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ABSTRACT

The preliterate child must acquire from reading instruction at least the following skills: (a) appropriate scanning behavior, (b) letter and word recognition, (c) letter-sound generalizations, and (d) comprehension of written materials, at least to the degree that the reader can comprehend the same message when received aurally. Almost all modern methods for teaching reading include letter-sound learning somewhere in the teaching sequence, although the amount and exact placement of this training account for the central disagreement between methods. Classroom comparisons of different teaching methods have contributed little to a general understanding of reading pedagogy, while more closely controlled laboratory experiments have not been able to simulate the complex interactions of variables which characterize the classroom. A more valid experimental procedure might be to work with existing (or new) programs, altering small, discrete segments of the materials and methods and measuring marginal gain. In this way critical components of an instructional program could be isolated and examined in a "real life" situation. This is, in essence, what Piaget has advocated under the title "experimental pedagogy." (Author)

Technical Report No. 188

LANGUAGE AND COGNITION IN READING

by

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Report from the Project on
Basic Prereading Skills

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Basic Prereading Skills: Identification and Improvement element of the Reading and Related Language Arts Project in Program 2, Processes and Programs of Instruction. General objectives of the Program are to develop curriculum materials for elementary and preschool children, to develop related instructional procedures, and to test and refine the instructional programs incorporating the curriculum materials and instructional procedures. Contributing to these Program objectives, this element has two general objectives: (1) to investigate ways to test for skill deficits and to overcome them and (2) to develop a kindergarten-level program, including diagnostic tests and instructional procedures, for teaching basic prereading skills. Tests and instructional programs will be developed for visual and auditory skills, including letter and letter-string matching with attention to order, orientation and detail, and speech-sound matching,and blending.

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Abstract

The preliterate child must acquire from reading instruction at least the following skills: (a) appropriate scanning behavior, (b) letter and word recognition, (c) letter-sound generalizations, and (d) comprehension of written materials, at least to the degree that the reader can comprehend the same message when received aurally.

The basic perceptual processes which the child must acquire begin with the scanning movements of the eyes: relatively long fixations, during which the intake of reading material occurs, and rapid saccades or jerks to the next fixation point. Words are presumed to be recognized from left to right, using immediate visual information, partial identifications saved from the last fixation, and syntactic/semantic context. Integration of recognized words into syntactic/semantic storage is assumed to take place in parallel with the visual scanning-recognition process.

Letter-sound generalizations are rarely used by the competent reader, but are necessary for acquiring proficient reading ability. Their primary function is to facilitate the development of word recognition ability, which they do by providing a means for (a) checking the identification of a word previously encountered, but still not known well enough to be identified with high confidence from its visual features or from context, and (b) generating the pronunciation of words not encountered before in print, but which may be in the reader's listening vocabulary. Acquisition of specific letter-sound generalizations develops slowly from Grade 1 through high school, and depends heavily upon the number of specific exemplars which the reader encounters for each pattern.

Almost all modern methods for teaching reading include letter-sound learning somewhere in the teaching sequence, although the amount and exact placement of this training account for the central disagreement between methods. Classroom comparisons of different teaching methods have contributed little to a general understanding of reading pedagogy, while more closely controlled laboratory experiments have not been able to simulate the complex interactions of variables which characterize the classroom. A more valid experimental procedure might be to work with existing (or new) programs, altering small, discrete segments of the materials and methods, and measuring marginal gain. In this way critical components of an instructional program could be isolated and examined in situ. This is, in essence, what Piaget has advocated under the title "experimental pedagogy."

I
Introduction

Purpose

Reading is a complex process involving perceptual, linguistic, and cognitive skills which themselves are not well understood. When confronted with something he recognizes as writing, the experienced reader can guide his eyes to appropriate fixation points, recognize words and possibly some phrases as whole units, sense syntactic/semantic boundaries, generate expectations for words outside of his immediate vision, and "understand" what the text says. He is also capable of translating written materials into speech, both through sight recognition of familiar words whose pronunciations he retrieves as integrated units and through application of letter-sound generalizations. Most of these skills are lacking in the preliterate child who, in addition, does not understand what reading is all about; that sequences of letters between spaces and other terminal markers can be translated into recognizable words and that the words together convey information, just as in oral communication.

The purpose of reading instruction is to aid children in developing these skills, which are, at a minimum:

1. an understanding of what writing is,
2. appropriate scanning behavior,
3. letter and word recognition,
4. letter-sound generalizations,
5. comprehension of written materials at least to the degree that the reader can comprehend the same message when received aurally.

This article is concerned with the nature of these skills and how they are acquired by healthy, normal children in learning to read their native language. It will not be concerned with either adult literacy or native literacy, or with reading disabilities that can be attributed to brain damage, emotional disturbances, or the vagaries commonly lumped under the title of dyslexia.

The basis of this article is the experimental studies of reading and reading-related skills performed over the last 100 years by psychologists, linguists, and educators, among others. Special attention will be given to my own work on orthography, started in collaboration with the late Ruth H. Weir at Stanford University, and on basic reading skills, started in collaboration with Robert C. Calfee at the University of Wisconsin.

On the Definition of Reading

The importance of literacy in modern society and the long and confusing history of reading instruction, spanning several millenia of comparing Method A to Method B, are adequately covered elsewhere, and will not be discussed here.[1] But the definition of reading, because of its importance in evaluating the outcome of reading instruction, requires clarification.

Reading is the translation from writing to a form of language from which the reader is already able to derive meaning. By this definition, reading is restricted to processes involving languages with which the reader can communicate by means other than reading (for all except the deaf and dumb, by speech). In addition, reading depends heavily upon the existing language habits of the reader, perhaps more so for the beginning reader than for the experienced one, but nevertheless, they form the basis upon which literacy is acquired. For the beginning reader the form

of language mentioned in the definition above is usually overt speech, since this is, for practical reasons, the form of language which is easiest to manipulate in an instructional setting. As basic reading habits are established, the form of language gradually shifts to subvocalized speech, then to a more internal form that I will not attempt to define specifically.[2] The basic assumption here is that many of the same language habits used in listening are available for reading; how they are utilized by the reader depends upon his reading ability and upon the particular reading task. Speed reading and rapid skimming, for example, make considerably different demands on language habits than does more deliberate reading.

The emphasis in this definition for the teaching of reading is on the existing language and comprehension abilities of the reader. These, regardless of what they are, are what he must utilize in reading. Mismatches between the language and content of the reading material and the language and understanding of the reader are potential barriers for learning to read; or in different terms, if the learner can not understand the material when it is presented to him orally, he will have considerably more difficulty attempting to read it. Learning to read should not be confused with reading; in the latter situation, reading can be used to introduce new words, ideas, or language forms, but in the former task these are hinderances to achieving the intended goal.

Reading is not simply translation from writing to speech; that procedure, often called decoding, can be part of reading and appears to be a necessary ability for initial reading in normal children, but is not within itself reading. A person may learn to pronounce Hebrew or Russian from their respective orthographies, yet the acquisition of this skill does not result in an understanding of Hebrew or Russian texts. In the other extreme, reading is not translating from writing to meaning; that is reading plus some other abilities. A lawyer may have difficulty obtaining meaning from writings on microbiology and a microbiologist may have difficulty interpreting legal tracts, yet both might be competent readers within their own fields or within technically neutral fields. The writing-to-meaning definition would be acceptable if it could be shown that written language were so different from speech that the extraction of meaning during reading required knowledge of numerous language structures and forms which did not occur in speaking. But this is simply not true for English or any other known language. There are, obviously, differences between writing and speech, and there are forms of writing, like legal tracts, that are difficult to understand orally, but the disjunction of writing and speech pales in comparison to the conjunction.

While this belaboring of definition may appear pedantic—and would be in many other disciplines—it is prompted by the identification of definition and teaching procedure which has pervaded the field of reading over the past 50 years. From the writing-to-speech definition comes a purblind concentration on oral reading, enunciation, and meaningless syllables; from the comprehension view, an equally nihilistic devotion, but to meaningful units and comprehension rather than to sound units. The definition offered here is not a compromise of these extremes. It is an attempt to emphasize the distinctive processes that logically characterize the reading process, which by necessity requires attention both to language and meaning, without assigning central roles to those that are common to other modes of communication.

The Measurement of Comprehension

Although adequate comprehension is an important goal of reading instruction and most methods for teaching reading employ frequent tests of this ability, both the definition of comprehension and the acceptable means for gauging it are among the most controversial issues in modern pedagogy. The central problem is in separating reading comprehension from intelligence and experiential factors which might influence a person's ability to derive information from a text. A physician will probably derive more information from an article on advances in cardiology than will a literary critic, but from this difference it would not be advisable to conclude that the doctor reads better than the critic. Similarly, one child may bring to any given comprehension task specific knowledge which allows him to organize and retain the reading matter better than other children with the same basic reading skills.

A similar problem occurs in comparing reading abilities across cultures. If different contents are used, then complexity of the passages will be difficult to compare, and if the same passages are used, one culture may be favored over another. The way around all of these difficulties is not to measure reading comprehension alone, but to measure both listening and reading comprehension for similar materials, using a variety of difficulty levels. The resulting measures, when appropriately combined, will not only give an assessment of individual reading comprehension relative to the reader's ability to comprehend orally, but will also give a measure for comparing reading abilities across cultures.

Several tests have been developed for such comparisons of listening and reading comprehension, and at least one extensive study of the listening/reading comprehension ratio has been done. Goldstein (1940) tested both listening and reading comprehension in 280 adults (18 to 64 years of age), representing a wide range of intelligence, educational achievement, and cultural backgrounds. His results show:

1. For relatively easy materials, listening comprehension is significantly superior to reading comprehension, but this difference disappears progressively as the materials become increasingly more difficult. For difficult materials, neither mode is superior.
2. Intelligence is inversely related to superiority of listening comprehension on easy materials. The less intelligent subjects showed a greater superiority for listening comprehension than the more intelligent adults.
3. The greatest modality differences were obtained on medium-difficulty materials. Scores from both modalities were too high on extremely easy materials and too low on extremely difficult materials to allow adequate comparison.

The reading-listening differential, as pointed out by Goldstein (1940, p. 59), is an index of reading educability. A pupil who scores low on reading comprehension but high on listening comprehension has (assuming no physical defects) a high potential for improvement; a student who scores low on both probably does not.

The Relationship Between Linguistics and Reading

As a final introductory note, two important distinctions must be made. The first distinction is between the structure of a component of reading and the appropriate techniques for teaching skills based upon that structure. Or, stated differently, the first distinction is between a knowledge of the subject matter and a knowledge of the learner. There is a structure to both language and to English orthography, and it is to the credit of several linguists that they labored long and hard to impress these facts upon those most responsible for the teaching of reading. But it was the failing of these same persons to assume that knowledge of language and orthography was not only a necessary condition for deciding how reading was to be taught, but also a sufficient one. Reading involves language, but it also involves perception and cognition, no matter how they are defined, and no amount of ordering of phonemes, morphemes, letter-sound correspondences, or any of the other paraphernalia of modern linguistics can by itself produce an efficient pedagogy. Knowing the exact relationship between letters and sounds does not completely determine which orthographic patterns should be introduced in initial reading (if any), or their sequencing, or the teaching procedures to be employed.

Consider, as an example, the possible procedures for teaching the two pronunciations for the letter a, as they occur in the final e (e.g., mate) and final consonant (e.g., mat) patterns. Assuming that these patterns should be taught, should they be introduced sequentially as is done in most current reading programs, or should they be introduced simultaneously, as suggested by Levin and Watson (1963)? If sequentially, which correspondence should be introduced first, /æ/, which occurs in the simplest environments, or /e/, which is easier to manipulate as a separate sound and which has a wider distribution than /æ/? In sequential presentation, /æ/ is usually introduced first, yet there is neither experimental nor

observational data to justify this choice. The data needed are primarily psychological and pedagogical, not linguistic: e.g., the time and effort required for teaching with each procedure and how each affects learning and transfer.

The role of the linguist, qua linguist, is to describe the structure of one of the components of reading. It is the task of others, however, to discover how such structures bear upon the learning process.

The second distinction is between the abilities of the competent reader and the development or acquisition of reading. Reading skills possessed by experienced readers represent goals for the teaching of reading, but they in no way indicate by themselves how reading should be taught. That adults may recognize whole words or be able to apply letter-sound relationships on request does not mean that beginning reading must be taught by means of whole words or by means of letter-sound correspondences.[3] How reading should be taught depends upon a variety of factors, not the least of which are: (a) the skills which the child brings to the reading task, (b) the learning abilities of the child, (c) the relationship between writing and language, and (d) the teaching environment, which at a minimum includes teachers, resources, and the society in which the school is placed.

If a child when he first begins to learn to read can not manipulate separate sounds, then it would be senseless to try to teach him individual letter-sound correspondences, regardless of how regular the letter-sound relations may be in the language he is to read. Similarly, if the child learns more efficiently from inductive than from deductive methods, we would tend less towards telling him the features he is to pay attention to in word recognition than we would towards attempting to have him induce these features through discrimination exercises.

And finally, even if all children could learn to read through a program which required 18 hours per day of individual attention, we would reject this procedure because it exceeds the limits of time and resources that most modern societies are willing to devote to the teaching of reading.

II
Analysis of the Reading Process

Basic Perceptual Processing

Eye Movements

During reading the eyes move in saccades or jerks, in one direction while reading a line and in the opposite direction for the return sweep at the end of a line. This stop-and-go movement, first observed by the French ophthalmologist Javal (1879), consists of rapid movement during which no verbal material is recognized, followed by relatively long fixation periods during which as many as 30 letters may be perceived. For the average adult, (silently) reading nontechnical material, the fixations occupy approximately 94% of the reading time while the movements occupy the remaining time (Tinker, 1965, p. 69).

In addition to the saccadic movements and return sweep, there are also regressive movements, composed of saccadic jumps in a direction opposite from the normal reading progression. These occur more frequently in the reading movements of poor than of good readers, and result from a variety of causes, the two most important being misreadings and beginning-of-the-line adjustment after a return sweep.

The number of fixations per line varies according to reading ability, type of material being read, and to a lesser degree, the physical properties of the text: line width, type style, and type size. Buswell (1922) found that the average number of fixations per line for 13 college students reading easy materials (3.5-inch line width) was about six, with each fixation lasting for an average of 225 msec. Comparable results have been found by Ballantine (1951) and Gilbert (1953).[4] (In Buswell's study, six fixations per line would yield seven letter spaces per fixation.) There is a positive relationship between span of fixation and reading ability, but the size of the correlation has never been satisfactorily established.[5]

The factors which determine the distance that the eyes will move between the fixation points have not been thoroughly investigated. These distances vary widely for a reader, not only across different types of material, but also within a single line. For a given reader, the distance to be traversed is probably a function both of reading habit and of the immediate textual situation, that is, how much of the text lying immediately ahead he thinks he can recognize in one fixation, judging from the syntactic/semantic form of what he has read so far and the vague forms and spaces that he observes in his peripheral vision ahead of his fixation area. Published records of fixations during reading do not show a preference for either printing or blank spaces as fixation points; however, since an area is fixated rather than a point, almost all fixations during reading subtend printed matter.[6]

Fixations

At a normal reading distance the most sensitive area of the retina, the fovea, subtends an angle of about 70 min. of an arc, which is sufficient for about four letter spaces of an average size. Visual reception declines gradually outside of the fovea, but recognition is still fairly accurate at a distance of 12-15 letter spaces away for single letters (Ruediger, 1907).[7] But letters within letter strings and words are considerably more difficult to recognize in indirect vision than are single letters surrounded by white spaces. Korte (1923) has shown that not only are

single letters more legible than words, but also that capital letters are more legible in indirect vision than lower case ones and short words more legible than long words. Furthermore, images in the normal direction of scanning (to the right for English, to the left for Hebrew) are more likely to be perceived than those in the opposite direction.

Except for unimportant nystagmic movements, the eyes are locked on an area of text during the fixation period, and intake of words, letters, punctuation, and other textual forms must occur during this time. Whether anything more than dark and light is observed during saccadic jumps is still a controversial issue, as is the claim that the backward masking of input during these jumps eliminates iconic storage of the last fixated material.[8]

According to Gilbert (1959, p. 11) "...the fixation pause must be long enough in duration to allow time not only to see but also time to process the visual stimuli." Gilbert tested college students on their ability to recognize tachistoscopically presented phrases. Immediately after each presentation, a 2/24-sec. mask of nonsense material was exposed. Without the mask, a 2/24-sec. exposure of a four-word string yielded a mean of 91.63% response for 64 subjects; with the mask, 56.14% correct.[9] The difference in mean percentage of words correctly identified between the best 25% of the readers and the poorest was significant at each exposure level in favor of the better readers.

Since tachistoscopic thresholds for word and phrase recognition are generally lower than those for actual reading, these data establish a lower bound on the fixation time for positive word identification. However, unclear images outside the foveal area play a large role in reading behavior. Their various functions are summarized succinctly by Tinker (1965, p. 13):

> These impressions, which vary greatly in clearness, provide preliminary partial perception of successive words. In addition they orient the reader for the perception of successive words in the sentence or phrases as well as provide essential stimuli for successive fixations of the eyes.

Support for this was found early in this century in an important experiment by Hamilton (1907). Sentences were exposed briefly on a screen and subjects were instructed to report everything they saw, including vague impressions. When subjects guessed at the identification of words which they could not positively identify, the responses they gave were similar enough to the stimuli in general form or in identical letters to indicate that recognition is not an all-or-none process, but that partial information is often obtained and stored. As would be expected, all of the reports of uncertain identification (marginal impressions) referred to materials to the right of the fixation area (English phrases, sentences, and nonsense words were used).

Word Recognition

General Processing

Within a single fixation, words are presumed to be recognized from left to right (or from right to left for Hebrew) as whole units, although the process of word recognition remains highly controversial. However, after nearly a century of experimentation, it is safe to hypothesize that two major sets of variables contribute to the word recognition process: stimulus variables and context variables. The stimulus variables include the shapes and positions of certain letters of a word, word length, and to a more limited degree, word shape. Context variables include expectancies of what words could occur at a given point in a sentence, based both upon the sentence context and upon the subject's prior experience with the material being read, and how familiar the subject is (visually) with the actual word. These two sets of factors most often work side-by-side, but also may be in conflict.[10]

Word recognition usually starts de novo at the beginning of a paragraph; in almost all other positions the reader brings to the recognition task expectancies derived from the preceding context and from his prior experiences, plus, for all except the first word of a line, partial identifying information from the twilight zone of the last fixation. Recognition in these circumstances can be viewed as directed search or hypothesis checking; further data are collected

only to the point where a hypothesis is confirmed, then remaining data are ignored. The physical features which have been shown experimentally to be most important for recognition are the first and last letters of a word, and what Zeitler (1900) called dominant letters: the capitals, and the ascenders and descenders (b, d, f, h, k, l, t; g, j, p, q, y).[11] The greater legibility of initial and final letters over embedded letters has been demonstrated by Wagner (1918) and Woodworth (1938, p. 720) for nonsense strings, but studies by Goldscheider and Muller (1893) and by Vernon (1931) indicate that the most important letters for recognition vary from word to word, and are not always the most discriminate ones.

Strong evidence against word shape as a consistent cue in perception has been provided by Smith, Lott, and Cronnell (1969), who tested visual search in passages of text printed in various combinations of letter case and letter size. Location speeds for words within normal text were no greater than those for the mixed case forms, created by alternating upper and lower case, letter-by-letter, throughout the text. In the latter situation, word shapes were altered significantly from those usually encountered in print, yet identification was not impaired. Word shape, nevertheless, may provide cues for recognition under special circumstances. Tinker (1965) hypothesized that general outline is important for recognizing sight-words (generally, function words) and McGinnies, Comer, and Lacy (1952), among others, have suggested that under some conditions word-length is an important cue.

There is no evidence that letter-sound generalizations are consistently used in word recognition by adults, although they may be employed for recognition of unfamiliar or difficult-to-perceive words. Hardyck and Petrinovich (1969) have observed that even good readers begin to subvocalize when reading becomes difficult (either perceptually or cognitively) and most people are aware of attempting to sound out totally unfamiliar words in printed texts. But the number of unfamiliar words encountered by the average reader is small compared to the familiar ones, and the average speed of silent reading is such that sounding of letter units could occur rarely. In oral reading, adults probably generate pronunciations not through letter-sound translation, but through retrieval of articulatory instructions after a word is recognized. The eye-movement patterns for oral reading reported by Buswell (1922) and others seem to preclude a letter-sound procedure.

Context Variables

Whatever the exact stimulus cues are for word recognition, it is clear that they are highly influenced by context variables. Before the turn of the century, Pillsbury (1897) demonstrated this through tachistoscopic presentation of familiar words into which typographic errors had been introduced. Subjects were asked to report everything they perceived—whole words, letters, etc.—and how certain they were of each item reported. "In many cases it was noticed that the letters which were most certain and of whose presence the subject is most confident were not on the slide; but were added, subjectively." (Pillsbury, 1897, p. 362). Studies of experienced proofreaders (Crosland, 1924) show similar results for words in context when meaning is observed.

Word familiarity has been repeatedly shown to have an influence on recognition. Vernon (1931) reported that unfamiliar words were misread more often in tachistoscopic presentations than familiar words.[12] More recently, the frequency effect has been demonstrated by Howes and Solomon (1951) and Solomon and Howes (1951).

The influence of context upon word recognition can be seen both in experimental data and in observations of reading errors. Tulving and Gold (1963) found that words which fit a previously exposed context were recognized significantly faster than words which did not, and both Swanson (1937, p. 47) and Fairbanks (1937, p. 93-94), in studies of oral reading errors made by adults, noted that the errors made by the better readers seldom changed the meaning of what was being read. The poor readers not only frequently changed the meaning of a passage through misreading, but also recognized their errors less frequently than the better readers, as evidenced by self-correction (or lack thereof).[13]

Processing Model

As a synthesis of the data just described, the following sketch for a processing model for reading is offered.

A linear segment of text, stretching considerably farther to the right (for English) than to the left is placed in an input register which has a rapid decay time. Scanning begins from the left and continues until either all words are identified or the image completely decays. Then, using partially identified segments in the right marginal field, plus data based upon the complexity of the material being read, a jump is made to another fixation point. During scanning, words are recognized as whole units and integrated as soon as possible into syntactic/semantic structures. Hypotheses are constantly being generated for what words should come next and constantly being tested.[14] For most words, recognition begins with partial knowledge gained from the previous fixation plus hypotheses formed from syntactic/semantic information. Recognition proceeds with identification of dominant or determining letters, based upon the hypotheses generated, and stops when a hypothesis has been supported to the satisfaction of the reader. Through this process, details of highly predictable words are observed considerably less than those of less predictable words, and therefore substitution errors tend both to fit the syntactic/semantic context and to bear a physical similarity to the stimulus items they replace. A high degree of parallel processing is assumed, in the sense that while primitive read-out or scanning of fixated words is occurring, already recognized words are being integrated into syntactic/semantic structures and new hypotheses of what may occur next are being generated. Reading speed for clearly discernible text will vary according to a complex interrelation of (a) absolute predictability of words and phrases, (b) ability of the reader to predict which words and phrases will occur, which will itself depend on at least I.Q., concentration, and familiarity with the content of the material being read, and (c) the amount and type of material which the reader is attempting to retain. Accurate recognition on the basis of visual features alone would probably limit reading speed to considerably less than 700 words/minute. However, by using contextual cues and by accepting a lower criterion level for identification, considerably higher maximum speeds can be obtained. Further increases in speed will result from reducing the level of visual recognition from complete recognition to a point where a set of possible identifications, manageable in terms of immediate memory, results. This set is retained in memory for two or three words forward, so that, by considering allowable sequences within strings of such sets (under the assumption that the text is meaningful), a greater portion of recognition can be done by cognitive processing, which we assume is fast relative to visual processing.

III
Development of Reading Ability

Skills of the Prereader

Understanding the Task

Some children enter reading instruction with a well-formed concept of what reading is all about; they recognize many of the letters by names, know a few words by sight, and may attempt to sound out sentences. These children will learn to read under almost any teaching method, even one centered upon the local telephone directory. But most children in this world do not enter the reading situation so well prepared. More often than not they are unaware of either the purpose or the nature of reading; they do not know that letters represent sounds, and that these sounds can be blended into words and words into meaningful sentences. Reid (1966, p. 60), who interviewed children during their first year of reading instruction in Scotland, writes:

> ...reading, prior to the experience, is a mysterious activity to which they (the children) come with only the vaguest of expectancies. In some cases the children... were not even clear whether one "read" the pictures or the other "marks" on the paper.[15]

In short, some children come to their first year of reading instruction ready to learn to read, but most do not. Those who do have been instructed already, either formally or informally, in identifying letters and in the process and value of reading. It should be no surprise, therefore, that the best single predictor at the end of kindergarten or at the beginning of first grade of later reading success is letter-name knowledge. The child who can name many of the letters has a high probability of succeeding, but the child who can name only a few may have difficulties.[16] Whether this is solely a function of the amount of instruction the child receives before he enters school, or is a complex of prior experience and mental development, remains to be investigated.

Language Skills

Although children come to the reading task with differing experiences and expectations, almost all can use language to communicate with adults and with peers. Articulation errors, though still occurring at the age of six, particularly for English fricatives, result mostly from slow motor development and are not direct indicators of reading problems. Phonemic discrimination is also well-developed at the first grade level, as adequate testing will reveal even for those children so cavalierly classed as "verbally deprived."[17] Morphology, syntax, and vocabulary continue to develop beyond this level, yet all three are sufficiently developed here to allow the child to express his immediate needs and impressions.[18] Reading problems related to morphology, syntax, and vocabulary may result, however, from the failure of reading texts to reflect accurately the level of development of each of these skills at various ages.[19]

The child's ability to use language for communication presents mostly tactical problems for the teaching of reading—selection of appropriate language forms and designation of which words must be taught orally before instruction begins. But the child's ability, or lack thereof,

to treat language analytically is a far more serious concern and has been identified as a crucial reading variable in a number of different cultures. At some point in almost all reading programs, sounds are treated as individual units which the child must manipulate, as in rhyming, matching of words by initial or final sounds, or by attaching sounds to letters and blending them into words. These tasks are, for reasons that are still not understood, difficult for many children at the kindergarten and first grade levels. Zhurova (1963) reports that Russian children still have trouble at the age of seven in isolating the initial sound of a word, especially if the sound is a stop. Bruce (1964) tested British children on their abilities to remove a medial sound from a word to produce a second word (e.g., eliminating /t/ from stand to give sand) and found that below the age of seven they could not learn the task. Schenk-Danzinger (1967) reports similar results in Austria as do Calfee, Chapman, and Venezky (in press) in the United States.[20] Once children learn to represent sounds with letters, these difficulties seem to disappear, but so far little success has been reported in training them in prereaders.[21]

Perceptual and Cognitive Skills

For the average child the perceptual and cognitive demands of initial reading instruction, aside from sound-abstraction, are not excessive. At the kindergarten level children can match letters of the alphabet, although left-right reversals for single letters (e.g., confusing lower case b and d) and order reversals for letter strings (e.g., confusing was and saw) are common. Letter and word reversals may continue through first and even second grade, but are not considered to be a serious problem for reading. Most other skills required for learning initial reading—scanning left-to-right, following simple instructions, etc.—appear to be available by the end of kindergarten, even in children from lower socioeconomic environments. Some skill deficits, however, such as those associated with sound manipulation and word identification, appear to be more drastic in the lower socioeconomic children. (Cognitive functions like the use of context for generating word recognition hypotheses are important for the advanced stages of reading and were discussed under Perceptual Processing.)

Patterns of Skill Deficits

Given that many children enter formal education with deficits in skills which relate to reading, the next question which requires answering concerns the distribution of these deficits. If children who are weak in any one skill tend to be weak in all other skills, a single prereading or remedial reading program might be appropriate. If, on the other hand, one skill deficit could not be predicted from another with a high degree of accuracy, then individual instruction would be required to meet the varying patterns of skill deficits present in any class. One insight into this problem can be gained from a study recently completed at the University of Wisconsin (Chapman, in press). Tests for attention to letter orientation, letter order, letter detail, and for sound matching and sound blending were administered to 138 middle-class kindergarten children in February/of 1971. The distribution of mastery scores is shown in Table 1, where mastery has been defined as better than 90% correct; learning groups (fast, medium, slow) were defined on the basis of scores on a picture-sound association test.[22] Only six children showed mastery of all five tests, yet only 42 of the 138 children failed all tests. The distribution of specific deficits varies widely across children. There is no well-defined upper group which mastered all the tests and there is a relatively small group, composed of about 30% of the children, who failed all the tests. The implications of these results (assuming that the tests are valid) are that if prereading skill deficits are to be overcome through instructional programs, then a high degree of individualization is required. Programs which treat an entire class as a unit, such as most of the so-called reading readiness programs now in use, may allow each child to make marginal, across-the-board gains, but fail to give the concentrated practice each child needs in his specific weaknesses. This may be an explanation for why reading success can be predicted so accurately from kindergarten tests—regardless of the intervening instruction.

Table 1

Number of Basic Prereading Skills Mastered by Fast, Medium, and Slow Learners

No. of Tests Mastered	Picture-Sound Association Learning Rate			All Ss
	Fast	Medium	Slow	
None	3	25	14	42
One Only	5	15	4	24
Two Only	2	19	5	26
Three Only	12	14	4	30
Four Only	5	4	1	10
All Five	4	2	0	6
Total	31	79	28	138

Stages of Reading

The child's initial attempts at reading involve multiple fixations on each word, frequent regressive movements of the eyes, and a painfully slow response time for recognizing words or assigning sounds to letters. Oral reading errors are frequent; yet surprisingly, substitution errors by both good and poor readers most generally preserve meaningfulness although not always the meaning that would occur with the correct response (Weber, 1970). According to Biemiller (1968), the error responses of beginning readers progress through three phases: an early phase, characterized by a predominance of context-errors (errors which fit the context, but show little graphic similarity to the stimulus word); a middle phase, characterized by a predominance of nonresponse errors; and a final phase, characterized by context errors on easy words and nonresponse or graphically similar substitutions on more difficult words.

By the end of first grade the average American child reads orally at a rate of about 45 words per minute (Durrell 1940, p. 143) and makes somewhere between 15 and 16 fixations in silent reading for a 3.5-inch line (about one fixation for each pair of letters) with about four regressive movements per line (Buswell, 1922).

By the end of second grade, the better readers know all of the invariant letter-sound correspondences and most of the major variant ones (e.g., long and short pronunciations of a, e, i, o, and u), although their performances vary widely according to pattern (see next section). In addition, most children by this level can sound out one- and two-syllable words that they have never seen before.

By fourth grade, silent reading speed has overtaken oral reading speed (Durrell, 1940, p. 143), reading comprehension has overtaken listening comprehension for average difficulty material (Durrell, 1969), the perceptual processes used in scanning and fixation have made their most important development (Buswell, 1922), and some of the variable letter-sound patterns (for English) have been learned about as well as they ever will be (Calfee, Venezky, & Chapman 1969). While there is continual improvement, at least through the eighth grade, for all of these skills, this latter increase is nowhere as dramatic as the one between first and fourth grade.

Development of Letter-Sound Generalizations

Importance

Letter-sound generalizations are important for learning to read alphabetic or syllabic writing systems, although their use does not by itself guarantee competent reading behavior. Their primary function is to facilitate the development of word recognition ability, which they do by providing a means for (a) checking the identification of a word previously encountered, but still not known well enough to be identified with high confidence from its visual features or from context, and (b) generating the pronunciation of words not encountered before in print, but which may be in the reader's listening vocabulary. For either of these aids, perfectly predictable correspondences are not necessary because in both situations the reader has other cues to work with; the pronunciation of the printed form must only approximate the actual pronunciation in most circumstances for the appropriate match to be made. For example, in the sentence "The cowboy ran the horse into the street," the word ran may, if not recognized correctly by sight or context, be pronounced /ren/ initially, but if the reader is aware of the preceding context (and speaks a standard brand of English), he will probably recognize that this is not the correct form and try another pronunciation. Observations of children in oral reading show exactly this process at work.[23] Without the ability to approximate sound from spelling the child would be dependent upon other readers for substantiating his word identifications and consequently would develop this ability quite slowly.[24]

The reliance on letter-sound generalizations in word recognition slowly decreases as word identification ability increases, and the competent reader probably makes little use of them in normal reading. Nevertheless, the ability to apply letter-sound generalizations continues to develop at least through eighth grade. Whether this is due to a continual reliance upon sounding out words or is a result of increasingly more efficient memory organization and retrieval is not known. But since the use of letter-sound generalizations appears to depend heavily upon examples stored in memory, organization and retrieval probably account for a significant part of this development.

Acquisition of Specific Patterns

The acquisition of specific letter-sound patterns has been studied recently by Calfee, Venezky, and Chapman (1969), Johnson (1970), and Venezky, Chapman, and Calfee (in press). In the first study ever reported on the development of letter-sound correspondences, Calfee, Venezky, and Chapman (1969) compared responses to synthetic ("nonsense") words of second, fourth, sixth, and eighth graders, high school juniors, and college undergraduates. Major differences were noted between the long-short vowel patterns and the c patterns, in that the c patterns showed a strong response bias for the /k/ pronunciation well into high school. Good readers and poor readers differed both in their overall response accuracy and in the relative percentages of wild (that is, nonoccurring) responses which each group gave in situations where the correct response was not given. On both measures, the better readers performed best.

Johnson (1970) compared first, second, and third graders' responses to digraph vowels, using synthetic words as stimulus items. By the end of first grade most children in this study were capable of generating plausible responses to synthetic words from their spellings. (For digraph vowel spellings in which the type counts predicted widely different pronunciation rankings from the token counts, the responses obtained tended to agree with the type count predictions.)

Venezky, Chapman, and Calfee (in press) extended the earlier Calfee, Venezky, and Chapman (1969) study to a larger subject population and to a more extensive testing of each pattern. The more important results of this study are summarized below.

C patterns. The different pronunciations for the letter c are among the most predictable in English orthography, yet in spite of this predictability appropriate transfer of the c pattern to new words develops slowly through the elementary grades and seldom approaches the theoretical level of predictability.

The correct responses for c in

initial and medial position before a, o, u and in final position are well learned by sixth grade (91.6%, 85.6%, and 82.1%, respectively), but the responses to initial and medial c before e, i, and y are correct in only 58.9 and 63.7%, respectively, of their occurrences. Initial c before a, o, and u shows the highest percentage of correct responses, progressing from about 82% in second grade to almost 92% by sixth grade Initial c before i, e, and y, on the other hand, shows the lowest percentage of correct responses, advancing from about 22% in second grade to 59% in sixth grade

Additional information on response strategies is revealed by the figures for correct plus plausible responses for the two categories of initial c (Table 2—plausible pronunciations are those that occur in other environments for the same letter). That these percentages are quite high, and are nearly identical for a, o, u and e, i, y even in Grade 2 where there is a significant difference between correct responses for the two patterns, indicates that the range of plausible responses for c is learned early, but that the/k/ pronunciation is so dominant that it persists for c before e, i, and y past the fourth grade. If the subjects were attempting to apply the appropriate rule, we would expect a greater similarity between the correct response totals for the two patterns. Instead, it appears that a single response, /k/, is available for all occurrences of initial c, and only slowly does it give way to /s/ for c before e, i, and y. A possible reason for this response bias is that words with c before e, i, and y are rarely introduced in reading lessons until after the time when emphasis is given to letters and sounds. In part this results from the distribution of c pronunciations in the English vocabulary; among the more common words, only the following have initial c before e, i, or y and most of these, by tradition, are proscribed from readers before the fourth grade: cider, cinder, circle, citizen, city, civil, cease, ceiling, celery, cell, cellar, cent, center, certain, cycle.

The data for medial and final c are similar to those for initial c. Percentages of /k/ responses to medial c before a, o, and u and to final c are almost identical. And similar to the initial position responses, correct-plus-plausible percentages for the two different medial patterns are both close to 100% and nearly identical. Responses for medial and final position also show the gradual influence of an increasing reading vocabulary as opposed to the acquisition of overtly stated rules.

Table 2[a]

Percentage of Correct and Plausible Responses to c Patterns

Position	2	4	6
Initial			
before a,o,u	89.9	90.9	95.3
before i,e,y	87.9	92.0	95.8
Medial			
before a,o,u	76.5	89.1	95.9
before i,e,y	77.6	90.9	95.8
Final	82.1	87.8	92.8

[a]Differences between means within a grade which exceed 1.1 are statistically significant (t test, $p < .005$); differences between means across grades which exceed 7.3 are statistically significant (t test, $p < .005$).

Equal in significance to the overall responses are the individual responses to c before e, i, and y for each class quartile, shown in Figure 1.[25] What is most important is that while the top quartile continues to give more correct responses than the other quartiles, all four curves show the same general upward trend, indicating that the differences between the upper and lower quartiles (that is, between the best and poorest readers) is quantitative rather than qualitative; the poorer readers are continuing to acquire the correct responses.

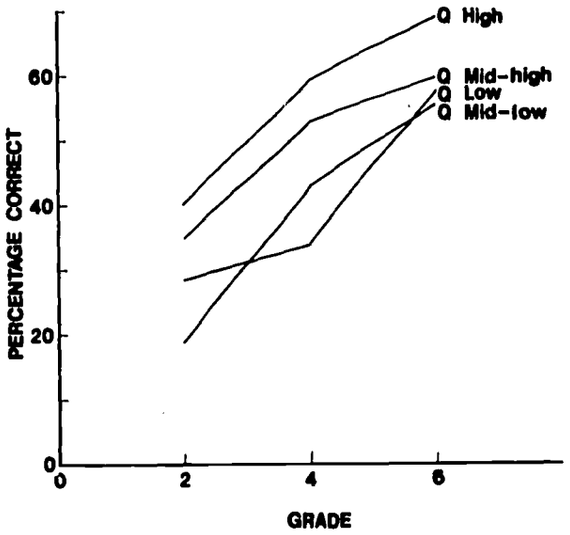

Figure 1. Responses to initial and medial c before e, i, and y.

G patterns. The g patterns are theoretically quite close to the c patterns, in that both behave differently before high and mid front vowels than they do in any other environment. However, in initial position the exceptions to the g pattern among common words outnumber the examples and include such forms as get, gift, girl, and give. For medial position, the exceptions are restricted to -ger forms (anger, finger, tiger, etc.) plus a few miscellaneous items (e.g., begin, target, bogey).

In responses to synthetic words, /ǰ/ pronunciations before i and e, even at a college level, are relatively infrequent in initial position and exceed 50% for medial position only at the college level. The percentages correct when /g/ is the correct response are nearly identical to the corresponding c responses when /k/ is correct, all showing a high percentage of correct responses by the end of sixth grade.

The low number of correct responses through college for g before e and i, particularly in initial position, suggests that examples are more influential than verbalization of rules for g pronunciations. For initial position, the only common words with g pronounced /ǰ/ are gem, general, germ, giant, and ginger. Less common are generate, genius, genuine, geography, geometry, gin, giraffe, and gist.

The exceptions, as mentioned above, make a formidable list: gear, geese, geld, get, geyser, giddy, gift, gig, giggle, gild, gilt, gill, gimlet, gird, girdle, girl, girth, give, gizzard. If a generalization for g before e or i is to be taught, then a suitable pool of examples will be required, but these can not be introduced under present attitudes towards grade-level vocabulary until the higher primary grades, and at these levels letter-sound generalizations are rarely stressed. Even under ideal circumstances, it is not clear that this generalization merits any attention. From the child's standpoint, it may be easier to handle a list of exceptions to g-/g/ than to have a complex rule with an equally long list of exceptions.

Checked and free vowel patterns. The percentages of correct and correct-plus-plausible responses for the free and check vowel patterns are shown in Table 3.

The free/checked patterns show their steepest improvements between second and fourth grades but continue to improve through the sixth grade. The improvement from grade to grade by quartiles is similar to that shown for c before e, i, and y, with lower quartiles continuing to improve through Grade 6. The lack of an appreciable difference between correct responses for free and checked vowels is surprising, in that the checked vowel patterns are usually introduced first in the reading program. Of special interest is the contrast between the development of these patterns and the c ones. In both instances there are two major pronunciations which can be predicted on the basis of following graphemes. Furthermore, in both instances one pronunciation is usually introduced first in the teaching of reading and learned to some criterion before the second pronunciation is exposed. Yet

Table 3[a]

Percentage of Correct Responses to
Free and Checked Vowel Patterns

Patterns	Grade 2	4	6
-VCe			
Correct	49.2	67.5	74.2
Correct and Plausible	75.5	86.2	89.9
-VC#			
Correct	62.0	75.0	78.0
Correct and Plausible	75.0	86.0	89.3

[a]Differences between means within a grade which exceed 1.1 are statistically significant (t test, p < .005); differences between means across grades which exceed 7.3 are statistically significant (t test, p <.005).

there are major differences in the development of the correct pronunciations. For c, there is a strong bias towards the pronunciation introduced first (/k/), yielding a high percentage of corrent responses in second grade for c before a, o, and u, but a low percentage of correct responses at the same level when e, i, or y follows. The most significant improvement in the c pronunciations involves a gain in /s/ at the expense of /k/; the percentage of correct-plus-plausible responses showing little gain.

For the checked and free vowels, on the other hand, there are gains in both correct responses and in combined correct-plus-plausible responses for the two different categories. Not just the appropriate responses for each pattern, but also the range of plausible responses are learned over this period. There is no tendency at the second grade level to assign one pronunciation to both the checked and free environments of each letter. Furthermore, at all grade levels there are more correct responses to the free/checked patterns than there are to c before e, i, and y.

The differences between these patterns are probably due to the relatively early introduction of the free pronunciations of the vowels as opposed to the /s/ pronunciation of c, plus the relatively large number of words available for demonstrating both checked and free pronunciations. It appears from these data that if predictable variant pronunciations exist for a spelling unit, they must be introduced early in the reading instruction and illustrated with numerous examples. Exactly what "early"

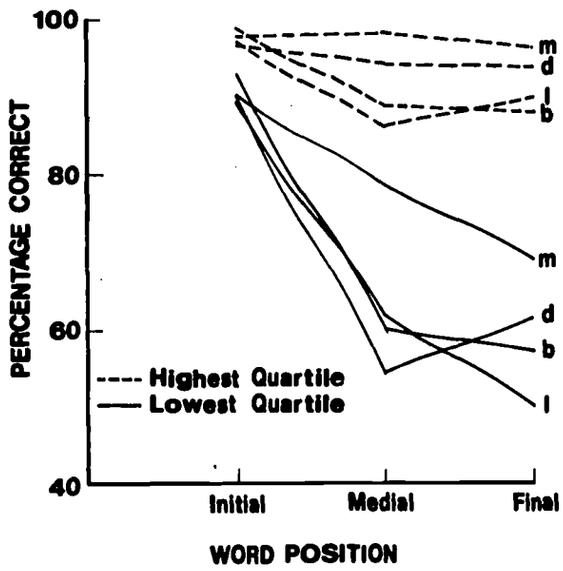

Figure 2. Responses to invariant consonants at the end of Grade 2.

means can not be determined precisely from these data; certainly before fourth grade, and probably before third grade. Whether or not the variant pronunciations should be introduced simultaneously as suggested by Levin and Watson (1963) and others needs to be determined experimentally.

Invariant consonants. One of the most important distinctions between good and poor readers at the second and fourth grade levels is their responses to invariant consonant spellings. Shown in Figure 2 are percentage correct responses for the lowest (QL) and highest (QH) quartiles to the spelling b, d, l, and m, taken from Venezky, Chapman, and Calfee (in press).

For initial position the lowest quartile is only slightly lower than the highest quartile in percentage of correct responses, but for medial and final positions the differences in performance are large, with the lowest group showing a marked degeneration. That the responses for the lowest quartile for initial position are consistently in the 90% range shows that the letter-sound correspondences have been learned. What appears to be lacking is a concern for word details beyond the beginning of the word, a phenomenon also reported by Marchbanks and Levin (1956) for word recognition by kindergarten and first grade children and by Bennett (1942) for oral reading errors of poor readers in the third, fourth, and fifth grades. Although this is not the only problem that poor readers exhibit, it is frequently reported not only for learning to read English, but also for Hebrew, where inflectional suffixes are extremely important. Whatever the source of the problem—lack of appreciation of detail, low criterion level for identification, impulsivity, etc.—training procedures for overcoming it are needed before certain letter-sound relationships can be learned.

Sound Blending

Introduction

In pronouncing aloud a printed word which is visually unfamiliar, a beginning reader can either be observed engaging in the following processes or can by logical analysis be assumed to engage in them.

1. Sounds are assigned to letters or letter strings.
2. Some or all of the sounds resulting from step 1 are blended to form a phonologically continuous unit.
3. The new, continuous unit is compared, either in memory or through subvocal or audible speech, to similar units, yielding either
   a. a satisfactory identification of the word, or
   b. a decision that the new unit is not the same as anything retrievable from memory, but is nevertheless an acceptable pronunciation for the spelling, or
   c. a decision that an incorrect pronunciation has been generated.

The consequence of steps 3a and 3b is an overt pronunciation, the consequence of 3c might be a recycling of steps 1-3 or steps 2-3 until either 3a or 3b occurs, or the reader gives up. (Giving up may result in no response or in a pronunciation which the reader assumes to be incorrect.) With beginning readers, the first two steps can often be observed by monitoring the whispering which frequently occurs when they attempt to pronounce aloud unfamiliar spellings. The third step, in one form or another, is deduced from the trial and error procedure that the same whispering reveals.

Information on the first step—the assignment of sounds to letters—was discussed in the previous section. Of the two remaining steps, the second—blending—is the least understood. A small amount of work, however, has been done on testing for blending ability and in isolating factors which influence blending ability.

Testing

The Roswell-Chall Auditory Blending Test (1963) which is typical of most of the more commonly used blending tests, assays blending ability with 30 monosyllabic real words which an experimenter pronounces slowly for a child; the child is to respond

with each correct word (e.g., a-t: at; d-esk: desk; ch-ain: chain). A score of 7 or better at the first grade level or 11 or better at the second grade level indicates adequate blending. A positive relationship between test results and silent reading ability is reported (Chall, Roswell & Blumenthal, 1963). According to Desberg (1969a) the test was developed on a sample population of 62 Negro children in two first grade classes in New York City. The artificiality of the task is no doubt the cause of the low criterion level; letter-sound tests by Calfee, Venezky, and Chapman (1969) and by Johnson (1970) show that first and second grade children—even poorer readers—can blend when confronted with synthetic spellings which they are to pronounce. (In short, "no response" was rare in these situations, even from first graders tested in the spring, and responses consisting of separate sounds did not occur.) In the reading task, the child generates his own sounds to blend, and has the stimulus for these sounds in front of him at all times, so that memory for the sounds does not become a significant variable, as it is in the Roswell-Chall test.

Balmuth (1966) developed a similar test, using 30 nonsense syllables which contained from one to five pauses when presented orally by an experimenter. Like Roswell-Chall, Balmuth found a positive relationship between her task and silent reading achievement, but in addition compiled various rank orderings for factors which affected blendability.

Experimentation

The most productive work on blending has been done by Laumbach (1968), with a replication by Coleman (1970). Both Laumbach and Coleman orally presented long lists of CV and VC syllables to kindergarten age children in a task identical to the Roswell-Chall test procedure. The two most significant results were (a) that after several hundred presentations (in multiple sessions), mean correct for the test population rose above 80%, indicating that a concept (or strategy) had been induced, and (b) that VC was easier to blend than CV. Although this brute force approach leaves much to be desired as an instructional procedure, it does indicate that whatever concept is required for mastering this task (and therefore the Roswell-Chall and Balmuth task), it is acquirable at the kindergarten level. (Since no stimulus was presented more than once, paired associate learning is ruled out.) Both Laumbach and Coleman also produced rank orderings of various phonological features which affected blendability.

Desberg (1969b) found that the intersound interval used by the experimenter was not a significant variable, but speculated that auditory discrimination of the separate sounds was. (Desberg [1969a] reviews the major studies of blending, including some not included here.)

Speculations on the Blending Process

None of the studies just cited reveals what processes compose blending, although the Laumbach and the Coleman results rule out a pure matching strategy; this means that either the sounds are fused, or the subject generates a new unit which he compares sound-by-sound with the stimuli. In its most pristine form, the fusion process implies a mechanical joining, with appropriate interfacing, of the stimulus sounds to produce a response. But the means for achieving this are cloudy at best. Once the individual sounds are identified, we assume that their acoustical representations are discarded for a more economical form of storage, whatever that is. Therefore, mechanical blending is impossible if it is to be based on the input signals. This does not eliminate the possibility that the internal representations of the individual sounds are sent to the articulatory mechanism—and that the fusion takes place in this output stage. But this begs the question, since we have no explanation for how a fused unit emerges from independent units, given that the independent units can be articulated separately, and that the articulatory instructions for some fused forms are significantly different from those for the independent units which form them. That is, even if the separate units could be articulated with zero pause between them, the result would not always be a fused unit. The reservation here is for blending of syllables and for blending of V + C (or V + C-cluster), where mechanical fusing may be possible. For syllable blending, rapid articulation of the separate syllables will produce a word, although the stress

patterns may be slightly unnatural. This form of blending is distinct from blending single sounds in that anticipation of the following unit is not required during articulation of a syllable. This conclusion was one of the results obtained by Brown (n.d.) who tested preschool children on blending various types of phonological units.

Sound blending involves anticipatory articulation, that is, left-to-right articulation of the stimulus sounds, each sound being articulated with the anticipation of the sound to follow it. The complete process requires (a) memory for the sounds to be articulated, (b) the concept of a continuous speech act, yielding a word or word-like form, and (c) anticipatory articulation. By the time that the child is encouraged to produce pronunciations from spellings, he has already acquired the concept that printed words can be translated into spoken words, and has usually acquired the ability to recognize a handful or more of printed words by sight. Furthermore, studies of oral reading errors at the beginning of reading instruction show that children rarely produce nonwords when making substitution errors. Instead, the substitution generally is conditioned more by the sentence context than it is by the word spelling (Biemiller, 1968; Weber, 1970). Whatever trouble children may have in verbalizing what a word is, they show little confusion in generating words at the appropriate time in the actual reading task. Hence, the concept of continuous articulation to produce a recognizable word is formed early in reading instruction; what remains for blending is to ensure its application to pronunciation from spelling.

In the auditory stimulus situation, there are no previously trained props to evoke word responses. Therefore, the child must learn what is desired as output from him, and then learn how to generate it from the sounds he hears—assuming that the sounds can be retained in memory long enough to be used. Instruction in blending, therefore, should concentrate on three factors:

1. Reducing the memory load (for auditory stimuli),
2. Preparing the child to give a continuous unit as a response, rather than a sequence of discrete sounds,
3. Teaching the strategy of continuous, anticipatory articulation.

The first factor can be satisfied by using visual stimuli to which the children have already assigned sounds, or at least in part by having the sounds repeated one or more times before they are blended. Factor 2 might be satisfied by preliminary exercises in which the child selects pictures in response to sound sequences. Factor 3 is nothing more than the process used for articulating words, raised to an operational level. The basic strategy to be used by the child is to say a word made up of the sounds which an experimenter offers—retaining the temporal positions of the sounds. It is doubtful, however, that this needs to be taught.

In short, most of the difficulty that children have in blending tests is a function of the test procedure, and not of blending deficits per se; blending in a reading task differs markedly from the typical blending test paradigm.

IV
Teaching to Read

Correspondences vs. Whole Words

Almost all modern methods for teaching reading include letter-sound learning somewhere in the teaching sequence, although the amount and exact placement of this training accounts for the central disagreement between methods. Phonics or linguistics programs tend to initiate the teaching procedure with emphasis on letters and sounds, while global or synthetic-analytic methods tend to begin with whole words or phrases, which only at a later stage are analyzed into syllables and unit sounds.

The basic tenet of the phonics school is that since letter-sound relationships are needed in reading, they should be taught from the beginning of reading instruction. The counter argument is not that letter-sound correspondences are unnecessary, but that the beginning reader has difficulty in dealing with such abstractions, and that more efficient learning is achieved by beginning with whole words.

Nonsystematic procedures such as those that Bloomfield inveighed against in the 1940's are no longer in the majority. Hence the differences between methods have become more and more reduced to differences in the sequencing of learning as opposed to differences in goals or basic philosophy. On one hand, this allows more rigorous comparisons of methods, since the desired outcomes of training are nearly identical, but on the other hand a more exacting criterion has emerged, in that the comparison of any letter-sound method with any whole-word method is no longer valid (if it ever was). One must find the optimal teaching sequence based upon letters and sounds, and compare this in terms of desired outcomes with the optimal teaching sequence based upon whole-words. From a practical standpoint, this requires that comparisons be made within common approaches before comparisons can be made across methods. Otherwise, one may compare the worst of procedure A with the best of procedure B. This may have some interest within itself, but its application to the teaching of reading is questionable.

Teaching Letter-Sound Patterns

For a child to give the appropriate responses to any of the letter-sound patterns described above, he must at a minimum have learned to recognize letters, store and retrieve sounds, associate the appropriate sound with each letter, and blend sounds into words. The first task has been shown by Olson (1958) and Calfee, Chapman, and Venezky (in press) to be easily accomplished by kindergarten children. The remaining three tasks, however, have not been adequately examined. In general, it has been observed that when kindergarten children are required to learn oral responses for visual stimuli, no difficulty is encountered for small stimulus sets as long as the responses are familiar to the child (Muehl, 1962). That is, a kindergarten child can learn to respond "dog, tree, house," etc. to geometric forms or to letter strings, indicating that the task of associating a familiar response with either a familiar or unfamiliar stimulus is not the central problem in learning letter-sound correspondences. But the same task with meaningless individual sounds or with meaningless syllables is quite difficult for most kindergarten children (Calfee, Chapman, & Venezky, in press). That the difficulty is not in the child's ability to produce the required responses can be seen from tasks which require children to

imitate pronunciations of meaningless sounds (Zhurova, 1963; McNeill & Stone, 1965; Marsh & Sherman, 1970). The difficulty, therefore, appears to be in the storage and retrieval of the sound.

It is speculated further that the core of the problem is in memory organization and retrieval—the ability to arrange the sounds by themselves in memory and to retrieve them at the proper time. This speculation is based upon two observations: first, that young children seem to learn fairly easily to recall certain meaningless sounds, in particular those that represent noises made by animals or objects (e.g., the hoot of an owl, the hiss of a radiator); and second, in the teaching of sounds for letters, considerable success is reported when proper mediation is provided.[26]

But even if it can be shown that certain forms of mediation lead to rapid acquisition of letter-sound associations, this can not be accepted as proof that such associations should be the basis of early reading instruction. Aside from examining sound-blending, which is required for pronouncing all words of more than one letter, it would remain to be shown that this teaching procedure was more efficient for letter-sound learning and later word recognition than various other commonly employed procedures, especially those that begin with whole word identification and then proceed to letter-sound generalizations. Attempts to compare training methods on adults (Bishop, 1964) and on children (Jeffrey & Samuels, 1967) have been limited, so far, to short training sessions with limited and highly artificial reading situations; the relationship of studies of this design to learning to read is tenuous at best.

Research Methodology

The experimental approach to questions of reading methodology has generally involved experiments with small numbers of children (20 to 60 or so) who are paced individually through a few training and testing sessions with small lists of letters, words, syllables, or correspondences. Yet the results of these studies are offered, albeit with caveat emptor inoculations, as evidence for how children in groups should engage in sustained learning over a school year or more, absorbing not four or eight items, but many hundreds or thousands. Success and failure in a half-hour laboratory session may not be isomorphic to success and failure in the on-going classroom.

On the other hand, experiments done over long periods in the classroom are difficult to control to the same degree assumed necessary for the laboratory, are expensive, and require continual preparation and monitoring tasks which few experimenters who are not working full-time on research are willing to undertake. What appears to be needed is a re-evaluation of the methodology of reading investigation. The relative values of the experimental procedures now in vogue may need recalculating, and different forms of classroom experimentation may need to be introduced. There does not appear to be any escape from using the classroom to test many of the important phases of reading methodology, but this should not imply that the only legitimate classroom procedure is to dump different reading programs into similar classrooms and compare the final products. Over 70 years of such tests have contributed little to anything except the national debt.

A more valid procedure might be to work with existing (or new) programs, altering small, discrete segments of the materials and methods, and measuring marginal gains. In this way critical components—that is, components that show the greatest sensitivity to differing procedures—could be isolated and methods perfected to the point that overall comparisons could be made, if any need exists for them. This will be a lengthy procedure, devoid of the instant solutions offered by the neatly controlled laboratory study, but the relevance of significant results will have been established in situ rather than by postexperimental speculation. Piaget (1970, p. 21) has recommended something similar in attempting to revive Claparede's (1911) "experimental pedagogy," which he distinguishes from psychology thusly:

> Experimental pedagogy is concerned, in practice, solely with the development and the results of pedagogic processes proper, which does not mean... that psychology does not constitute a necessary reference for it, but that the problems posed are different from those of psychology, and that they are

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concerned less with the general and spontaneous characteristics of the child and its intelligence than with their modification by the process in question.

Piaget's suggestions for applying experimental pedagogy to reading tend, however, towards the Method A vs. Method B approach, albeit with more tightly controlled designs than are commonly employed. Nevertheless, experimental pedagogy, distinguished from psychology by its emphasis on modification of intelligence and other characteristics of the child over time, is an adequate cover for the development of new approaches to reading research.

V
Conclusions

From a logical standpoint, both reading and learning to read are complex processes, each composed of a multiplicity of poorly understood subprocesses. Memory, language processing, word and letter recognition, letter-sound translation, sound-blending, visual scanning, and a variety of other tasks are all involved, yet none of these is well enough understood that its role in reading and reading acquisition can be assayed with certainty. The procedures employed by the competent reader, whatever they are, represent endpoints or objectives for the teaching of reading, but they translate no more readily into pedagogical procedures than do the pyramids into the techniques used to construct them. For both of these developments, the scaffolding that was so essential for construction is no longer visible in the final product. Letter-sound generalizations, for example, appear to be essential for acquiring word recognition ability, but are infrequently used by experienced readers.

The initial barriers to learning to read center primarily upon functions in the auditory domain, viz. recall, blending, and replacement of speech sounds; for more advanced reading, the vagaries that enter into comprehension become the limiting factors.

From all of these uncertainties, there is some comfort to be derived for our humanistic souls from the observation that the average child has considerably less trouble in learning to read than psychologists and linguists do in defining reading.

Footnotes

1. The most scholarly treatments of the history of reading methodology are Mathews (1966) and Chapter 1 of Fries (1963). On the history of reading research, there is no single, comprehensive source. Anderson and Dearborn (1952) discuss many of the early studies as does Gray (1925). The most concise summary of both methodology and research was made by Barton (1963, p. 249):

   > It does appear...from an analysis of manuals, texts on reading instruction, introductions to readers, and similar advice to teachers over the last 150 years, that almost all of the issues raised in the last ten years were being raised long before there was any such thing as educational research.

2. Subvocal speech in reading was studied experimentally for the first time at the end of the nineteenth century, and extensively in recent years by Edfeldt (1960) and Hardyck and Petrinovich (1969). But neither the role of subvocal speech nor the nature of the subvocalizations themselves has been clarified. Subvocalizing may be no more than a mechanism for decreasing silent reading speech when perception or comprehension becomes difficult. On the other hand, it might aid in the comprehension of difficult materials by providing a phonological image for the reader to "listen to."
3. Justification for teaching practices has often been drawn from misinterpretations of the extrinsic validity of experimental studies. Cattell's studies of word and letter recognition (Cattell, 1885), in which perceiving was confounded with responding, were for many years the Sanctus for the whole-word approach, and the results of Erdmann and Dodge (1898), showing that word shape was a major cue for word recognition under an atypical reading situation, were extended without question to typical reading situations where they were no longer valid.
4. The difference in results from Buswell (1922), Ballantine (1951), and Gilbert (1959) are discussed by Anderson and Dearborn (1952) and Tinker (1965). In general, both Ballantine and Gilbert found more improvement between Grades 4 and 8 in the basic perceptual skills than did Buswell, but the differences were not large.
5. Buswell (1957) claims to have found in college students a high correlation (.63) between reading comprehension and span of attention as derived from eye movement records during silent reading. However, insufficient data are offered to allow a critical evaluation of this result. The data published in Buswell (1922) clearly do not show a high correlation for Grades 3 - 6.
6. Except for the fixation following a return sweep, all fixations may be in areas observed during the previous fixation.
7. Ruediger exposed single letters (u or n) to the left or right of the fixation point for 50 msec. However, under normal reading conditions a considerably more dense perceptual field exists.
8. Iconic storage is used here in the sense of Neisser (1967, pp. 15–35). The effects of backward masking in reading have been demonstrated by Gilbert (1959).
9. The t-ratio was significant at better than the .01 level.

10. Proofreading is primarily a fight against this conflict.
11. Stimulus cues in word perception are reviewed by Tinker (1965), Anderson and Dearborn (1952), and Vernon (1931).
12. Rebert (1932) reported a similar effect with numbers; familiar forms (e.g., 1776, 3.1416) were recognized in a single fixation, but unfamiliar ones required two or more fixations for recognition.
13. Weber (1968) reviews the literature on reading errors.
14. Neisser, Novick, and Lazar (1963) demonstrated that with extensive practice, scanning for multiple targets may not be any more difficult than scanning for a single target. The reader might attempt to test simultaneously several hypotheses about the identity of a single word, or, conceivably, several hypotheses about the identity of two adjacent words.
15. Similar results are reported by Weintraub and Denny (1965).
16. This result was reported in several independent studies: Wilson and Flemming (1938), high IQ status; de Hirsch, Jansky, and Langford (1966), average IQ children; and Durrell (1958), high IQ children.
17. Rudegeair and Kamil (1969), Berlin and Dill (1967), and Blank (1968) have all demonstrated that the standard phonemic discrimination test, upon which Deutsch (1964) and others have based their claims for inadequate phonemic discrimination in speakers of nonstandard English, is invalid as was used for these subjects. When adequate testing procedures are used, the deficits tend to disappear.
18. Reservations on this point have been expressed by Loban (1963) and Singer (1969).
19. The mismatch between the syntax of commonly used reading series and that of the children who are taught with them has been explored by Hatch (1969). Studies of children's vocabularies have shown large individual differences, even within the same cultural setting, but the standard vocabulary tests now in use—in particular, the picture vocabulary tests—may not be measuring the vocabulary variables most important for reading. In reading, children are infrequently called upon to identify a picture. Rather, they must recognize words which they use orally but do not recognize visually. Furthermore, it may be more important to learn how rapidly a child can acquire new vocabulary than it is to sample what he has already learned. It is considerably easier to teach children a reading vocabulary than it is to develop a reading program using only those words that the majority of any large group of first grade children recognize.
20. Schenk-Danzinger (1967, p. 61) reports:

> Maturity for assigning sound-meanings to letter-signs...does not develop before the age of 6 - 7. This faculty presupposes the first objectivity of language; the ability to analyze the written or spoken word.... Reading readiness for languages with correspondence of sound and sign can thus be defined as the stage when the child is able to isolate the sound (phoneme) and identify them with their corresponding signs. About 20% of first graders do not reach reading readiness.

21. McNeill and Stone (1965) had limited success in training children to distinguish /s/ from /m/ in real and synthetic words.
22. Letter-naming, which was also tested, has been omitted from this summary because it bears no direct logical relationship to learning to read.
23. Studies of children's reading errors (Weber, 1970) show that even the poorest readers at the first grade level make substitutions that are appropriate for the preceding context.
24. The only record of a person learning to read (for his first reading task) an alphabetic language without letter-sound generalizations was Tarzan, who learned to read English by himself in the jungle at a time when his language repertoire was limited to Ape, Snake, and a little Alligator and Elephant. The feat was due, according to Tarzan's creator, to "superior genetic endowment," a variable not since found to have such potency for reading. (Edgar Rice Burroughs, Tarzan of the Apes, 1910).
25. Quartile breaks are based upon scores received on standard reading and intelligence tests administered by the

different schools. In all instances, the closest approximation possible to a reading score was used.

26. Letter names; upon which the initial teaching of reading was based for almost 2,000 years, are poor mediators for English letter sounds. The name for h does not contain the sound it represents; that of w retains its descent from two u's, and that of y, neither its sound nor its origin. (According to the OED, the English name for y is "...of obscure origins.") The names for f, s, and x, and for the sonant symbols l, m, n, and r, are composed of a checked vowel followed by a consonant sound (or sounds). The remaining consonant names in English are open syllable names based upon the acrophonic principle. But al least seven letters (c, g, a, e, i, o, u) have names which do not contain the sound most commonly introduced first in reading programs.

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