with the long-term semantic and structural memories, progressing to the semantic interpretation or projection, and moving from right to left through the model.

In conclusion, the field of psycholinguistics holds significant promise in developing an understanding of language processing which in turn should generate valuable knowledge about the reading process and other communication skills. This result is suggested in the overview of research presented in this discussion providing support for the psychological reality of selected linguistic units. Formulations such as those realized in the systems of communication model should enable reading researchers and specialists to work more profitably toward a theory of reading.

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Reading: A Psycholinguistic Guessing Game[1]

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AS SCIENTIFIC understanding develops in any field of study, preexisting, naive, common sense notions must give way. Such outmoded beliefs clutter the literature dealing with the process of reading. They interfere with the application of modern scientific concepts of language and thought to research in reading. They confuse the attempts at application of such concepts to solution of problems involved in the teaching and learning of reading. The very fact that such naive beliefs are based on common sense explains their persistent and recurrent nature. To the casual and unsophisticated observer they appear to explain, even predict, a set of phenomena in reading. This paper will deal with one such key misconception and offer a more viable scientific alternative.

Simply stated, the common sense notion I seek here to refute is this:

"Reading is a precise process. It involves exact, detailed, sequential perception and identification of letters, words, spelling patterns and large language units."

In phonic centered approaches to reading, the preoccupation is with precise letter identification. In word centered approaches, the focus is on word identifications. Known words are sight words, precisely named in any setting.

This is not to say that those who have worked diligently in the field of reading are not aware that reading is more than precise, sequential identification. But, the common sense notion, though not adequate, continues to permeate thinking about reading.

Spache (*8*) presents a word version of this common sense view: "Thus, in its simplest form, reading may be considered a series of word perceptions."

[1] Paper read at the American Educational Research Association, New York, February 1967, and published in the *Journal of the Reading Specialist*, May 1967. Reprinted with permission of the author and publisher.

The teacher's manual of the Lippincott *Basic Reading* (*6*) incorporates a letter by letter variant in the justification of its reading approach: "In short, following this program the child learns from the beginning to see words exactly as the most skillful readers see them . . . as whole images of complete words with all their letters."

In place of this misconception, I offer this: Reading is a selective process. It involves partial use of available minimal language cues selected from perceptual input on the basis of the reader's expectation. As this partial information is processed, tentative decisions are made to be confirmed, rejected, or refined as reading progresses.

More simply stated, reading is a psycholinguistic guessing game. It involves an interaction between thought and language. Efficient reading does not result from precise perception and identification of all elements, but from skill in selecting the fewest, most productive cues necessary to produce guesses which are right the first time. The ability to anticipate that which has not been seen, of course, is vital in reading, just as the ability to anticipate what has not yet been heard is vital in listening.

Consider this actual sample of a relatively proficient child reading orally. The reader is a fourth grade child reading the opening paragraphs of a story from a sixth grade basal reader (*5*).

"If it bothers you to think of it as baby sitting," my father said, "then don't think of it as baby sitting. Think of it as homework. Part of your education. You just happen to do your studying in the room where the baby brother is sleeping, that's all." He helped my mother with her coat, and then they were gone.

hoped © a
So education it was! I ~~opened the~~ dictionary and picked out a

s PH He
word that sounded good. "Phil/oso/phi/cal!" ~~I~~ yelled. Might

what it means 1. Phizo 2. Phiso/soophical
as well study ~~word meanings first~~. "~~Philosophical~~: showing calmness

his 1. fort 2. future 3. futshion
and courage in ~~the~~ face of ill fortune." I mean I really yelled it. I guess a fellow has to work off steam once in a while.

He has not seen the story before. It is, by intention, slightly difficult for him. The insights into his reading process come primarily from his errors, which I choose to call miscues in order to avoid value implications. His expected responses mask the process of their attainment, but his unexpected responses have been achieved through the same process, albeit less successfully applied. The ways that they deviate from the expected reveal this process.

In the common sense view that I am rejecting, all deviations must be treated as errors. Furthermore, it must be assumed in this view that an error either indicates that the reader does not know something or that he has been "careless" in the application of his knowledge.

For example, his substitution of *the* for *your* in the first paragraph of the sample must mean that he was careless, since he has already read *your* and *the* correctly in the very same sentence. The implication is that we must teach him to be more careful, that is to be more precise in identifying each word or letter.

But now let's take the view that I have suggested. What sort of information could have led to tentatively deciding on *the* in this situation and not rejecting or refining this decision? There obviously is no graphic relationship between *your* and *the*. It may be of course, that he picked up *the* in the periphery of his visual field. But, there is an important non-graphic relationship between *the* and *your*. They both have the same grammatical function: they are, in my terminology, noun markers. Either the reader anticipated a noun marker and supplied one paying no attention to graphic information or he used *your* as a grammatical signal ignoring its graphic shape. Since the tentative choice *the* disturbs neither the meaning nor the grammar of the passage, there is no reason to reject and correct it. This explanation appears to be confirmed by two similar miscues in the next paragraph. *A* and *his* are both substituted for *the*. Neither are corrected. Though the substitution of *his* changes the meaning, the peculiar idiom used in this dictionary definition, "in the face of ill fortune," apparently has little meaning to this reader anyway.

The conclusion this time is that he is using noun markers for grammatical, as well as graphic, information in reaching his tentative conclusions. All together in reading this ten page story, he made twenty noun marker substitutions, six omissions and two insertions.

He corrected four of his substitutions and one omission. Similar miscues involved other function words (auxiliary verbs and prepositions, for example). These miscues appear to have little effect on the meaning of what he is reading. In spite of their frequency, their elimination would not substantially improve the child's reading. Insistence on more precise identification of each word might cause this reader to stop seeking grammatical information and use only graphic information.

The substitution of *hoped* for *opened* could again be regarded as careless or imprecise identification of letters. But, if we dig beyond this common sense explanation, we find 1) both are verbs and 2) the words have *key* graphic similarities. Further, there may be evidence of the reader's bilingual French-Canadian background here, as there is in subsequent miscues (*harms* for *arms, shuckled* for *chuckled, shoose* for *choose, shair* for *chair*). The correction of this miscue may involve an immediate rejection of the tentative choice made on the basis of a review of the graphic stimulus, or it may result from recognizing that it cannot lead to the rest of the sentence, "I hoped a dictionary . . ." does not make sense. (It isn't decodable). In any case, the reader has demonstrated the process by which he constantly tests his guesses, or tentative choices, if you prefer.

Sound*s* is substituted for sound*ed*, but the two differ in ending only. Common sense might lead to the conclusion that the child does not pay attention to word endings, slurs the ends or is otherwise careless. But, there is no consistent similar occurrence in other word endings. Actually, the child has substituted one inflectional ending for another. In doing so he has revealed 1) his ability to separate base and inflectional suffix, and 2) his use of inflectional endings as grammatical signals or markers. Again he has not corrected a miscue that is both grammatically and semantically acceptable.

He for *I* is a pronoun for pronoun substitution that results in a meaning change, though the antecedent is a bit vague, and the inconsistency of meaning is not easily apparent.

When we examine what the reader did with the sentence "*Might as well study word meanings first,*" we see how poorly the model of precise sequential identification fits the reading process. Essentially this reader has decoded graphic input for meaning and then encoded meaning in oral output with transformed grammar and changed vocabulary, but with the basic meaning retained. Perhaps as he encoded his output, he was already working at the list word which followed, but the tentative choice was good enough and was not corrected.

There are two examples, in this sample, of the reader working at unknown words. He reveals a fair picture of his strategies and abilities in these miscues, though in neither is he successful. In his several attempts at *philosphical,* his first attempt comes closest. Incidentally, he reveals here that he can use a phonic letter-sound strategy when he wants to. In subsequent attempts he moves away from this sounding out, trying other possibilities, as if trying to find something which at least will sound familiar. Interestingly, here he has a definition of sorts, but no context to work with. *Philosophical* occurs as a list word a number of times in the story. In subsequent attempts, the child tried *physica, physicacol, physical, philosovigul, phizzlesovigul, phizzo sorigul, philazophgul.* He appears to move in concentric circles around the phonic information he has, trying deviations and variations. His three unsuccessful attempts at *fortune* illustrate this same process. Both words are apparently unknown to the reader. He can never really identify a word he has not heard. In such cases, unless the context or contexts sufficiently delimit the word's meaning, the reader is not able to get meaning from the words. In some instances, of course, the reader may form a fairly accurate definition of the word, even if he never recognizes it (that is matches it with a known oral equivalent) or pronounces it correctly. This reader achieved that with the word *typical* which occurred many times in the story. Throughout his reading he said *topical.* When he finished reading, a check of his comprehension indicated that he knew quite well the meaning of the word. This phenomenon is familiar to any adult reader. Each of us has many well-defined words in our reading vocabulary which we either mispronounce or do not use orally.

I've used the example of this youngster's oral reading not because what he's done is typical of all readers or even of readers his age, but because his miscues suggest how he carries out the psycholinguistic guessing game in reading. The miscues of other readers and any matching or coded signal which results is a kind of by-product.

In oral reading, the reader must perform two tasks at the same time. He must produce an oral language equivalent of the graphic input which is the *signal* in reading, and he must also reconstruct the meaning of what he is reading. The matching in Chomsky's interpretation model is largely what I prefer to call a recoding operation. The reader recodes the coded graphic input as phonological or oral output. Meaning is not normally involved to any extent. This recoding can even be learned by someone who doesn't speak the language at all, for example, the bar-mitzvah boy may learn to recode Hebrew script as chanted oral Hebrew with no ability to understand what he is chanting; but when the reader engages in semantic analysis to reconstruct the meaning of the writer, only then is he decoding.

In oral reading there are three logical possible arrangements of these two operations. The reader may recode graphic input as oral language and then decode it. He may recode and decode simultaneously. Or, he may decode first and then encode the meaning as oral output.

On the basis of my research to date, it appears that readers who have achieved some degree of proficiency decode directly from the graphic stimulus in a process similar to Chomsky's sampling model and then encode from the deep structure, as illustrated in Chomsky's model of sentence production. Their oral output is not directly related to the graphic stimulus and may involve transformation in vocabulary and syntax, even if meaning is retained. If their comprehension is inaccurate, they will encode this changed or incomplete meaning as oral output.

The common misconception is that graphic input is precisely and sequentially recoded as phonological input and then decoded bit by bit. Meaning is cumulative, built up a piece at a time in this view. This view appears to be supported by studies of visual perception that indicate that only a very narrow span of print on either side of the point of fixation is in sharp focus at any time. We might dub this the "end of the nose" view, since it assumes that input in reading is that which lies in sharp focus in a straight line from the end of the nose. Speed and efficiency are assumed to come from widening the span taken in on either side of the nose, moving the nose more rapidly or avoiding backward movements of the eyes and nose, which of course must cut down on efficiency.

This view cannot possibly explain the speed with which the average adult reads, or a myriad of other constantly occurring phenomena in reading. How can it explain, for example, a highly proficient adult reader reading and rereading a paper he's written and always missing the same misprints. Or how can it explain our fourth grader seeing "Study word meanings first" and saying, "Study what it means"?

No, the "end of the nose" view of reading will not work. The reader is not confined to information he receives from a half inch of print in clear focus. Studies, in fact, indicate that children with severe visual handicaps are able to learn to read as well as normal children. Readers utilize not one, but three kinds of information simultaneously. Certainly without graphic input there would be no reading. But, the reader uses syntactic and semantic information as well. He predicts and anticipates on the basis of this information, sampling from the print just enough to confirm his guess of what's coming, to cue more semantic and syntactic information. Redundancy and sequential constraints in language, which the reader reacts to, make this prediction possible. Even the blurred and shadowy images he picks up in the peripheral area of his visual field may help to trigger or confirm guesses.

Skill in reading involves not greater precision, but more accurate first guesses based on better sampling techniques, greater control over language structure, broadened experiences and increased conceptual development. As the child develops reading skill and speed, he uses increasingly fewer graphic cues. Silent reading can then become a more rapid and efficient process than oral reading, for two reasons: 1) the reader's attention is not divided between decoding and recoding or encoding as oral output, and 2) his speed is not restricted to the speed of speech production. Reading becomes a more efficient and rapid process than listening, in fact, since listening is normally limited to the speed of the speaker.

Recent studies with speeded up electronic recordings where distortion of pitch is avoided have demonstrated that listening can be made more rapid without impairing comprehension too.

Though the beginning reader obviously needs more graphic information in decoding and, therefore, needs to be more precise than skilled readers, evidence from a study of first graders by Goodman (*4*) indicates that they begin to sample and draw on syntactic and semantic information almost from the beginning, if they are reading material which is fully formed language.

Here are excerpts from two primer stories (*1, 2*) as they were read by a first grade child at the same session. Ostensibly (and by intent of the authors) the first, from a second preprimer, should be much easier than the second, from a third preprimer. Yet she encountered problems to the point of total confusion with the first and was able to handle exactly the same elements in the second.

Note, for example, the confusion of *come* and *here* in "Ride In." This represents a habitual association in evidence in early reading of this child. Both *come* and *here* as graphic shapes are likely to be identified as *come* or *here*. In "Stop and Go," the difficulty does not occur when the words are sequential. She also substitutes *can* for *and* in the first story, but encounters no problem with either later. *Stop* stops her completely in "Ride In," a difficulty that she dosen't seem to know she has when she reads "Stop and Go" a few minutes later. Similarly, she calls (ride) *run* in the first story, but gets it right in the latter one.

Though there are miscues in the second story, there is a very important difference. In the first story she seems to be playing a game of name the word. She is recoding graphic shapes as phonological ones. Each word is apparently a separate problem. But in "Stop and Go" what she says, including her miscues, in almost all instances makes sense and is grammatically acceptable. Notice that as *Sue* becomes better known she becomes *Suzie* to our now confident reader.

A semantic association exists between *train* and *toy*. Though the child makes the same substitution many times, nothing causes her to reject her guess. It works well each time. Having called (train) *toy*, she calls (toy) *too* (actually it's an airplane in the pictures), not once, but consistently throughout the story. That doesn't seem to make sense. That's what the researcher thought too, until the child spoke of a "little red *too*" later in retelling the story. "What's a 'little red too,'" asked the researcher. "An airplane," she replied calmly. So a train is *toy* and a plane is a *too*. Why not? But, notice that when *toy*

RIDE IN

Run
~~Ride~~ in, Sue.
Run
~~Ride~~ in here.
Come here
~~Here~~ I ~~come~~, Jimmy.
Can Come
~~And~~ ~~here~~ I (stop).

STOP AND GO

Jimmy said, "Come here, Sue,
too
Look at my ~~toy~~ (train.)
See it go.
toy
Look at my lit/tle ~~train~~ go."
toy
Sue said, "Stop the ~~train~~.
Come
Stop it ~~here~~, Jimmy."
toy
Jimmy said, "I can stop the ~~train~~.
toy
See the ~~train~~ stop."
too.
Sue said, "Look at my ~~toy~~.
toy.
It is in the ~~train~~.
too
See my little red ~~toy~~. Jimmy.
toy
It can ride in the ~~train~~."
toy
Jimmy said, "See the ~~train~~ go.
Look at it go."
Suzie too
~~Sue~~ said, "Look at my little red ~~toy~~.
toy
See it go for a ~~train~~ ride."
Suzie too
~~Sue~~ said, "My little red ~~toy~~!
said too
© Jimmy, (my) ~~toy~~ is not here.
toy
It is not in the ~~train~~.
toy
Stop the ~~train~~, Jimmy.
too
Stop it and look for my ~~toy~~."

occurred preceding *train*, she could attempt nothing for *train*. There appears to be a problem for many first graders when nouns are used as adjectives.

Common sense says go back and drill her on *come, here, can, stop, ride, and;* don't let her go to the next book which she is obviously not ready to read.

But the more advanced story, with its stronger syntax, more fully formed language and increased load of meaning makes it possible for the child to use her graphic cues more effectively and supplement them with semantic and syntactic information. Teaching for more precise perception with lists and phonics charts may actually impede this child's reading development. Please notice, before we leave the passage, the effect of immediate experience on anticipation. Every one of the paragraphs in the sample starts with "Jimmy said" or "Sue said." When the reader comes to a line starting *Jimmy*, she assumes that it will be followed by *said* and it is not until her expectation is contradicted by subsequent input that she regresses and corrects her miscue.

Since they must learn to play the psycholinguistic guessing game as they develop reading ability, effective methods and materials used by teachers who understand the rules of the game, must help them to select the most productive cues, to use their knowledge of language structure, to draw on their experiences and concepts. They must be helped to discriminate between more and less useful available information. Fortunately, this parallels the processes they have used in developing the ability to comprehend spoken language. George Miller (7) has suggested ". . . psycholinguists should try to formulate performance models that will incorporate . . . hypothetical information storage and information processing components that can simulate the actual behavior of language users."

I'd like to present now my model of this psycholinguistic guessing game we call reading English. Please understand that the steps do not necessarily take place in the sequential or stretched out form they are shown here. [The model appears on page 272.].

1. The reader scans along a line of print from left to right and down the page, line by line.
2. He fixes at a point to permit eye focus. Some print will be

central and in focus, some will be peripheral; perhaps his perceptual field is a flattened circle.

3. Now begins the selection process. He picks up graphic cues, guided by constraints set up through prior choices, his language knowledge, his cognitive styles, and strategies he has learned.
4. He forms a perceptual image using these cues and his anticipated cues. This image then is partly what he sees and partly what he expected to see.
5. Now he searches his memory for related syntactic, semantic, and phonological cues. This may lead to selection of more graphic cues and to reforming the perceptual image.
6. At this point, he makes a guess or tentative choice consistent with graphic cues. Semantic analysis leads to partial decoding as far as possible. This meaning is stored in short-term memory as he proceeds.
7. If no guess is possible, he checks the recalled perceptual input and tries again. If a guess is still not possible, he takes another look at the text to gather more graphic cues.
8. If he can make a decodable choice, he tests it for semantic and grammatical acceptability in the context developed by prior choices and decoding.
9. If the tentative choice is not acceptable semantically or syntactically, then he regresses, scanning from right to left along the line and up the page to locate a point of semantic or syntactic inconsistency. When such a point is found, he starts over at that point. If no inconsistency can be identified, he reads on seeking some cue which will make it possible to reconcile the anomalous situation.
10. If the choice is acceptable, decoding is extended, meaning is assimilated with prior meaning, and prior meaning is accommodated, if necessary. Expectations are formed about input and meaning that lies ahead.
11. Then the cycle continues.

Throughout the process there is constant use of long- and short-term memory.

I offer no apologies for the complexity of this model. Its faults lie, not in its complexity, but in the fact that it is not yet complex enough to fully account for the complex phenomena in the actual behavior of readers. But such is man's destiny in his quest for knowledge. Simplistic folk lore must give way to complexity as we come to know.

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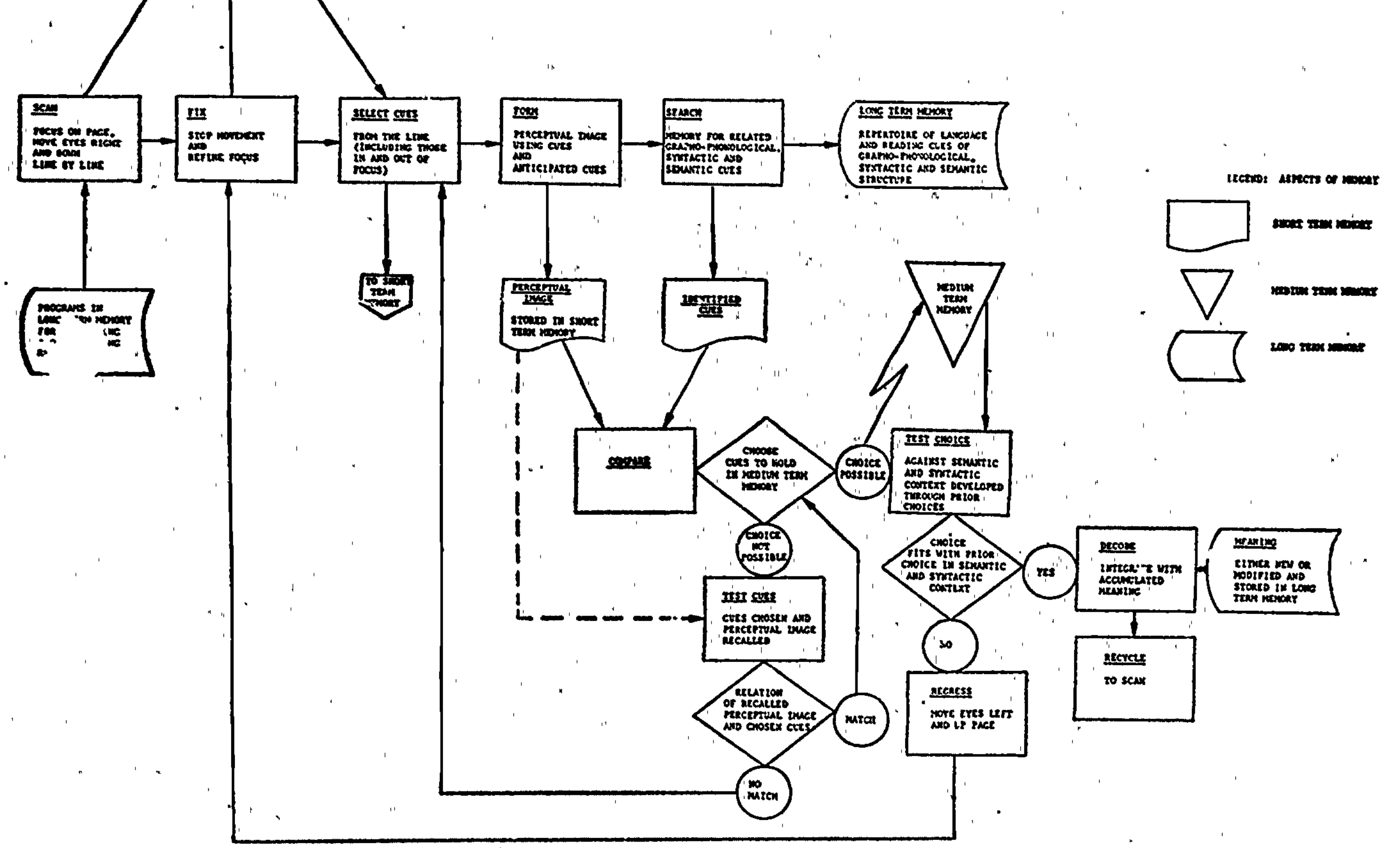
A FLOW CHART OF GOODMAN'S MODEL OF READING



Editor's Note: This chart is an updated version of the model described in Goodman's article. It is taken from a report on "The Convergence Technique Application to Reading" presented to the U.S. Office of Education by William J. Gephart

The Reading Competency Model

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WHAT FOLLOWS is a sketch of the reading process, in model form, for a competent reader. This idealized individual is assumed to be in full possession of his sensing systems, speaks, has an average IQ, and is emotionally stable—that is, is normal in the fullest sense of the term. Competency in reading is defined by two factors: overall reading ability as measured by a general reading test which, we will assume, taps basic reading skills, and the w-o ratio—the ratio of comprehension of written materials to that of oral materials. (It is assumed that this ratio can be determined accurately for any given population.[1]) A competent reader is one whose reading scores and w-o ratio approach that of the general adult population. For the present model, silent reading will be assumed, although subvocalization will be a functional component. The input to the model is printed materials, in the English language, like this paper; the output is a vagary called *understanding;* the model describes a procedure for generating output from input.

Central to the reading process is high speed (by human standards) visual scanning, dual-processing, and the search for the *largest manageable unit* (LMU). The scanning process is directed by 1) general knowledge such as the nature of written materials, properties

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[1] We will not be concerned here with the experimental procedures for determining the w-o ratio, other than to state that a reliable test must deal with both familiar and unfamiliar material and have some compensation for the differences in reading and speaking rates. (Whether or not subvocalizers should be discriminated against in such a test is a moot point.)

of the real or imaginary world, language habits, common sentences types, and 2) immediate knowledge, obtained from the material being read. General knowledge will be stored in the Integrated Knowledge Store (IKS) while immediate knowledge will be in the Temporary Knowledge Store (TKS). (While these could be labeled long term memory and short term memory, there are associations invoked by these latter terms which we would like to avoid at present. Furthermore, the Temporary Knowledge Store will need a longer persistence than is generally attributed to short term memory.) Two forms of immediate knowledge must be distinguished: a) that which is deduced from the material being read and which therefore creates logical sets (expectancies) for particular words, phrases, or ideas; and b) that which is most immediate to where the eye is processing at any time, that is, intra-sentence, intra-phrase, or intra-word data that aid in the search for LMU's. The deductions drawn from what is being read may become part of the IKS without overt processing on the part of the reader; the other class of immediate knowledge just mentioned will obtain this status only by overt effort. Thus, the spelling of a word may be encountered dozens of times; yet, unless the reader consciously attempts to retain its graphic form, he will not in general have facilitated his ability to spell it. (He may, however, be able to spell the word for other reasons. All that is being said here is that there is little or no facilitation of spelling from reading because information like spelling is used only to locate LMU's and is discarded as soon as it is no longer needed.)

Two major forms of processing generally take place simultaneously: syntactic-semantic integration of what has just been scanned and forward scanning to locate the next LMU. All of this is directed by the Control Unit which mediates between the various stores and the ongoing processes. Information passes from the scanning and integrating into the Scratch Pad Store (SPS), from whence it may be routed to other stores. Information retrieved from the other stores also passes into the Scratch Pad Store, to be used in processing.

The control unit, or homunculus, is chiefly a convenience for discussion. It is analogous to a computer monitor system which mediates between running programs and peripheral devices—scheduling jobs, locating routines for performing specific functions, and controlling the flow of data into and out of the machine. Integration involves connecting isolated units to what has already been picked up and generating new predictions about what will occur next. If a form which is in focus is not smoothly interpretable, the foreword scanning will slow down and may actually stop. (Reverse scanning may be required to correct a misinterpretation or misreading.)

The LMU's can be phrases, words, letter strings, or single letters. They are the largest units that can be chunked rapidly. Forward scanning achieves several goals at once: major breaks are detected (end of line, punctuation, phrase boundary), word separations are noted, and not-immediately-identifiable words are tagged. Since phrase boundaries are observed during this process, a certain amount of syntactic-semantic information must be available. What we hypothesize is that there is an initial identification made of each LMU, so that forward scanning can continue while the LMU is positively identified and integrated. If the initial identification is found to be incorrect, the forward scanning may have to be repeated. (We are not speculating here on the manner in which these two processes are achieved, that is, whether it is parallel processing or serial processing with rapid switching between the two tasks.)

Word identifications are made by parallel-search of the Associative Word Store (AWS), or if not found there, by search of a larger, less-well organized store (the Low Frequency Store—LFS).[2] The AWS contains the most frequently encountered items, organized for retrieval on the basis of initial letters, final letters, and word length. Using some minimal amount of information (first letters, plus length, plus expectancies derived from previously scanned material), a match in the associate store is attempted; if made, the remainder of the word is compared to the stored item; a mismatch at this point will cause further searching in the table. (Many items in this table, like *the* and *of*, function as single perceptual units.) An item not matched in the associative store will be compared to items in the Low Frequency Store; failure to find a match immediately will cause subvocalization and rescanning. We know from work done by Edfeldt (*3*) and Hardyck and Petrinovich (*8*) that competent readers

[2] For a survey of research on visual word recognition, see Deborah Lott, "Visual Word Recognition: Its Implications for Reading and Instruction," SWRL Technical Report TR 17 (Inglewood, California, July 1969).

begin to subvocalize when the material becomes difficult perceptually or conceptually. Furthermore, the works of Calfee et al (1969) and Venezky et al (1968) show that adults are capable of applying a great number of letter-sound generalizations, even though they can not verbalize the generalizations themselves.

Central to the entire scanning process is attention-tagging: each item scanned—letters, letter-units, words, phrases—is marked during forward scanning with a tag which indicates, for integration, how much attention must be paid to the item. (It is assumed that items requiring no special attention receives a zero tag—that is, are unmarked.) The tag indicates that the particular item has not been identified yet—or the degree of identification made. (For example, a strange proper noun will be identified in forward scanning as a proper noun and may even be classed by type—personal name, street, etc.—yet still be marked for special attention.) Integration involves: 1) identification of tagged items, 2) relating newly acquired material with what is already stored, and 3) predicting what should be scanned for next.

Scanning, therefore, is central to the reading process, and involves a balance between two processes: integration and forward scanning, the former being strongly dependent upon the latter. If the material requires excessive attention during integration, either because of perceptual or conceptual difficulty, forward scanning is restrained. The balance between integration and scanning, however, may also be controlled by the intent of the reader: reading 'light' novels or other materials requires primary attention to forward scanning with little integration. Digestion of dense writings, on the other hand, requires extensive integration with limited forward scanning.[3] Poorer readers may not be able to shift the balance between these two processes for different materials and goals.

Forward scanning seeks out word and phrase breaks, and asks, along the way, "Is there anything unfamiliar in the terrain?" If so, tags are assigned to indicate the degree of strangeness. Searching, however, is always oriented towards the biggest digestible gulp—the largest manageable unit. The information stores referenced dur-

[3] For the competent reader, forward scanning always occurs. The degree of forward scanning is marked by the distance between what is being scanned and what is being integrated.

ing scanning are summarized below. A diagram of the model is shown in Figure 1.

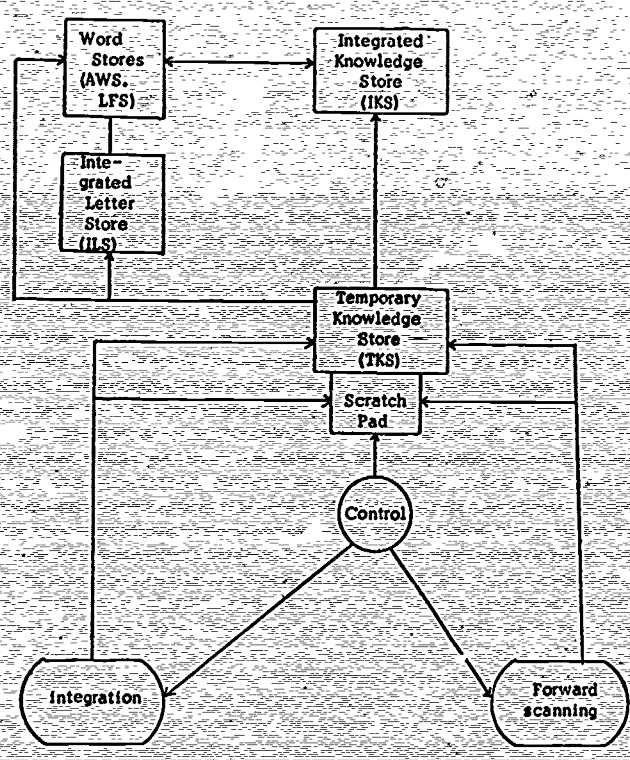

FIG. 1. Schematic of reading model.

IKS (Integrated Knowledge Store)
This store contains the most stable knowledge that the reader has: how reading works, sentence types, knowledge of the real and imaginary worlds, etc.

ILS (Integrated Letter Store)
Similar to the IKS, this store also contains, for the mature reader, stable information—information on letters and letter expectancies. This is the store that indicates to the forward scanner, for example, that *zxxp* is a strange word.

TKS (Temporary Knowledge Store)
This store contains integrated information about what is currently being read, obtained from the Scratch Pad Store (also a part of the TKS). Part of it may pass into IKS, but

most of it probably will not. In here are stored such data as those related to the style of writing (e.g., use of sentence fragments, constant misspelling of a word), general subject matter of what is being read, color of print, and type style. Whether an item passes from the TKS to the IKS will depend upon its frequency of transfer into the TKS, its frequency of retrieval from the TKS and the amount of integration that is occurring during each of these processes.

SPS (Scratch Pad Store)
The part of the TKS which contains data needed to analyze either the current LMU being integrated or the next LMU's. In general, little of this data is carried across major relational breaks (for non-compound sentences, major relational breaks generally correspond to sentence terminations). If a word is being scanned, its various components are stored here; as a sentence is scanned, the various grammatical units are stored here, along with predictions derived from interactions between this store and other stores. Some of these might be: "finite verb needed," "subject is probably next," "look for adverbial modifier." Information here decays rapidly, but may pass into the IKS).

Word stores

AWS (Associative Word Store)
Contained here are the most frequently encountered words and word parts with strong linkages to their semantic and syntactic functions, and to their pronunciations. Access to word beginnings, plus length is extremely rapid.

LFS (Low Frequency Store)
Words which do not fit the AWS are stored here. The retrievability of any entry varies with usage—both in absolute retrievability and in mode of retrieval (graphemic shape, phonemic shape). Most entries have connections to articulation instructions, although the strength of some of these linkages may be so weak that the reader, if a prounuciation is necessary, must generate it from the spelling.

Entered in the various stores are not only words but word parts like *-ed*, *-ness*, and *-s*. The strength of a connection to an item in a word store from any other store varies according to the direction of the connection. Thus, the connection from the spelling *civil* to its pronunciation /sɪv-əl/ may be relatively strong, while the connection from /sɪv-əl/ to *civil* may be relatively weak. (This mechanism is needed to account for observed differences in reading and spelling ability.)

Both word stores change over time, although the AWS changes slowly after reading competency has been reached. The major change that occurs in the LFS is the variation in the connections between the visual representation of a word and its various other representations. Retrieval through the acoustic form of a word is considerably more rapid in the LFS than retrieval by any other means; in the AWS, on the other hand, visual and acoustical retrieval are equally rapid.

Subvocalization or oral pronunciation depends, for the competent reader, primarily upon stored instructions for articulation that are connected (with varying strengths) to the visual forms of words. We are assuming that the most accessible form of a word in both word stores is a form which combines both articulatory instructions and highly normalized acoustic patterns. These are the first impressions of words which a child obtains and are strengthened continually with time, both in the accessibility of the patterns themselves, and their linkages to other information: semantic, syntactic, graphemic. When a word like *then* is encountered in oral reading (or in subvocalization) the competent reader does not generate the pronunciation from his knowledge of letter-sound correspondences, but retrieves it as an integrated unit. If he cannot find the articulatory instructions, either because the visual form is not identified or the articulatory pattern is inaccessible, then he will employ letter-sound generalizations to generate a pronunciation.

But even in this situation the competent reader is probably not depending upon a complete letter-sound approach, but is employing simultaneously visual form, context, and sub-vocal sound components to identify the word. The internal sound generation continues until the word is identified or the reader gives up in attempting to identify it. Thus, only as much sound (subvocal sound, that is) is generated as needed.

To label letter-sound patterns 'generalizations' is to oversimplify the situation. Overt letter-sound rules are rarely available, other than to some linguists and reading specialists. Instead, a considerable amount of search within the word and letter stores occurs. Acoustic feedback is continually monitored to check on the correspondences generated. Often this feedback becomes more dominant than the word and letter search, yielding English-like pronunciations but non-English letter-sound correspondences, as in /jɪn/ for *ghin.*

For purposes of this paper we are assuming that all letter-sound generalizations are realized as higher order organizations of real words which contain the related patterns, with special facilities for rapid access during reading. We are not, however, speculating at this time on the relative contributions of types and tokens, although we recognize this as an important problem, both theoretically and pedagogically.

Implications of the Model

Research on the reading process

The most important hypotheses implicit in the model offered here are:

1. Competent reading requires the dual functions of forward scanning and integration, the balance between the two being a function of the material being read and the intent of the reader.
2. Forward scanning is a chunking and tagging process in which unit boundaries are sensed and difficult or uninterpretable items are marked for further processing.
3. The function of forward scanning is to find the largest unit that can be readily identified and integrated. To do this, the reader utilizes predictions formed from processing the preceding textual material, general knowledge, high-speed word and phase recognition, patterns of the language being read, and the nature of writing. Where all of these aids fail to identify a word, letter-sound generalizations are employed.
4. In oral reading, most word pronunciations are retrieved as whole units from memory. Generation by letter-sound relationships is employed only when a word is not recognized or when the phonological form is not readily retrievable.
5. Extremely common words are retrieved from a highly organized store which can be searched rapidly on the basis of such features as initial letters and length. Less common

words are stored differently and are more accessible by sound than by any other form.

6. Letter-sound generalizations result chiefly from the organization of memory.

To ascertain the validity of this model, each of these hypotheses should be tested as exhaustively as possible. While the results of such testing will undoubtedly force significant revisions in the model, there is within these hypotheses an implied research program which attacks interesting and relevant problems and builds upon a well established base provided by Levin and Cohn (1967), Gibson (1965), Sternberg (1968), and Neisser (1967).

The basic structure of the model described above consists of three processes: *forward scanning, integration,* and finally *comprehension,* as reflected in the flow of data from the temporary stores to the permanent stores (IKS, AWS, LFS). It is further assumed that these stages function in a highly interdependent fashion in the skilled reader. Research is necessary to answer such questions as the following: Is it necessary to postulate three stages to account for skilled reading? What are the functional properties of each of the stages? What operations do these stages perform while a person is reading, and how long do these operations take for various types of material? What is the precise form of the interdependencies that exist among the stages?

These are not easy questions to investigate. Skilled reading takes place at an extremely rapid rate. The processes are internal to the subject, and some skill is required to measure such processes without simultaneously affecting them. There is a substantial amount of research on word recognition, and a growing body of literature on the various processes involved in reading and understanding sentences. Unfortunately, it is far from certain that the processes involved in word recognition or even in sentence comprehension in the experimental settings are typical of those involved in high-speed reading.

There are three main classes of variables to be considered in any significant research program which has as its goal evaluation of a reading model: task variables, stimulus variables, and subject variables. This section will focus on the first of these, because unless we can discover a set of tasks which satisfactorily reveal underlying processes in reading, then investigation of stimulus and subject variables is stalemated. It is of little interest to show again that reading speed is slower and comprehension is poorer for certain types of materials and certain classes of subjects unless we can at the same time gain some insight into why those relations exist.

Task variables. In much of the current work on cognitive psychology, it has proven useful to distinguish between three types of cognitive processes—*perception, memory,* and what may best be called *strategy* or *set.* Studies of perception of the sort that have been conducted by Sternberg (*13*), Neisser (*11*), and Haber (*6, 7*) have tended to focus more and more on temporal aspects of human performance. For example, Sternberg has used reaction time measures to investigate rate of search through memory, i.e., the amount of time required by a subject to search through a list of items previously stored in memory to determine whether a target item is in that list. Neisser has studied the process of visual search, in which a subject is given a target item to search for, and asked to push a button as soon as he spots the target item in a list of items shown to him. Data obtained using such tasks has proven extremely orderly and replicable. The value of such research is that it allows the investigator to study temporal processes without slowing them down or interfering with them. This approach also lends itself well to the investigation of the effects of degradation of the stimulus material and of the effects of perceptual interference introduced by similarity of the configurations being tested.

Where studies of the perceptual process try to look at the processing of information as it happens, studies of memory evaluate the end effects of such processing. To the extent that the subject retains a record while reading not only of the final comprehended messages but also records of selected aspects of the intermediate stages, memory studies would be appropriate for investigation of the reading process.

Preliminary studies. Consider the following task which might be given to a subject to perform. The subject reads a passage of material, in which certain target letters, words, word associates, or events are embedded. Whenever one of the targets is encountered the subject is instructed to push a response switch as rapidly as possible. The eye-movements of the subject are simultaneously monitored so that the relationship between the scanning process and other stages of the processing operation can be determined. (For the present, we will make the rather simpleminded assumption that scanning and position of the eye are operationally equivalent.) In addition to manipulating the character of the target item, the number of target items in memory will also be systematically varied so that sometimes the subject will be searching for a single item, and other times he will be looking for any one of four target items. As previously noted, this particular variable, memory load, has produced very stable results in other search experiments. (Preliminary work in our laboratory suggests that memory search performance when embedded in the context of a normal reading task yields data quite similar to those found when the subject is required to recognize single words.)

In examining the results of such a study, one would want to look at two aspects of the data. First of all, when measured against a control baseline in which the subject is simply reading the material for meaning as quickly as possible, do the patterns of eye movement seem different than when the subject is asked to perform a simultaneous memory search task? Secondly, assuming that the pattern of eye movement does remain unchanged, and assuming that the onset of the forward scanning operation begins simultaneously with movement of the eyes to a particular section of the passage, does reaction time increase as a function of the nature of the material? One might expect this increase, given that forward scanning, integration, and comprehension are serial processes, or that they are processes that take increasingly greater amounts of time. Finally, what is the relationship between memory load and reaction time as measured from onset of eye movements? Consider the form which such results might take under one particular interpretation of the model. Assume that the operation of the model insofar as detection of the target is concerned is essentially serial. In other words, it takes a certain base time α msec. for scanning and input to occur, a basetime β msec. for integration to take place, and a basetime γ msec. for comprehension to take place. Suppose further that search occurs only at the stage which is relevant, so that if letters are being searched for, only the scanning stage will be affected, whereas if the target items are events, then searching will occur only in the comprehension stage. Assume further that the search time is δ msec. per item in memory in all stages. In support of this assumption, there are data from several studies of memory search which suggest that the rate of search is varied only slightly whether digits, letters, or words are used as stimulus materials. Under this set of assumptions, reaction time should increase linearly with memory load.

There are, however, some immediate problems which arise in attempting to carry out such an experiment. Selection of stimulus materials is clearly a crucial matter. Although predictability of the target items should be minimized, the material should not be too difficult. Second, eye movements will have to be determined precisely, and thirdly, there is a good possibility that different subjects might adopt different criteria with regard to how much effort and capacity to devote to the reading task and how much to devote to the search task. Again, preliminary research in our laboratory suggests that with suitable instructions this need not be a major concern. Nevertheless, it is extremely important to assume that the subject is focusing on the reading aspect of the task. These problems are typical of those which arise in any research program, where good judgment and the best use of available data are often the difference between interpretable results and nonsense. However, there is evidence both from laboratory research and from observational data to suggest that reading, like driving, is such a highly practiced and overlearned skill that a subject may perform other functions simultaneously with only minimal interference of the basic skill itself.

In any event, if the task described above seems to work well with simple materials, and with good readers, then it will begin to be interesting to manipulate other variables, such as the difficulty of the material, the embeddedness of the target elements within the syntactic and semantic structure of the passage, the skill of the reader, and the payoff matrix (the relative value of reading rapidly or for meaning). Without too much difficulty, one could imagine a parallel series of experiments using the same materials and procedures but investigating *recognition memory* for target items of one kind or another.[4] Here, one would expect that the recognition

[4] A useful distinction has been made between storage and retrieval of memorial information. Storage can best be tested by recognition tests, whereas both

of events from a passage would be carried out more precisely than the recognition of individual letters or words, since by the time recognition memory can be tested, the information would have been processed through the comprehension stage. It might also be interesting to look at reaction times during a recognition memory task, where one would expect the results to be just the opposite of those found in perception. In other words, reaction time to events should take place more quickly than reaction time to words or to word associates and these in turn should require less time than information about individual letters. Some other problems for investigation are sketched below.

1. Dual functioning

   The dual functioning of forward scanning and integration can probably be tested in a manner similar to the eye-voice span experiments (*9*). What must be shown is that at any given time during silent reading, certain materials have been integrated while others have been chunked and tagged, but not integrated. To test in this area, one must first determine the relationship between eye movements and reading processes. We assume that forward scanning is closely related to foveation while integration is a more cognitive process. Therefore, the best test would be one that interrupts the reading process at some point and tests for recall of either integrated material or scanned material. A task must be devised, however, that does not allow integration of scanned material after scanning is interrupted. (It seems logical to assume, furthermore, that dual processing occurs not only for oral and silent reading but for listening also.)

2. Chunking and tagging

   This area appears to draw most heavily on current research on memory search. Some of the questions to be answered are:

   a. What units are recognized in forward searching?
   b. How do these units relate to syntax as specified by various grammatical theories?
   c. Can tachistoscopic recognition procedures be employed, or do they require processing that is not used in reading?
   d. What components of unfamiliar words or phrases are recalled when complete recognition is not possible?

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storage and retrieval processes are involved in the productive recall of information.

3. Common words vs. uncommon words

   a. Can we show a major difference between recognition of common words and uncommon words in terms of the recognition procedures?

Remedial Reading

We will be concerned here with the remedial reader who has progressed beyond the point of recognizing letters, segmenting sounds, and producing some approximation to real speech when he reads—that is, we assume he has an appreciation for the game itself, but doesn't play it very well. What we would like to discover are differential abilities in the processes or skills which the model predicts are important for reading. If we cannot find these, then we probably have little use for the model in remediation. Sketched below are questions, which when translated into tests, would explore these processes.

1. Does the remedial reader recognize common words and phrases as readily as competent readers?

2. Does he show the same integration—forward scanning ability as a competent reader? If not, one cause may be failure to locate the proper breaks. Other possible barriers to forward scanning are: a) failure to utilize scratch pad information or b) poor recognition skills for unfamiliar words. If this is the stumbling block, then he should perform reasonably well when familiar words are used, but degrade rapidly as unfamiliar words are added.

3. Does he show the same attention tagging as competent readers, as measured by recall of word and phrase parts for below-threshhold exposures? A poor reader may operate in more of an all-or-none fashion than a skilled reader. That is, if he fails to recognize a word immediately, he may give up rather than attempting to utilize additional cues (sound, context) for identification.

An Acquisition Model

It is considerably easier to speculate on how a complex mental process operates than it is to specify how that particular ability is acquired, especially if the acquiring organism is a young child.

Aside from motivation and attention, which are significant variables for learning at any age level, there are important changes in learning ability which the child goes through during the time he is acquiring literacy (*17, 1*). Such cognitive growth probably plays a major role in how rapidly reading ability develops, yet there is little relevant experimental data in this area to base a learning model for reading on. How, for example, is the child's inability to deal with abstractions to be modeled? And how does it relate to such abilities as segmenting sounds in words? [Elkonin (*4*) in Russia, Smilansky (*12*) in Israel, and others have shown that certain abstract tasks, like comparing initial sounds in words, are greately facilitated if visual props for the words are present.] Furthermore, what assumptions should we make about learning to learn? Is there, for example, a fixed relationship between amount of material learned and ability to acquire new material?

Aside from these problems, there are a host of specific skills which must be acquired, some of which are sketched below. (In what follows, it is assumed that initial reading is oral.)

1. Preliminary Skills
   a. Left-to-right, top-to-bottom orientation for printing.
   b. Awareness that writing can be translated into speech.
   c. Discrimination of letters and words.
2. Aural-Oral Skills
   a. Manipulation of separate sounds in words, either in reception or production.
   b. Blending of sounds into familiar words.
   c. Connecting words into familiar sequences.
3. Letter-sound Skills
   a. Linking letters to sounds.
   b. Discriminating cues which indicate which of several sounds is to be attached to a letter.
4. Processing Skills
   a. Balancing of forward scanning and integration.
   b. Using stored information to aid in forward scanning.
   c. Searching for units larger than letters or single words.

The central problems that an acquisition model must attend to are what must be learned and how the learning takes place. In its initial states the visual components of the word stores do not exist, the letter store has little organization, letter-sound generalizing ability is lacking, and the ability to integrate and forward scan have not been developed. Functions must be derived to specify both the addition (or subtraction) to each store which results from a given input and the development of control ability. But it is not just the existence of data within memory stores which produces competent reading, but more importantly the ability to call the information into play when it is needed, which in turn is a function of both the state of the learner and the organization of the stored data. (We are assuming for this model that both the quantity of data in any store and its internal configuration—that is, its interconnections—are significant.) With this in mind, let us consider first the general functioning of the acquisition model, then a simple function for changing the Associative Word Store.

In its initial state, the model would contain data appropriate for a nonreading six-year old. This would, for simplicity, include an empty letter store, no visual patterns in either word store, but some knowledge of language and the real world. Input to the model initially would be pairs of letters, and functions dependent upon discrimination ability, attention ability, and organizational ability for a child (probably selected randomly from within the expected ranges) would determine both the probability of making a correct discrimination and what the new discrimination strengths of each letter in the store would be after each input sequence (assuming feedback).

Then words would become the primary input, along with (initially) their pronunciations. Similar functions would have to be derived to determine whether or not a word is recognized as a unit, whether its pronunciation can be retrieved or generated, and what effect the input (with feedback in the situation where the response is not given with the input) has on the state of the various stores. As an example of one such function, let Rp represent the probability that word p will be identified in reading. Assume further that there is no distinction between integration and forward scanning in the early stages of learning to read. (Another way to express this is to say that the degree of forward scanning possible is a function of the amount of information in the AWS. For little data in AWS, forward scanning approaches zero.)

Then $Rp = \sum^{n}(f(ci, i, oi) - g(tij))$ where

- ci is the status of the control unit, a reflection of the ability of the beginning reader to process the word.
- oi is the current level of organization in the AWS. For zero organization, that is, whole word storage with no connections to initial letters, etc., oi becomes negative and decreases rapidly as new words are entered into the store.
- i is the number of times the word has been processed.
- tij is the time between the current integration of Word p and the next time word p is encountered. g(tij) is, therefore, a decay function.

The functions *f* and *g* specify the effects that each variable—ci, oi, i, tij will have at any time on the probability that word *p* will be recognized. The sum of these functions from *1* to *n* will give the probability of recognition after *n* exposures to a word.

Similar functions are proposed for building up the other stores so that full simulation of the model could be carried out. To do this, however, a number of basic properties would have to be determined. Among these are:

1. How do children learn to generalize? For a given generalization, how many examples are needed, what effects do exceptions yield, and how much transfer is there to similar tasks? (Specifically, how are letter-sound generalizations acquired?)
2. How does a child learn to scan ahead of where he is pronouncing in oral reading? Is this an all-or-none ability? Is this a basic skill, or is it, as implied by the equation given above, dependent primarily upon words stored in the Associative Word Store?
3. Are letter-sound generalizations utilized by children in initial reading, or are they artifacts of the reading process? (We know, for example, that by the end of second grade, a child can apply many generalizations to artificial words when asked to do so in a test situation, but we do not know if he applies the same processes in reading.)

If these (and other) questions can be answered, it may be possible to simulate not only the development of reading, but also reading behavior displayed by children who fail to become competent readers. If this were possible, then the model would have an obvious value. At present, however, we are not overly optimistic about our ability to construct such a model, due to the scarcity of data on basic developmental phenomena.

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The Nature of the Reading Process[1]

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AS YOU silently read this very paragraph, what are you doing? If you are a skilled reader and are attending carefully to what this paragraph is trying to say, you will notice the following. First, what are your eyes doing? Moving together in a swift and well-coordinated way, your eyes are making a series of fixations, jumping from place to place on the page of print. The jumps are exceedingly rapid; you see little while your eyes are jumping. What is important are the fixations, when your eyes come to rest. Most of these fixations are actually on or close to the line of print, but unless you are reading quite slowly you cannot easily predict or control where your eyes will fixate. The fixations are usually quite short in duration; each one will last about one-quarter of a second on the average.

Usually the fixations progress from left to right along the first line of print, then back to the beginning of the next line and again from left to right across the line, and so on. For the average adult reader there will be about two fixations per inch of ordinary type like this. Some of these fixations may be very brief, amounting to minor adjustments in order to bring the print better into view. During most of the fixations, you receive an impression of a certain amount of printed material; that is, you instantaneously perceive and recognize one or more words, perhaps up to four or five in some cases. You are more likely to recognize the words that are in the immediate area of fixation; words outside this immediate area may be less well recognized, but some of them have been recognized in a previous fixation, and others may be more clearly recognized in a future fixation. Some of the words may never be clearly recognized, but you apprehend enough of the stimulus to fill them in from the general drift of what you are reading.

1 Prepared by the author for the Advisory Committee on Dyslexia and Related Reading Disorders.

Let us just think about this process of instantaneous word recognition. Most of the words you see are words you have seen many times before; even though in actuality they may be relatively rare, they are familiar enough to you to permit "instantaneous" recognition. Of course recognition is not really instantaneous; it takes a certain amount of time. Experiments in which words are exposed very briefly show that common words can be recognized quite accurately in less than 1/10 of a second; even words that are quite rare can be recognized with at least 50 percent accuracy in exposures of about 1/5 of a second. During the average fixation lasting 1/4 of a second it is often possible to take in several words. The point is that most words are recognized extremely rapidly. If you are a skilled reader you do not have to stop to figure out the pronunciation of a familiar word from its spelling; you are hardly conscious of the spelling at all. Still less do you attend to the particular phonetic values of the letters; in reading the word *women* it would scarcely occur to you to note that the "o" in the first syllable stands for a sound that rhymes with /i/ in *whim*. The printed word *women* is a gestalt-like total stimulus that immediately calls to mind the spoken word that corresponds to it—or if not the spoken word itself, some underlying response which is also made when the word is spoken. As a skilled reader, you can consider yourself lucky to have a large "sight" vocabulary.

The actual process by which we recognize words is not well understood, simply because the whole process of "pattern perception," as it is called, is one of the most mysterious problems in psychology. How, for example, do we recognize a table, a goblet, or a flagpole for what it is, regardless of the angle of regard? Nevertheless, it is a simple fact that we *can* learn to recognize words even though the words may be printed in different typefaces or written in different cursive styles, and in different sizes. Now even though word recognition is rapid, it obviously depends to a large extent on cues from the letters composing the word. There is little confusion among such highly similar items as *cob, rob, mob,* and *nob* even in fast single exposures. We do know that in recognizing longer words, the letters standing at the beginning and end are more critical than letters in the middle, for in fast exposures these middle letters can sometimes be altered or replaced without this being noticed by the reader. In ordinary reading we frequently fail to notice words that contain printer's errors. But there is little evidence to support the idea that a mature reader recognizes words merely by their outlines or general shape. It is unlikely that if you see the shape  you will recognize the word *dog;* you might just as well think it to be *day* or *dug*. Beginning readers sometimes use mere shape cues in trying to recognize words, but they will be overwhelmed with confusion if they depend solely on such cues apart from the recognition of the letters themselves. In the mature reader the process of rapid word recognition seems to depend upon his ability to integrate the information provided by the separate letters composing the word, some letters being more critical as cues than others. Because the recognizability of a word is apparently correlated rather highly with its frequency of use, word perception seems to be a skill that depends upon large amounts of practice and exposure.

Suppose, however, that the skilled reader comes to a word that he has never seen before, like *dossal, cunctation,* or *latescent,* or an unfamiliar proper name like *Vukmanovich* or *Sbarra.* Though the skilled reader can hardly be said to "recognize" a word he has never seen before, he nevertheless recognizes elements of it—letters and patterns of letters that give him reasonably good cues as to how the word should be pronounced. *Dossal* may be recognized as similar to *fossil* and pronounced to rhyme with it, the first letter cuing the /f/ sound. *Cunctation* may give a little more difficulty but be recognized as somewhat similar to *punctuation* and at the same time to *mutation;* by following the total pattern of cues the reader may be able to infer the correct pronunciation. *Latescent* will probably be recognized not as a compound of *late* and *scent,* but as a member of a family of words like *quiescent, fluorescent,* etc. Somewhat the same principles apply to the reading of foreign proper names; even if he is not familiar with the foreign language involved, the skilled reader will be sensitive to the possible values of the letters and letter-combinations in the name, and come up with a reasonable pronunciation.

It should be noted that thus far we have been speaking of the recognition of words as particular combinations of letters. Actually, in English there are numerous instances of homographs—words that are pronounced in different ways depending on their use. The word "read" is an interesting example: in the context *to read* it rhymes with *bead,* but in the context *to have read,* it rhymes with *bed.* The skilled reader instantaneously interprets the word in its proper "reading" or pronunciation depending upon the context—i.e., the surrounding words and their meanings.

This takes us, in fact, to the next stage of our analysis of the reading process. As you take in material recognized in the succession of rapid fixations that is characteristic of skilled reading, it somehow merges together in such a way as to build up in your mind an impression of a meaningful message—a message that is in many ways analogous to the message you would apprehend if someone read the paragraph aloud to you, with all its proper inflections and accents. Some people report that as they read they can "hear" (in the form of internal auditory images) the message as it might be spoken; at least they report that they "hear" snatches of such a message. Other readers feel that they apprehend a meaning from the printed message directly—that is, without the intervention of any auditory images. In slow readers, or even in skilled readers reading very difficult material, one may notice slight articulatory movements that suggest that the reader is trying to pronounce the words subvocally.

The process of scanning a paragraph for a meaningful message does not, of course, always run smoothly. As one reads, there may be momentary lapses of attention (which can be due to lack of interest, distractions, or even stimulation from the content itself), or of comprehension (which can be due to the difficulty of the material, poor writing, or other conditions). The process of com; ,ehension seems to have some influence on the movements of the eyes: when the reader fails to attend or comprehend, his eyes may "regress," moving back to fixate on a portion of the material already scanned. Difficulties in recognizing particular words may cause the eyes to dwell on or around a particular point in the text longer than the usual amount of time. There are large differences among individuals in all the reading processes we have mentioned. Some readers can read with markedly fewer fixations per line; some read with an abnormally high number of fixations per line and exhibit many more regressions than normal. Few individuals have the same pattern of eye movements, even when they read at approximately the same speed. Obviously, there are wide individual differences in rate and accuracy of comprehension.

The *essential* skill in reading is getting meaning from a printed or written message. In many ways this is similar to getting meaning from a *spoken* message, but there are differences, because the cues are different. Spoken messages contain cues that are not evident in printed messages, and conversely. In either case, understanding language is itself a tremendous feat, when one thinks about it. When you get the meaning of a verbal message, you have not only recognized the words themselves; you have interpreted the words in their particular grammatical functions, and you have somehow apprehended the general grammatical patterning of each sentence. You have unconsciously recognized what words or phrases constitute the subjects and predicates of the sentence, what words or phrases modify those subjects or predicates, and so on. In addition, you have given a "semantic" interpretation of the sentence, assigning meanings to the key words in the sentence. For example, in reading the sentence "He understood that he was coming tonight" you would know to whom each "he" refers, and you would interpret the word *understood* as meaning "had been caused to believe" rather than "comprehended." Somehow you put all these things together in order to understand the "plain sense" of what the message says.

Even beyond getting the simple meaning of the material you are reading, you are probably reacting to it in numerous ways. You may be trying to evaluate it for its truth, validity, significance, or importance. You may be checking it against your own experience or knowledge. You may find that it is reminding you of previous thoughts or experiences, or you may be starting to think about its implications for your future actions. You may be making inferences or drawing conclusions from what you read that go far beyond what is explicitly stated in the text. In doing any or all of these things, you are "reasoning" or "thinking." Nobody can tell you exactly what to think; much of your thinking will be dependent upon your particular background and experience. At the same time, some thinking is logical and justified by the facts and ideas one reads, while other kinds of thinking are illogical and not adequately justified by the facts and ideas one reads. One aspect of a mature reader's skill consists in his being able to think about what he reads in a logical and well-informed way. This aspect of reading skill sometimes takes years to attain.

We have described the process of reading in the skilled reader—a process that is obviously very complex. How is this process learned or attained?

As in the case of any skill, reading skill is not learned all at once. It takes a considerable amount of time. Furthermore, the process of learning to read is *not* simply a slow motion imitation of the mature reading process. It has numerous components, and each component has to be learned and practiced.

There are probably a great many ways to attain reading skill, depending upon the order in which the various components are learned and mastered. It may be the case that some ways are always better than others. On the other hand, children differ in their aptitudes, talents, and inclinations so much that it may also be the case that a particular way of learning is better for one child while another way is better for another child. It all depends upon which components of reading skill a given child finds easier to learn at a given stage of his development. In referring to different orders in which component skills would be learned, we do not mean to imply a lock-step procedure in which the child first learns and masters one skill, then goes on to learn and master another skill, and so on. Actually, a child can be learning a number of skills simultaneously, but will reach mastery of them at different periods in his development. From the standpoint of the teacher, this means that different skills may need to be emphasized at different periods, depending upon the characteristics of the individual child. This is particularly true in the case of the child who is having difficulty in learning to read.

Let us try to specify the components of reading skill. Some of these components come out of our analysis of the mature reading process; others out of a further analysis of *those* components.

1. *The child must know the language that he is going to learn to read.* Normally, this means that the child can speak and understand the language at least to a certain level of skill before he starts to learn to read, because the purpose of reading is to help him get messages from print that are similar to the messages he can already understand if they are spoken. But language learning is a lifelong

process, and normally there are many aspects of language that the individual learns solely or mainly through reading. And speaking and understanding the language is not an absolute prerequisite for beginning to learn to read; there are cases on record of children who learn to read before they can speak, and of course many deaf children learn the language only through learning to read. Foreign-born children sometimes learn English mainly through reading. Children who, before they begin to read, do not know the language, or who only understand but do not speak, will very likely require a mode of instruction specially adapted to them.

2. *The child must learn to dissect spoken words into component sounds.* In order to be able to use the alphabetic principle by which English words are spelled, he must be able to recognize the separate sounds composing a word and the temporal order in which they are spoken—the consonants and vowels that compose spoken words. This does not mean that he must acquire a precise knowledge of phonetics, but it does mean that he must recognize those aspects of speech sound that are likely to be represented in spelling. For example, in hearing the word *straight,* the child must be able to decompose the sounds into the sequence /s, t, r, ey, t/.

3. *The child must learn to recognize and discriminate the letters of the alphabet in their various forms (capitals, lower case letters, printed, and cursive).* (He should also know the names and alphabetic ordering of the letters.) This skill is required if the child is to make progress in finding correspondences between letters and sounds.

4. *The child must learn the left-to-right principle by which words are spelled and put in order in continuous text.* This is, as we have noted, a very general principle, although there are certain aspects of letter-sound correspondences that violate the principle—e.g., the reverse order of *wh* in representing the sound cluster /hw/.

5. *The child must learn that there are patterns of highly probable correspondence between letters and sounds, and he must learn those patterns of correspondence that will help him recognize words that he already knows in his spoken language or that will help him determine the pronunciation of unfamiliar words.* There are few if any letters in English orthography that always have the same sound values; nevertheless, spellings tend to give good clues to the

pronunciation of words. Often a letter will have highly predictable sound values if it is considered in conjunction with surrounding letters. Partly through direct instruction and partly through a little-understood process of inference, the normal child can fairly readily acquire the ability to respond to these complex patterns of letter-sound correspondences.

6. *The child must learn to recognize printed words from whatever cues he can use—their total configuration, the letters composing them, the sounds represented by those letters, and/or the meanings suggested by the context.* By "recognition" we mean not only becoming aware that he has seen the word before, but also knowing the pronunciation of the word. This skill is one of the most essential in the reading process, because it yields for the reader the equivalent of a speech signal.

7. *The child must learn that printed words are signals for spoken words and that they have meanings analogous to those of spoken words. While decoding a printed message into its spoken equivalent, the child must be able to apprehend the meaning of the total message in the same way that he would apprehend the meaning of the corresponding spoken message.* As in the case of adult reading, the spoken equivalent may be apprehended solely internally, although it is usual, in early reading efforts, to expect the child to be able to read aloud, at first with much hesitation, but later with fluency and expression.

8. *The child must learn to reason and think about what he reads, within the limits of his talent and experience.*

It will be noticed that each of these eight components of learning to read is somehow involved in the adult reading process—knowing the language, dissecting spoken words into component sounds, and so forth. Adult reading is skilled only because all the eight components are so highly practiced that they merge together, as it were, into one unified performance. The well-coordinated, swift eye movements of the adult reader are a result, not a cause, of good reading; the child does not have to be *taught* eye movements and therefore we have not listed eye-coordination as a component skill. Rather, skilled eye movements represent the highest form of the skill we have listed as 4—the learning of the left-to-right principle. The instantaneous word recognition ability of the mature reader is the highest form of the skill we have listed as 6—recognition of printed words from whatever cues are available; and usually this skill in turn depends upon the mastery of some of the other skills, in particular 5—learning patterns of correspondence between letters and sounds. The ability of the adult reader to apprehend meaning quickly is an advanced form of skill 7, and his ability to think about what he reads is an advanced form of skill 8.

The "great debate" about how reading should be taught is really a debate about the *order* in which the child should be started on the road toward learning each of the skills. Few will question that mature reading involves all eight skills; the only question is which skills should be introduced and mastered first. Many points of view are possible. On the one hand there are those who believe that the skills should be *introduced* in approximately the order in which they have been listed; this is the view of those who believe that there should be an early emphasis on the decoding of print into sound via letter-sound relations. On the other hand, there are those who believe that the skills should be introduced approximately in the following order:

1. The child should learn the language he is going to read.
6. The child should learn to recognize printed words from whatever cues he can use, but initially only from total configurations.
7. The child should learn that printed words are signals for spoken words, and that meanings can be apprehended from these printed words.
8. The child must learn to reason and think about what he reads.
4. The child should learn the left-to-right principle, but initially only as it applies to complete words in continuous text.
3. The child should learn to recognize and discriminate the letters of the alphabet.
2. The child should learn to dissect spoken words into component sounds.
5. The child should learn patterns of correspondence between letters and sounds, to help him in the advanced phases of skill 6.

This latter view is held by those who argue that there should be an early emphasis on getting the meaning from print, and that the child should advance as quickly as possible toward the word-recognition and meaning-apprehension capacities of the mature reader. Skills 2, 3, and 5 are introduced only after the child has achieved considerable progress towards mastery of skills 4, 6, 7, and 8.

These are the two main views about the process of teaching reading. If each one is taken quite strictly and seriously, there can be very clear differences in the kinds of instructional materials and procedures that are used. It is beyond our scope to discuss whether the two methods differ in effectiveness. We would emphasize, rather, that methods may differ in effectiveness from child to child. Furthermore, it is possible to construct other reasonable orders in which the various components of reading skill can be introduced to the child. There is currently a tendency to interlace the approaches distinguished above in such a way that the child can attain rapid sight recognition of words at the same time that he is learning letter-sound correspondences that will help him "attack" words that he does not already know.

For the child who is having difficulty in learning to read, it may be necessary to determine exactly which skills are causing most difficulty. The dyslexic child may be hung up on the acquisition of just one or two skills. For example, he may be having particular trouble with skill 3—the recognition and discrimination of the letters of the alphabet, or with skill 2—the dissection of spoken words into component sounds. On determining what skills pose obstacles for a particular child, it is usually necessary to give special attention to those skills while capitalizing on those skills which are easier for the child to master.

Uncertainties and Research Problems

The above description of the nature of the reading process is based on the findings of nearly three-quarters of a century of research. A good deal is known about reading behavior, yet there are many questions that have not been answered with precision and certainty. We shall list the most important of these.

Questions about the mature reading process

1. How does the individual's ability to recognize words instantaneously develop? What cues for word recognition are most important? How and when does awareness of spelling clues and inner speech representation recede, if at all? What is the extent of the sight vocabulary of the mature reader? (It should be noted that most studies of word recognition processes have been conducted with adults; there is need for developmental studies in which word recognition processes would be investigated over different chronological age levels.)

2. How do skilled readers process unfamiliar words? To what extent, and how, do they use patterns of letter-sound correspondences?

3. How do skilled readers find the proper readings of homographs and other types of ambiguous words?

4. What are the detailed psychological processes by which skilled readers comprehend the simple meaning of what they read? In what way do lexico-semantic, syntactical, and typographical factors interact to yield this comprehension?

5. How are eye movements controlled by comprehension processes, and how does the individual develop skill in scanning print?

6. How does the mature reader acquire skill in reasoning and inferential processes?

7. What are the major sources of individual differences in rate and accuracy of comprehension in mature readers?

Questions about certain components of reading skill as they affect learning

1. In what way does knowledge of the spoken language interact with learning to read? What kinds and amounts of competence are desirable before the child undertakes any given task in learning to read?

2. What is the nature of the ability to discriminate sounds in the spoken language and to dissect words in terms of these sounds? How does it develop, and what role does it play in the beginning reader's learning of letter-sound correspondences? How can this ability be taught?

3. How do children learn to recognize and discriminate alphabetic letters in their various forms? When children have difficulty with letter recognition, how can these difficulties be overcome?

4. How do children learn the left-to-right principle in orthography, both as applied to individual words and to the order of words in continuous text? Are there children with special difficulties in learning this component of reading skill?

5. Exactly what are the most useful and functional patterns of letter-sound correspondence in English orthography, and in what order should they be learned? How, indeed, *are* they learned? Is it better to give direct instruction in them, or is it better to rely upon the child's capacity to infer these patterns from the experience he acquires as he learns to read? Should the characteristics of particular children be taken into account in deciding this?

6. When a child has acquired the ability to recognize words and read them in order, yet does not appear to comprehend the message as he would if it were spoken to him, what is the nature of the difficulty?

Questions about the ordering of the components of reading skill in the teaching process

1. In what way are the various skills prerequisite for each other? What aspects of each skill are necessary to facilitate progress in another skill?

2. Is there one best order in which to introduce the components of reading skill in the learning process, or are there different orders depending upon characteristics of individual children or groups of children? If so, how can these individual or group characteristics be determined?

3. On the assumption that there is an optimal ordering of skills for any given child, how much mastery of a given skill is desirable before another skill is introduced?

Reading as an Intentional Behavior[1]

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TO THE perception psychologist, reading is not an isolated behavior that can be understood adequately by itself. Depending as heavily as it does on the language skills and on directed visual search, reading text, as a perceptuomotor activity, has certain characteristics in common with listening to speech and with viewing scenes. The first characteristic shared by these three activities, which is more obvious in the case of reading than in the other two, is that these behaviors do not consist of automatic responses to the array or sequence of patterned stimulation that confronts the subject. The reader does not merely regard a block of text and immediately realize its message. He must *intend* to read the display, must "pay attention" to its meaning, if he is to be able to respond to its contents. What a phrase like "pay attenton to" might mean in this context has not received much thought or experimental research, but it would seem to be of fundamental importance to any understanding of what the reading process is all about.

Let us consider briefly some of the more obvious ways in which intention affects reading: 1) As noted, if a person looks idly at a page of text, with no intention to read, he may recognize only those few words on which his gaze may rest. 2) An efficient reader may read text for meaning at up to 4,800 letters per minute, but at that rate he is very likely not to notice minor spelling errors or omissions; therefore, this figure certainly does not mean that each letter is actually looked at, even though comprehension scores may be very high. 3) In fact, if the task requires the reader to look at or near each

[1] Supported by NICH and HD R01HD04213-01.

letter—for example, if he is checking for misspellings or broken letters, as in proofreading—then his reading rate will slow down and his comprehension score will drop. Here, then, are two clearly separable reading tasks: one with intention to extract meaningful content from the printed page; the other with intention to pay attention to the letters and the spelling of the words that make up the printed page. These and other tasks, set either by the goals given the reader, or by the relative difficulty or unfamiliarity of the material, affect the reader's visual search patterns and performances (*18*, *2*). Normally, of course, the subject is required neither to skim as lightly as possible nor to attend to each serif on each letter. Instead, his behavior is probably determined by the changing demands imposed by what he is reading—at one point, casting his eye far ahead; at another, looking at almost each individual letter. *Reading* is thus a very general term, covering a wide range of behaviors, involving diverse purposes and skills.

Skills in reading can be arranged in a logical hierarchy: the ability to discriminate letters and letter-groups, the ability to form grapheme-phoneme correspondences, and to spell out (*1*). In general, one might expect that these "lower" skills are to some degree necessary to the acquisition of higher ones—some minimum ability at letter-discrimination and at syllable- and word-recognition is needed in order for reading-for-meaning to proceed. Thus, it seems extremely likely that every practiced reader has had to acquire these "lower" skills at some stage in his career toward literacy, and that he can fall back upon them when the task requires it; for example, he can dissect some unfamiliar word or passage into its component letters, and then put it together again. But, these lower skills are probably used only occasionally. When the skilled reader reads normally, that is, when he uses his eyes to retrieve linguistic meaning from the printed page in as natural and content-oriented a way as he uses his ears to listen to speech, he probably looks at the text infrequently, compared to when he proofreads or compared to a less skilled reader. He "samples" the text in order to develop hypotheses about what the next string of symbols consists of, and to test those expectations at appropriate places further along in the text. This, of course, sounds more like what we think of as "skimming" than what we consider to be reading, but no hard distinction is really possible: "skimming" and "reading" represent points on a continuum of intention; they are not basically different activities. In fact, "skimming" is much closer to what the subject has learned to do when he is listening to speech or when he is looking at scenes, long before he comes to the special task of learning to read, that is, to the special task of using his eyes to "listen."

Before we consider how the various components of literacy might fit together in the intentional activity of normal reading, let us first examine in turn the prior behaviors of active listening and looking.

The first thing we should note about listening is that it, too depends on the subject's attention. As a great deal of research has shown (*7, 3, 21, 27*), if a subject is asked to attend to one of two fairly rapid monologs that are being presented to him simultaneously, but in two different "channels" (e.g., one in a male voice and one in a female voice, or one in the right ear and one in the left ear), he *seems* to fail to "hear" the content of the unattended message; at least, he cannot recall it. Nor will the subject respond to some sets of words to which he has been instructed to respond, if they have been embedded in the unattended channel.

Such selective attention is often explained as being the result of a "filter" that passes the signals that are presented on the attended channel, but which attenuates or even blocks the other channel's signals. On closer examination, however, the filter analogy requires too many unlikely and complex properties to be very helpful. And in fact it is not true that we can say, *as a general statement*, that the content of the unattended message is unheard. For example, if both channels contain the same message, but the unattended one is delayed so that it lags behind the attended one, after a while most subjects realize that both messages are the same (*27*). As another example: if the subject's own name is presented in the unattended channel, he will tend to hear it even though it is not in the channel to which he has been instructed to attend. Now, while it is easy to see how one could "tune" a filter to select one frequency rather than another, or to select one ear rather than the other, it is hard to see how to construct a filter to work in terms of analyzed verbal meaning (*9*). For these and other reasons, Neisser (*22*) and Hochberg (*14, 16*) have argued that it is not necessary to invoke any filter at all in order to explain selective attention in listening; instead, we need to consider more closely what is really involved in attentive listening to speech.

The study of which sounds listeners confuse with each other, and which they can discriminate, lends some support to the proposition that we do not normally do much with the raw phonic elements of speech (*20*). We usually respond, instead, to larger packets of sounds, judging them to be one phoneme or another on the bases of certain distinctive features—distinctive :atures which tend to be those which distinguish the listener's own speech-producing actions, for example, tongue placement. The perception of word-sounds may be accomplished, therefore, by a process of "analysis of synthesis," that is, by matching certain features of the sensory input against corresponding features of one's plans to articulate speech.

Neisser (*22*) and Hochberg (*16*) propose that listening to speech follows the same outline as listening to word-sounds: In active listening, the subject has available to him in his own speech-generating repertory organized strings of language, that is, speech-generating plans which may be of the order of words, phrases, or even of sentences in length, depending on the cliché content of the language habitually used. The listener unfolds or reviews these units as he listens, checking the stimulus input relatively infrequently to confirm or revise his hypotheses. Speech sounds that were not anticipated in this fashion, nor encoded and stored as part of some such higher speech structure, present too much unorganized material to retain, exceed the memory-span for such unorganized and independent material, and cannot be recalled. This would explain what happens in the two-channel experiments, without recourse to any concept of a filter: the subject makes active anticipatory responses to the initial phonemes that he receives in the channel to which he is attending and stores the results of his testing of those expectations. Sounds that were uttered on the nonattended channel may be briefly stored as unrelated sounds, and will usually fade from memory while the subject reports the message received on the attended channel. As we should expect from our analysis of the situation, the experiment cannot be performed unless the verbal material presented is organized into redundant and predictable sequences (*19*). This argument is presented in more detail elsewhere (*16*). What is important to us here is that if listening to speech rests upon anticipating the results of having sampled redundant trains of sound, then something like this hypothesis-testing should also occur in reading, which is rooted in the listening and speaking processes.

Let us now turn to the skills that the subject must have acquired from his experiences in looking at scenes—skills which also antedate by many years his acquisition of reading abilities. Because our eyes register fine detail only within a very small region of the retina (the *fovea*), we must learn about the visual world by a succession of glances in different directions. Hence, like listening to speech, looking at scenes must occur by a temporal sequence of patterned stimulation. But whereas the listener only has the redundancy of ordered speech or music to guide his anticipations of what the next moment's stimulation will bring, the subject viewing a normal world has two sources of expectations: 1) Like the listener, he has learned something about the shapes to be expected in the world, and their regularities (*14, 17*); 2) The wide periphery of the retina, which is low in acuity and therefore in the detail that it can pick up, nevertheless provides an intimation of what will meet his glance when the observer moves his eyes to some region of the visual field. And because such changes in fixation point are executed by *saccadic movements*, whose end-points are decided *before* the movement is initiated (i.e., saccades are *ballistic* movements), the contents of each glance is always, in a sense, an answer to a question about what will be seen if some specific part of the peripherally-viewed scene is brought to the fovea.

We do not know too much about the strategies and tactics of free eye-movement deployment in viewing scenes, but it seems safe to say that the major potentially informative parts of the scenes are scanned. This is followed by making whatever small excursions are necessary to fill in detail needed to decide what is being looked at. There is, in general, a relatively high number of large saccades, a great deal of recursion, and nothing at all that should make it easy for a subject to keep precise track of the temporal order in which any search of the visual field has been executed, that is, no mapping of spatial order into temporal sequence. But this is just the task that faces the child when he first learns to read: he has to put together letters into words by a sequence of small adjacent fixations.

Surely this is an unaccustomed task for the visuomotor system.[2] It is one which needs whatever assistance can be provided and is one which the reader will try to escape as soon as he can (Hochberg, 1964).

The task of reading text, which requires the child to make many small, sequential, adjacent saccades, can be made easier in various ways. The strain can be reduced by using large type or by moving one's finger under the type, letter by letter; above all, and most useful to the attainment of literacy, by "guessing" at what some syllable, or some word, or even phrase would turn out to be. This last point is particularly important. Normal text is highly redundant in many ways, so that the subject does not have to *see* every part of a letter clearly, or every part of a word, in order to know what is being said. In short, the subject will—and *should*—tend to "guess" at what is vaguely seen in peripheral vision—and the more he knows about the redundancies of spelling, grammar, and idiom employed by the text, or *the more the text approaches the patterns of speech that he is normally prepared to generate,* the more he can correctly anticipate the message, the more likely that his guesses will be right, and the fewer the fixations that he actually needs to make. But the knowledge is essential: training for fewer fixations can be of little use if the anticipations are not correct to begin with, and if consequent reinforcement stemming from the correctness of the guess and from the relief of the onerous necessity for small saccades, does not occur.

This reminds us of what is, of course, one of the primary characteristics of skill in reading: the fact that the practiced reader needs shorter and fewer fixations in order to identify letters, to recognize words, to read text. How is this skill acquired, and on what psychological processes does it rest? Much of the research to this point has used the method of *tachistoscopic presentation,* in which the subject is shown letters or other stimulus patterns at some short exposure. In some ways, though with many reservations (*15*), we may consider the tachistoscopic presentation as being analogous to a

[2] Adjustment to this task is not always satisfactorily achieved. Thus Taylor and Robinson (1963) found that inefficient early ocular motor activity may result in final motor habits which inhibit efficient reading after the original causes (difficulty with word identification and recognition) no longer exist.

single fixation that is made in the course of the reading process. Many years ago, Cattell (*5, 6*) showed that the exposure required to identify each of a tachistoscopically-presented set of unrelated letters, increased as the number of letters increased. The exposure time required to recognize some familiar word or phrase is, however, no longer than that for a single letter. In other words, the skilled reader is "picking up" as a unit what the unskilled reader would have to identify by multiple fixations. Since then, it has been amply shown that subjects can recognize words and shapes with which they are familiar at shorter exposure times than are needed for material with which they are unfamiliar (*13, 25*). Here, then, is one obvious reason why the skilled reader can make fewer and shorter fixations in reading text. This does not mean, however, that he *sees* the letters any differently, that is, that his sensory processes have been affected. There are reasons to believe that these effects of familiarity occur because of the subject's *response bias:* he is more ready to respond with a given letter, word, or phrase even when only partial or no sensory basis for that response is actually present (*10*), and he can better *recall* familiar material. That is, as with speech sounds, we would expect that the arrangement of the letters of a completely unfamiliar word would soon be forgotten, whereas once the skilled reader has identified the stimulus as being a familiar word, he can generate all the individual letters in sequence whenever he is called upon to do so (assuming he can spell it), regardless of the number of letters involved. In support of this suggestion, we should note that it is possible to demonstrate effects of familiarity on tachistoscopic word-recognition under conditions in which those effects are almost certainly due to the differential availability of memory units by which the strings of letters may be encoded and subsequently regenerated, and not due to differential sensory processing (*12, 14*). And the demonstration by Graf and Torrey (11) that comprehension scores are higher for written material that is broken at major linguistic boundaries than are comprehension scores for material broken at minor boundaries might be interpreted as the effect of greater ease of storing the material in the former condition.

By responding to the few features seen in clear foveal vision with an entire word or phrase, the skilled reader, then, has largely relieved himself of the necessity of looking closely at the text. He therefore needs to fixate only those parts of the array, further along the page, that will enable him to make new guesses and to check his previous ones. The better the reader, the more widespread can be the fixations by which he samples the text—just so long as the text provides him with contextual redundancy and as long as his task permits him to attend to the meaning or content, rather than to spelling or to individual letters.

The question then becomes, what guides the skilled reader's fixations? How does he decide what the text in question is, without looking at each letter?

As in listening to speech, of course, the skilled reader's expectations of what he will find when he looks further along the page are based in part on the syntax, and on the meaning of what he has just read. In order for sampling to be possible, and for anything less than letter-by-letter reading to suffice, some redundancy, of course, is needed. With our present spelling and syntax, redundancy in the middle of long sentences is close to 100 percent. Like the listener, therefore, the reader can formulate and test speech fragments. He need not look at each letter because he can guess at the next *n* letters, and he knows enough about the constraints of language to make a profitable guess at how much further along he should look next in order to test these fragments and formulate new ones. Thus, it has been found that reading errors are influenced by associative factors and by language habits based on syntactic framework (*8, 23, 24*), which is what we would expect if readers' hypotheses are only intermittently tested. Call this determinant of fixation CSG for cognitive search guidance (*15*). Unlike the listener, however, the reader is not restricted to previous content as the source of his extrapolations because he can, in addition, use the information given in peripheral vision, as modified by his linguistic expectancies. to select the places at which he should seek successive stimulus input. Thus, at the very least, he should be able to anticipate, through the use of interword spaces that appear in the peripheral vision, where he must look in order to fixate the most informative portions of words (that is, their termini), and which words are likely to be short functors. Call such determinants of fixation PSG for peripheral search guidance. The practiced reader must move his eyes under the combined control of CSG and PSG.

The beginning reader, who really must look at most or all of the letters, probably makes little use of PSG. He is, therefore, less hampered than is the better reader when the information available in peripheral vision is interfered with, for example, by filling in the interword spaces so as to make the word boundaries indiscriminable when viewed peripherally (*15*). Readers with "tunnel vision," that is, lacking peripheral vision, have very low reading rates. But, the discovery of what actually guides a skilled reader's fixations and how these can be improved calls for more than a simple demonstration of the importance of peripheral vision. One possible avenue of research which we are currently exploring with Roger Nelson and Murray Glanzer, is to present the reader cinematically with a paragraph of text in which a simulated fixation point, that is, an area of clear vision containing four or five letters, appears successively at various places in the text. This procedure provides the reader with an incomplete sample of the page. The independent variables in this investigation are these: how the samples are taken; how the simulated fixation points are presented throughout the text; and the amount of information, if any, that is transmitted in the periphery of the field, that is, outside of the simulated fixation point. When the reader performs at or near his normal reading rate, we may assume that we have simulated his sampling procedure. In other words, we have given him the information he normally employs in terms of the units by which he normally reads.

This picture of skilled reading is one of successive extrapolations, not of information processing, letter by letter. If it is an accurate picture, it will explain why it appears as though really skilled readers are processing a tremendous amount of information per second; whereas, in fact, they are not—they merely know a great deal about the language and about writers. If we are to attempt to teach readers to make such extrapolations and to use them, we shall have to keep two things in mind: first, we must fit the text—which we are teaching them to anticipate—to the anticipations that their speech habits already provide; second, we cannot expect them to transfer such skilled reading habits to less idiosyncratic text until the appropriate habits of speech and knowledge have been built up.

But, are we talking about "skimming" or "reading?" In view of the fact that visual perception almost always entails a procedure of sampling from a display of stimulus information that is redundant for the perceptual task at hand—another way of saying this is that it is very hard to present the adult with a perceptual task to which none of his previous visual experience is relevant—it is hard to see how the distinction between skimming and reading can be maintained as an absolute one. That is, the distinction must be referred to the size of the units that the task requires the subject to process. For example, if the task is to detect burred or broken serifs in the text, each letter must be fixated more than once; anything less is skimming. But this is not how people normally read, whether for entertainment or for information. It is plausible that children should be encouraged to predict and anticipate what is coming next in reading. The exact methods for so encouraging them, however, should be the subject for empirical study and not for speculation. Empirical studies are also needed to determine what the goals and the appropriate units are for the different intentions that initiate and maintain reading behavior, if reading behavior—as opposed to symbol-recognition, orthography, or tachistoscopic-perception—is to be understood in a way that is theoretically satisfying or socially useful.

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Learning to Read[1]

Experimental psychologists examine the process by which a fundamental intellectual skill is acquired.

ELEANOR J. GIBSON

EDUCATORS and the public have exhibited a keen interest in the teaching of reading ever since free public education became a fact (*1*). Either because of or despite their interest, this most important subject has been remarkably susceptible to the influence of fads and fashions and curiously unaffected by disciplined experimental and theoretical psychology. The psychologists have traditionally pursued the study of verbal learning by means of experiments with nonsense syllables and the like—that is, materials carefully divested of useful information. And the educators, who found little in this work that seemed relevant to the classroom, have stayed with the classroom; when they performed experiments, the method was apt to be a gross comparison of classes privileged and unprivileged with respect to the latest fad. The result has been two cultures: the pure scientists in the laboratory, and the practical teachers ignorant of the progress that has been made in the theory of human learning and in methods of studying it.

That this split was unfortunate is clear enough. True, most children do learn to read. But some learn to read badly, so that school systems must provide remedial clinics; and a small proportion (but still a large number of future citizens) remain functional illiterates. The fashions which have led to classroom experiments, such

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as the "whole word" method, emphasis on context and pictures for "meaning," the "flash" method, "speed reading," revised alphabets, the "return" to "phonics," and so on, have done little to change the situation.

Yet a systematic approach to the understanding of reading skill is possible. The psychologist has only to treat reading as a learning problem, to apply ingenuity in theory construction and experimental design to this fundamental activity on which the rest of man's education depends. A beginning has recently been made in this direction, and it can be expected that a number of theoretical and experimental studies of reading will be forthcoming (2).

Analysis of the Reading Process

A prerequisite to good research on reading is a psychological analysis of the reading process. What is it that a skilled reader has learned? Knowing this (or having a pretty good idea of it), one may consider how the skill is learned, and next how it could best be taught. Hypotheses designed to answer all three of these questions can then be tested by experiment.

There are several ways of characterizing the behavior we call reading. It is receiving communication; it is making discriminative responses to graphic symbols; it is decoding graphic symbols to speech; and it is getting meaning from the printed page. A child in the early stages of acquiring reading skill may not be doing all these things, however. Some aspects of reading must be mastered before others and have an essential function in a sequence of development of the final skill. The average child, when he begins learning to read, has already mastered to a marvelous extent the art of communication. He can speak and understand his own language in a fairly complex way, employing units of language organized in a hierarchy and with a grammatical structure. Since a writing system must correspond to the spoken one, and since speech is prior to writing, the frame work and unit structure of speech will determine more or less the structure of the writing system, though the rules of correspondence vary for different languages and writing systems. Some alphabetic writing systems have nearly perfect single-letter-to-sound correspondences, but some, like English, have far more complex correspondence between spelling patterns and speech patterns. Whatever the nature of the correspondences, it is vital to a proper analysis of the reading task that they be understood. And it is vital to remember, as well, that the first stage in the child's mastery of reading is learning to communicate by means of spoken language.

Once a child begins his progression from spoken language to written language, there are, I think, three phases of learning to be considered. They present three different kinds of learning tasks, and they are roughly sequential, though there must be considerable overlapping. These three phases are: learning to differentiate graphic symbols; learning to decode letters to sounds ("map" the letters into sounds); and using progressively high-order units of structure. I shall consider these three stages in order and in some detail and describe experiments exploring each stage.

Differentiation of Written Symbols

Making any discriminative response to printed characters is considered by some a kind of reading. A very young child, or even a monkey, can be taught to point to a patch of yellow color, rather than a patch of blue, when the printed characters YELLOW are presented. Various people, in recent popular publications, have seriously suggested teaching infants to respond discriminatively in this way to letter patterns, implying that this is teaching them to "read." Such responses are not reading, however; reading entails decoding to speech. Letters are, essentially, an instruction to produce a given speech sound.

Nevertheless, differentiation of written characters from one another is a logically preliminary stage to decoding them to speech. The learning problem is one of discriminating and recognizing a set of line figures, all very similar in a number of ways (for example, all are tracings on paper) and each differing from all the others in one or more features (as straight versus curved). The differentiating features must remain invariant under certain transformations (size, brightness, and perspective transformations and less easily described ones produced by different type faces and handwriting). They must therefore be relational, so that these transformations will not destroy them.

It might be questioned whether learning is necessary for these figures to be discriminated from one another. This question has been investigated by Gibson, Gibson, Pick, and Osser (*3*). In order to trace the development of letter differentiation as it is related to those features of letters which are critical for the task, we designed specified transformations for each of a group of standard, artificial letter-like forms comparable to printed Roman capitals. Variants were constructed from each standard figure to yield the following 12 transformations for each one: three degrees of transformation from line to curve; five transformations of rotation or reversal; two perspective transformations; and two topological transformations (see Fig. 1 for examples). All of these except the perspective transformations we considered critical for discriminating letters. For example, contrast V and U; C and U; O and C.

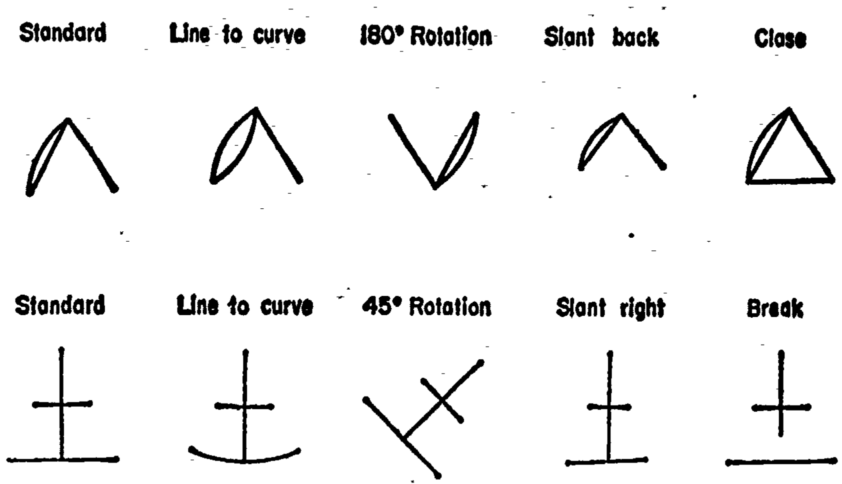

FIGURE 1. Examples of letter-like figures illustrating different types of transformation.

The discrimination task required the subject to match a standard figure against all of its transformations and some copies of it and to select only identical copies. An error score (the number of times an item that was not an identical copy was selected) was obtained for each child, and the errors were classified according to the type of transformation. The subjects were children aged 4 through 8 years. As would be expected, the visual discrimination of these letter-like forms improved from age 4 to age 8, but the slopes of the error curves were different, depending on the transformation to be discriminated (Fig. 2). In other words, some transformations are harder to discriminate than others, and improvement occurs at different rates for different transformations. Even the youngest subjects made relatively few errors involving changes of break or close, and among the 8-year-olds these errors dropped to zero. Errors for perspective transformations were very numerous among 4-year-olds and still numerous among 8-year-olds. Errors for rotations and reversals started high but dropped to nearly zero by 8 years. Errors for changes from line to curve were relatively numerous (depending on the number of changes) among the youngest children and showed a rapid drop among the older—almost to zero for the 8-year-olds.

The experiment was replicated with the same transformations of real letters on the 5-year-old group. The correlation between confusions of the same transformations for real letters and for the letter-like forms was very high ($r = +.87$), so the effect of a given transformation has generality (is not specific to a given form).

What happens, in the years from 4 to 8, to produce or hamper improvement in discrimination? Our results suggest that the children have learned the features or dimensions of difference which are critical for differentiating letters. Some differences are critical, such as break versus close, line versus curve, and rotations and reversals; but some, such as the perspective transformations, are not, and must in fact be tolerated. The child of 4 does not start "cold" upon this task, because some of his previous experience with distinctive features of objects and pictures will transfer to letter differentiation. But the set of letters has a unique feature pattern for each of its

TABLE 1

NUMBER OF ERRORS MADE IN TRANSFER STAGE BY GROUPS WITH THREE TYPES OF TRAINING

Group	Type of training: Standards	Type of training: Transformations	Errors
E1	Same	Different	69
E2	Different	Same	39
C	Different	Different	101

members, so learning of the distinctive features goes on during the period we investigated.

If this interpretation is correct, it would be useful to know just what the distinctive features of letters are. What dimensions of difference must a child learn to detect in order to perceive each letter as unique? Gibson, Osser, Schiff, and Smith (*4*) investigated this question. Our method was to draw up a chart of the features of a given set of letters (*5*), test to see which of these letters were most frequently confused by prereading children, and compare the errors in the resulting "confusion matrix" with those predicted by the feature chart.

A set of distinctive features for letters must be relational in the sense that each feature presents a contrast which is invariant under certain transformations, and it must yield a unique pattern for each letter. The set must also be reasonably economical. Two feature

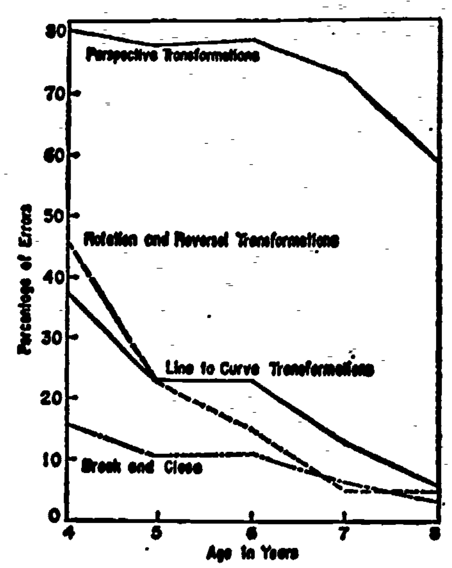

FIGURE 2. Error curves showing ra'e of improvement in discriminating four types of transformation.

lists which satisfy these requirements for a specified type f--e were tried out against the results of a confusion matrix obtained with the same type (simplified Roman capitals available on a sign-typewriter).

Each of the features in the list in Fig. 3 is or is not a character-

Features	A	B	C	E	K	L	N	U	X	Z
Straight segment										
Horizontal	+			+		+				+
Vertical		+		+	+	+	+			
Oblique /	+				+				+	+
Oblique \	+				+		+		+	
Curve										
Closed		+								
Open vertically								+		
Open horizontally			+							
Intersection	+	+		+	+				+	
Redundancy										
Cyclic change		+		+						
Symmetry	+	+	+	+	+			+	+	
Discontinuity										
Vertical	+				+				+	
Horizontal				+		+	+			+

FIGURE 3. Example of a "feature chart." Whether the features chosen are actually effective for discriminating letters must be determined by experiment.

istic of each of the 26 letters. Regarding each letter one asks, for example, "Is there a curved segment?" and gets a yes or no answer. A filled-in feature chart gives a unique pattern for each letter. However, the number of potential features for letter-shapes is very large, and would vary from one alphabet and type font to another. Whether or not we have the right set can be tested with a confusion matrix. Children should confuse with greatest frequency the letters having the smallest number of feature differences, if the features have been chosen correctly.

We obtained our confusion matrix from 4-year-old children, who made matching judgments of letters, programed so that every letter had an equal opportunity to be mistaken for any other, without bias from order effects. The "percent feature difference" for any two letters was determined by dividing the total number of features possessed by either letter, but not both, by the total number possessed by both, whether shared or not. Correlations were then calculated between percent feature difference and number of confusions, one for each letter. The feature list of Fig. 3 yielded 12 out of 26 positive significant correlations. Prediction from this feature list is fairly good, in view of the fact that features were not weighted. A multidimensional analysis of the matrix corroborated the choice of the curve-straight and obliqueness variables, suggesting that these features may have priority in the discrimination process and perhaps developmentally. Refinement of the feature list will take these facts into account, and other methods of validation will be tried.

Detecting Distinctive Features

If we are correct in thinking that the child comes to discriminate graphemes by detecting their distinctive features, what is the learning process like? That it is perceptual learning and need not be verbalized is probable (though teachers do often call attention to contrasts between letter shapes). An experiment by Anne D. Pick (*6*) was designed to compare two hypotheses about how this type of discrimination develops. One might be called a "schema" or "prototype" hypothesis, and is based on the supposition that the child builds up a kind of model or memory image of each letter by repeated experience of visual presentations of the letter; perceptual theories which propose that discrimination occurs by matching sensory experience to a previously stored concept or categorical model are of this kind. In the other hypothesis it is assumed that the child learns by discovering how the forms differ, and then easily transfers this knowledge to new letter-like figures.

Pick employed a transfer design in which subjects were presented in step 1 with initially confusable stimuli (letter-like forms) and trained to discriminate between them. For step 2 (the transfer stage) the subjects were divided into three groups. One experimental group was given sets of stimuli to discriminate which varied in new dimensions from the *same standards* discriminated in stage 1. A second experimental group was given sets of stimuli which deviated from *new standards*, but in the same dimensions of difference discriminated in stage 1. A control group was given both new standards and new dimensions of difference to discriminate in stage 2. Better performance by the first experimental group would suggest that discrimination learning proceeded by construction of a model or memory image of the standards against which the variants could be matched. Conversely, better performance by the second experimental group would suggest that dimensions of difference had been detected.

The subjects were kindergarten children. The stimuli were letter-like forms of the type described earlier. There were six standard forms and six transformations of each of them. The transformations consisted of two changes of line to curve, a right-left reversal, a 45-degree rotation, a perspective transformation, and a size transformation. Table 1 gives the errors of discrimination for all three groups in stage 2. Both experimental groups performed significantly better than the control group, but the group that had familiar transformations of new standards performed significantly better than the group given new transformations of old standards.

We infer from these results that, while children probably do learn prototypes of letter shapes, the prototypes themselves are not the original basis for differentiation. The most relevant kind of training for discrimination is practice which provides experience with the characteristic differences that distinguish the set of items. Features which are actually distinctive for letters could be emphasized by presenting letters in contrast pairs.

Decoding Letters to Sounds

When the graphemes are reasonably discriminable from one another, the decoding process becomes possible. This process, common sense and many psychologists would tell us, is simply a matter of associating a graphic stimulus with the appropriate spoken response—that is to say, it is the traditional stimulus-response paradigm, a kind of paired-associate learning.

Obvious as this description seems, problems arise when one takes a closer look. Here are just a few. The graphic code is related to the speech code by rules of correspondence. If these rules are known, decoding of new items is predictable. Do we want to build up, one by one, automatically cued responses, or do we want to teach with transfer in mind? If we want to teach for transfer, how do we do it? Should the child be aware that this is a code game with rules? Or will induction of the rules be automatic? What units of both codes should we start with? Should we start with single letters, in the hope that knowledge of single-letter-to-sound relationships will yield the most transfer? Or should we start with whole words, in the hope that component relationships will be induced?

Carol Bishop (7) investigated the question of the significance of knowledge of component letter-sound relationships in reading new words. In her experiment, the child's process of learning to read was simulated by teaching adult subjects to read some Arabic words. The purpose was to determine the transfer value of training with individual letters as opposed to whole words, and to investigate the role of component letter-sound associations in transfer to learning new words.

A three-stage transfer design was employed. The letters were 12 Arabic characters, each with a one-to-one letter-sound correspondence. There were eight consonants and four vowels, which were combined to form two sets of eight Arabic words. The 12 letters appeared at least once in both sets of words. A native speaker of the language recorded on tape the 12 letter-sounds and the two sets of words. The graphic form of each letter or word was printed on a card.

The subjects were divided into three groups—the letter training group (L), the whole-word training group (W), and a control group (C). Stage 1 of the experiment was identical for all groups. The subjects learned to pronounce the set of words (transfer set) which would appear in stage 3 by listening to the recording and repeating the words. Stage 2 varied. Group L listened to and repeated the 12 letter-sounds and then learned to associate the individual graphic shapes with their correct sounds. Group W followed the same procedure, except that eight words were given them to learn, rather than letters. Learning time was equal for the two groups. Group C spent the same time-interval on an unrelated task. Stage 3 was the same for the three groups. All subjects learned to read the set of words they had heard in stage 1, responding to the presentation of a word on a card by pronouncing it. This was the transfer stage on which the three groups were compared.

At the close of stage 3, all subjects were tested on their ability to give the correct letter-sound following the presentation of each printed letter. They were asked afterward to explain how they tried to learn the transfer words.

Figure 4 shows that learning took place in fewest trials for the letter group and next fewest for the word group. That is, letter training had more transfer value than word training, but word training did produce some transfer. The subjects of group L also knew, on

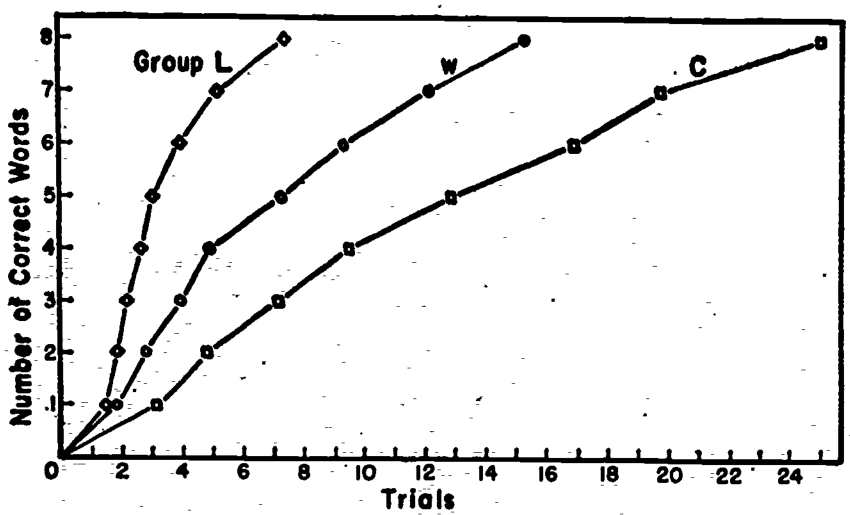

FIGURE 4. Learning curves on transfer task for group tra ned originally with whole words (W), group trained with single letters (L), and control group (C).

the average, a greater number of component letter-sound correspondences, but some subjects in group W had learned all 12. Most of the subjects in group L reported that they had tried to learn by using knowledge of component correspondences. But so did 12 of the 20 subjects in group W, and the scores of these 12 subjects on the transfer task were similar to those of the letter-trained group. The subjects who had learned by whole words and had not used individual correspondences performed no better on the task than the control subjects.

It is possible, then, to learn to read words without learning the component letter-sound correspondences. But transfer to new words depends on use of them, whatever the method of original training. Word training was as good as letter training if the subject had analyzed for himself the component relationships.

Learning Variable and Constant Component Correspondences

In Bishop's experiment, the component letter-sound relationships were regular and consistent. It has often been pointed out, especially by advocates of spelling reform and revised alphabets (*8*), that in English this is not the case. Bloomfield (*9*) suggested that the beginning reader should, therefore, be presented with material carefully programed for teaching those orthographic-phonic regularities which exist in English, and should be introduced later and only gradually to the complexities of English spelling and to the fact that single-letter-to-sound relationships are often variable. But actually, there has been no hard evidence to suggest that transfer, later, to reading spelling-patterns with more variable component correspondence will be facilitated by beginning with only constant ones. Although variable ones may be harder to learn in the beginning, the original difficulty may be compensated for by facilitating later learning.

A series of experiments directed by Harry Levin (*10*) dealt with the effect of learning variable as opposed to constant letter-sound relationships, on transfer to learning new letter-sound relationships. In one experiment, the learning material was short lists of paired-associates, with a word written in artificial characters as stimulus and a triphoneme familiar English word as response. Subjects (third-grade children) in one group were given a list which contained constant graph-to-sound relationships (one-to-one component correspondence) followed by a list in which this correspondence was variable with respect to the medial vowel sound. Another group started with a similarly constructed variable list and followed it with a second one. The group that learned lists with a variable component in both stages was superior to the other group in the second stage. The results suggest that initiating the task with a variable list created an expectation or learning set for variability of correspondence which was transferred to the second list and facilitated learning it.

In a second experiment, the constant or variable graph-sound relation occurred on the first letter. Again, the group with original variable training performed better on the second, variable list. In a third experiment adult native speakers of English and Spanish were compared. The artificial graphs were paired with nonsense words. Again there was more transfer from a variable first list to a variable second list than from a constant to a variable one. Variable lists were more difficult, on the whole, for the Spanish speakers, perhaps because their native language contains highly regular letter-sound relationships.

A "set for diversity" may, therefore, facilitate transfer to learning of new letter-sound correspondences which contain variable relationships. But many questions about how the code is learned remain to be solved, because the true units of the graphic code are not necessarily single letters. While single-letter-sound relations in English are indeed variable, at other levels of structure regularity may be discovered.

Lower- and Higher-Order Units

For many years, linguists have been concerned with the question of units in language. That language has a hierarchical structure, with units of different kinds and levels, is generally accepted, though the definition of the units is not easily reached. One criterion of a unit is recodability—consistent mapping or translation to another code. If such a criterion be granted, graphic units must parallel linguistic units. The units of the writing system should be defined, in other words, by mapping rules which link them to the speech code, at all levels of structure.

What then are the true graphic units? What levels of units are there? Exactly how are they mapped to linguistic units? In what "chunks" are they perceived? We must first try to answer these questions by a logical analysis of properties of the writing and speech systems and the correspondences between them. Then we can look at the behavior of skilled readers and see how units are processed during reading. If the logical analysis of the correspondence rules is correct, we should be able to predict what kinds of units are actually processed and to check our predictions experimentally.

Common sense suggests that the unit for reading is the single grapheme, and that the reader proceeds sequentially from left to right, letter by letter, across the page. But we can assert at once and unequivocally that this picture is false. For the English language, the single graphemes map consistently into speech only as morphemes—that is, the names of the letters of the alphabet. It is possible, of course, to name letters sequentially across a line of print ("spell out" a word), but that is not the goal of a skilled reader, nor is it what he does. Dodge (*11*) showed, nearly 60 years ago, that perception occurs in reading only during fixations, and not at all during the saccadic jumps from one fixation to the next. With a fast tachistoscopic exposure, a skilled reader can perceive four unconnected letters, a very long word, and four or more words if they form a sentence (*12*). Even first graders can read three-letter words exposed for only 40 milliseconds, too short a time for sequential eye movements to occur.

Broadbent (*13*) has pointed out that speech, although it consists of a temporal sequence of stimuli, is responded to at the end of a sequence. That is, it is normal for a whole sequence to be delivered before a response is made. For instance, the sentence "Would you give me your———?" might end with any of a large number of words, such as "name" or "wallet" or "wife." The response depends on the total message. The fact that the component stimuli for speech and reading are spread over time does not mean that the phonemes or letters or words are processed one at a time, with each stimulus decoded to a separate response. The fact that o is pronounced differently in BOAT and BOMB is not a hideous peculiarity of English which must consequently be reformed. The o is read only in context and is never responded to in isolation. It is part of a sequence which contains constraints of two kinds, one morphological and the other the spelling patterns which are characteristic of English.

If any doubt remains as to the unlikelihood of sequential processing letter by letter, there is recent evidence of Newman (*14*) and of Kolers (*15*) on sequential exposure of letters. When letters forming a familiar word are exposed sequentially in the same place, it is almost impossible to read the word. With an exposure of 100 milliseconds per letter, words of six letters are read with only 20 percent probability of accuracy; and with an exposure of 375 milliseconds per letter, the probability is still well under 100 percent. But that is more than 2 seconds to perceive a short, well-known word! We can conclude that, however graphemes are processed perceptually in reading, it is not a letter-by-letter sequence of acts.

If the single grapheme does not map consistently to a phoneme, and furthermore, if perception normally takes in bigger "chunks" of graphic stimuli in a single fixation, what are the smallest graphic units consistently coded into phonemic patterns? Must they be whole words? Are there different levels of units? Are they achieved at different stages of development?

Spelling Patterns

It is my belief that the smallest component units in written English are spelling patterns (*16*). By a spelling pattern, I mean a cluster of graphemes in a given environment which has an invariant pronunciation according to the rules of English. These rules are the regularities which appear when, for instance, any vowel or consonant or cluster is shown to correspond with a given prounuciation in an initial, medial, or final position in the spelling of a word. This kind of regularity is not merely "frequency" (bigram frequency, trigram frequency, and so on), for it implies that frequency counts are relevant for establishing rules only if the right units and the right relationships are counted. The relevant graphic unit is a functional unit of one or more letters, in a given position within the word, which is in correspondence with a specified pronunciation (*17*).

If potential regularities exist within words—the spelling patterns that occur in regular correspondence with speech patterns—one may hypothesize that these correspondences have been assimilated by the skilled reader of English (whether or not be can verbalize the rules) and have the effect of organizing units for perception. It follows that strings of letters which are generated by the rules will be perceived more easily than ones which are not, even when they are unfamiliar words or not words at all.

Several experiments testing this prediction were performed by Gibson, Pick, Osser, and Hammond (*18*). The basic design was to compare the perceptibility (with a very short tachistoscopic exposure) of two sets of letter-strings, all nonsense or pseudo words, which differed in their spelling-to-sound correlation. One list, called the "pronounceable" list, contained words with a high spelling-to-sound correlation. Each of them had an initial consonant-spelling with a single, regular pronunciation; a final consonant-spelling having a single regular pronunciation; and a vowel-spelling, placed between them, having a single regular pronunciation when it follows and is followed by the given initial and final consonant spellings, repectively—for example, GL/UR/CK. The words in the second list, called the "unpronounceable" list, had a low spelling-to-sound correlation. They were constructed from the words in the first list by reversing the initial and final consonant spellings. The medial vowel spelling was not changed. For example, GLURCK became CKURGL. There were 25 such pseudo words in each list, varying in length from four to eight letters. The pronunciability of the resulting lists was validated in two ways, first by ratings, and second by obtaining the number of variations when the pseudo words were actually pronounced.

The words were projected on a screen in random order, in five successive presentations with an exposure time beginning at 50 milliseconds and progressing up to 250 milliseconds. The subjects (college students) were instructed to write each word as it was projected. The mean percentage of pronounceable words correctly perceived was consistently and significantly greater at all exposure times.

The experiment was later repeated with the same material but a different judgment. After the pseudo word was exposed, it was followed by a multiple-choice list of four items, one of the correct one and the other three the most common errors produced in the previous experiment. The subject chose the word he thought he had seen from the choice list and recorded a number (its order in the list). Again the mean of pronounceable pseudo words correctly perceived significantly exceeded that of their unpronouncable counterparts. We conclude from these experiments that skilled readers more easily perceive as a unit pseudo words which follow the rules of English spelling-to-sound correspondence; that spelling patterns which have invariant relations to sound patterns function as a unit, thus facilitating the decoding process.

In another experiment, Gibson, Osser, and Pick (*19*) studied the development of perception of grapheme-phoneme correspondences. We wanted to know how early, in learning to read, children begin to respond to spelling-patterns as units. The experiment was designed to compare children at the end of the first grade and at the end of the third grade in ability to recognize familiar three-letter words, pronounceable trigrams, and unpronounceable trigrams. The three-letter words were taken from the first-grade reading list; each word chosen could be rearranged into a meaningless but pronounceable trigram and a meaningless and unpronounceable one (for example, RAN, NAR, RNA). Some longer pseudo words (four and five letters) taken from the previous experiments were included as well. The words and pseudo words were exposed tachistoscopically to individual children, who were required to spell them orally. The first-graders read (spelled out) most accurately the familiar three-letter words, but read the pronounceable trigrams significantly better than the unpronounceable ones. The longer pseudo words were seldom read accurately and were not differentiated by pronunciability. The third-grade girls read all three-letter combinations with high and about equal accuracy, but differentiated the longer pseudo words; that is, the pronounceable four- and five-letter pseudo words were more often perceived correctly than their unpronounceable counterparts.

These results suggest that a child in the first stages of reading skill typically reads in short units, but has already generalized certain regularities of spelling-to-sound correspondence, so that three-letter pseudo words which fit the rules are more easily read as units. As skill develops, span increases, and a similar difference can be observed for longer items. The longer items involve more complex conditional rules and longer clusters, so that the generalizations must increase in complexity. The fact that a child can begin very early to perceive regularities of correspondence between the printed and spoken patterns, and transfer them to the reading of unfamiliar items as units, suggests that the opportunities for discovering the correspondences between patterns might well be enhanced in programing reading materials.

I have referred several times to *levels* of units. The last experiment showed that the size and complexity of the spelling patterns which can be perceived as units increase with development of reading skill. The other levels of structure, both syntactic and semantic, contain units as large as and larger than the word, and that perception of skilled readers will be found, in suitable experiments, to be a function of these factors is almost axiomatic. As yet we have little direct evidence better than Cattell's original discovery (*12*) that when words are structured into a sentence, more letters can be accurately perceived "at a glance." Developmental studies of perceptual "chunking" in relation to structural complexity may be very instructive.

Where does meaning come in? Within the immediate span of visual perception, meaning is less effective in structuring written material than good spelling-to-sound correspondence, as Gibson, Bishop, Schiff, and Smith (*20*) have shown. Real words which are both meaningful and, as strings of letters, structured in accordance with English spelling patterns are more easily perceived than non-word pronounceable strings of letters; but the latter are more easily perceived than meaningful but unpronounceable letter-strings (for example, BIM is perceived accurately, with tachistoscopic exposure, faster than IBM). The role of meaning in the visual perception of words probably increases as longer strings of words (more than one) are dealt with. A sentence has two kinds of constraint, semantic and syntactic, which make it intelligible (easily heard) and memorable (*21*). It is important that the child develop reading habits which utilize all the types of constraint present in the stimulus, since they constitute structure and are, therefore, unit-formers. The skills which the child should acquire in reading are habits of utilizing the constraints in letter strings (the spelling and morphemic patterns) and in word strings (the syntactic and semantic patterns). We could go on to consider still superordinate ones, perhaps, but the problem of the unit, of levels of units, and mapping rules from writing to speech has just begun to be explored with experimental techniques. Further research on the definition and processing of units should lead to new insights about the nature of reading skill and its attainment.

Summary

Reading begins with the child's acquisition of spoken language. Later he learns to differentiate the graphic symbols from one another and to decode these to familiar speech sounds. As he learns to decode, he must progressively utilize the structural constraints which are built into it in order to attain the skilled performance which is characterized by processing of higher-order units—the spelling and morphological patterns of the language.

Because of my firm conviction that good pedagogy is based on a deep understanding of the discipline to be taught and the nature of the learning process involved, I have tried to show that the psychology of reading can benefit from a program of theoretical analysis and experiment. An analysis of the reading task—discriminatory and decoding aspects as well as the semantic and syntactical aspects—tells us *what* must be learned. An analysis of the learning process tells us *how*. The consideration of formal instruction comes only after these steps, and its precepts should follow from them.

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