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ABSTRACT

To design effective remedial phonics instruction, it is necessary to examine both learner characteristics and task requirements. The paper integrates research related to information processing and psycholinguistics to formulate questions which can be used to evaluate techniques and materials used with a learning disabled population. Information processing stages are described, including eye fixation, visual information storage, short term memory, and long term memory. Processing deficits which affect perceptual learning and interfere with coding in reading disabled students are noted. A critical survey of laboratory and field research related to initial reading acquisition indicates that attention needs to be paid to the following instructional principles: providing focus, teaching decoding strategies, limiting unit size, and giving sufficient practice. (Author)

RESEARCH INSTITUTE FOR THE STUDY OF LEARNING DISABILITIES
Teachers College, Columbia University

PHONICS INSTRUCTION FOR DISABLED LEARNERS: APPLYING THEORY TO METHOD

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The Research Institute is predicated on the assumption that many of the problems exhibited by learning disabled children arise because of difficulties they manifest in information-processing. The overall goals of the Institute are to investigate the nature of such information-processing difficulties and, on the basis of the findings of these investigations, to develop effective and efficient instruction for children with learning disabilities.

The Institute is composed of five independent task forces that focus on specific academic skill areas fundamental to the school curriculum: basic reading and spelling, reading comprehension, arithmetic, and study skills. All of the task forces are dedicated to the identification of specific disabilities in these skill areas and to the development of effective remedial instruction.

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Abstract

In order to design effective remedial phonics instruction, it is necessary to examine both learner characteristics and task requirements. This article integrates research related to information processing and psycholinguistics in order to formulate questions which can be used to evaluate techniques and materials used with a learning disabled population. A critical survey of laboratory and field research related to initial reading acquisition indicates that attention needs to be paid to the following instructional principles: providing focus, teaching decoding strategies, limiting unit size, and giving sufficient practice.

Phonics Instruction for Disabled Learners: Applying Theory to Method

It is generally accepted that children benefit from instruction in word attack during the initial stages of reading instruction. The ability to decode words allows the beginning reader to utilize regularities in language structure and to approach unfamiliar words in a systematic fashion. Decoding requires that the individual master auditory-visual linkages that can be applied to a large number of words.

Practitioners and researchers alike have noted that many children with poor reading achievement lack adequate decoding skills. In order to develop effective instruction for a reading disabled population, it is important to understand both the characteristics of the disabled learner and the requirements of the task at hand.

Defining the Reading Disabled Population

Based on a thorough review of existing statistical data and research evidence, The National Advisory Committee on Dyslexia and Related Reading Disorders (1969) concluded that 15% of children in school exhibit reading disorders. A large number of the children classified as reading failures are also termed learning disabled (LD). Although there are many definitions and conceptualizations of learning disabilities, there is general agreement that the LD child's failure to acquire academic skills is not due primarily emotional problems, intellectual limitations or sensory deficits.

The body of research literature which deals with characteristics of the LD population is extensive but often contradictory (Black, 1974).

However, it is possible to divide the studies into two broad categories: the neuropsychological and the underachievement perspectives (Bryant & McLoughlin, 1972).

The neuropsychological perspective focuses on perceptual, cognitive, and behavioral characteristics often associated with minimal brain dysfunction (Clements, 1966) or central processing disorders (Chalfant & Scheffelin, 1969). The underachievement perspective, on the other hand, stresses the child's lack of ability to function on specific academic tasks.

Many educators have grown disenchanted with the neuropsychological framework. Black (1973) and Mattis, French, and Rapin (1975) concluded that educational decisions cannot be based on a standard neurological diagnosis because reading deficits can be just as severe without the accompanying neurological "soft signs." Several researchers (e.g., Bateman, 1974; Chall, 1978; Ross, 1970) have concluded that there is a need to shift the focus of the field away from the child's deficiencies and towards the inadequacy of the educational environment. It is possible that future developments in neuropsychological assessment may become much more relevant for determining processing deficits related to learning problems.

In an attempt to develop an alternative more practical than the classical neurological model, clinical researchers have constructed categorical schemes to define the characteristics of the reading/learning disabled population within an educational framework. These category schemes often mirror the two basic instructional approaches to word

recognition: sight words (i.e., words are perceived as a visual gestalt) and decoded words (i.e., symbol-sound correspondences blended into words).

Children who exhibit sight word deficiencies are referred to as either visual dyslexics (Johnson & Myklebust, 1967) or dyseidetic dyslexics (Boder, 1973). These poor sight-word learners, however, appear to make up a very small percentage of the total population (Boder, 1973). Rather, a larger proportion of children classified as reading disabled are termed auditory or dysphonetic dyslexics (Johnson & Myklebust, 1967; Boder, 1973), because they exhibit deficiencies in basic decoding skills.

There is reason to assume that there is a substantial number of children who fail to achieve reading success by virtue of their poor decoding skills. It is likely that there are underlying processing deficiencies which contribute to difficulties in acquiring these skills. In order to develop intervention strategies which foster achievement in a disabled population, it is useful to consider both the processing capacities of the learner and the nature of the task demands.

Understanding the Learner: The Information Processing Perspective

These are numerous examples of information processing models of reading in the research literature (Gough, 1972; La Berge & Samuels, 1974; Mackworth, 1971; Smith, 1971). An information processing model assumes that the human mind processes information in stages, with each stage having its own boundaries and capacities (Bourne, Dominowski, & Loftus, 1979).

It is not uncommon to delineate two types of processing: "bottom-up" and "top-down" (Wildman & Kling, 1978-79). Wildman and Kling differentiate the two approaches in relationship to the degree of passivity ("bottom-up" processing begins with visual information and requires no anticipation by the reader) or activity ("top-down" processing requires anticipation and hypothesis generation) involved. While there is a great deal of support for the "top-down" position as a model for mature reading, it is likely that beginning readers also need to process orthographic symbols in a "bottom-up" fashion when they encounter unfamiliar words which do not contain easily identified letter groupings (Mason, 1977).

The description which follows traces the processing stages using a "bottom-up" format. It is important to be cognizant of the fact that a hierarchy of discrete stages, although helpful for understanding, may be somewhat artificial. Rumelhart (1977) hypothesized that word recognition results from simultaneous processing of information from the "bottom" (visual stimuli) and the "top" (cognitive expectancies based on context).

Stages Involved in Reading

Eye Fixation. The bottom step in the reading process begins with an eye fixation which ranges from 1/3 to 1/5 of a second (Taylor, Frackenpohl, & Pettee, 1960) and ends in a visual sweep referred to as a saccade. Although controversy exists over the nature of the processing (Brewer, 1972), it appears that individuals have the capacity to process at least one letter every 10-15 msecs. (Sperling, 1970). The beginning reader has to learn to deal with these "successive, restricted glimpses

of the word that he obtains about four times a second through his small area of foveal vision" (Hochberg, 1970, p. 221).

Visual Information Storage. Through a complex, physiological process, information gleaned during these fixations is registered as an unanalyzed, visual image (the icon) in a rapidly decaying "buffer" (Gough, 1972). If the visual information system operates properly, visual forms are held long enough for feature discrimination, decay fast enough to avoid interference with subsequent input, and provide adequate information for further neural activity (Senf, 1972).

Short-term Memory: Visual-Auditory Linkages. Visual features must be connected to their auditory counterparts in order to convey meaning. Senf (1972) pointed out that the beginning reader must cope with two forms of input, grapheme information from the printed page and phonological information produced from mental activity. The child needs to discriminate visual features, generate auditory counterparts, and integrate these linkages into meaningful words. Working memory (or short-term memory) is called upon to contain the result of a linkage between a visual input and an auditory phonemic representation (Calfee, Note 2; Gough, 1972; LaBerge & Samuels, 1974; Samuels, 1973; Senf, 1972; Simon, 1972). Material can be coded into short-term memory (STM) as individual letter, letter clusters, words, or word groups (Gough, 1972; LaBerge & Samuels, 1974). When individuals recode information into larger "chunks," they make efficient use of immediate memory capacity (Miller, 1956).

Long-term Memory. If information from text is to become useful to the individual, it must be coded in long-term memory (LTM) in an economical, efficient form. LTM holds not only learned items from STM but also rules for processing new information (Atkinson & Schiffrin, 1968).

These rules, stored in LTM, may serve as the basis for deciding what information needs to be attended to in the environment. Nodine and Steurle (1973) concluded, from a study of eye fixations during a letter matching task with kindergarten, first, and third-grade children, that older children require fewer eye fixations than kindergarteners because they are able to plan out the most efficient locus of attention. In part, the authors assumed that, by the end of first grade, children learned to focus on the distinctive features of letters when faced with a discrimination task.

Mason (1977) hypothesized that high-frequency letter clusters or patterns are another type of organizing strategy, or rule, for decoding unfamiliar words. Only if the word contains letter patterns which are unfamiliar, will the child process the visual stimuli in a "bottom-up" letter-by-letter fashion.

The notion that individuals benefit from anticipatory sets for grapheme patterns in words is an intriguing one. A discussion of phonological and orthographic "rules" which children acquire as they learn to read is elaborated on in a subsequent section of this paper.

Processing Deficits Noted in Reading Disabled Youngsters

Information processing models have generated a substantial body of

research related to the processing capacities of disabled learners. While many of the studies fail to pinpoint the hypothesized stage or stages during which the LD child manifests difficulty, there is data to support the notion of processing dysfunctions. Research evidence indicates that many disabled children have trouble taking in, storing, and retrieving information.

Deficits Which Affect Perceptual Learning. Senf (1972) hypothesized that one type of learning disability in basic reading may be due to the inability to receive accurate visual information. The individual could have defective form analyzers, irregular signal life, or a lack of inhibition for irrelevant environmental stimuli.

A great deal of research on dyslexia has focused on improper form perception (Bender, 1957; Benton, 1962; Orton, 1937; Silver & Hagin, 1960). Clinicians and researchers have noted that poor readers demonstrate a tendency to reverse letter forms (Doyle & Goyen, 1968; Orton, 1937; Wolfe, 1941). I. Liberman, Shankweiler, Orlando, Harris, and Bell Berti (1971) found, however, in an examination of reading errors made by poor readers, that single letter reversals made up of only a small percentage of total reading errors (15%). Shankweiler and I. Liberman (1978) concluded that "difficulties manifested in common error patterns are chiefly outside the domain of visual perception" (p. 123).

In addition to the fact that disabled readers do not demonstrate a preponderance of reversal errors, there is another reason to doubt the primacy of visual form imperception as a cause of reading failure. Reversal errors do not necessarily differentiate normal from disabled

readers. Ilg and Ames (1950) noted that letter reversals may be present in the reading of normal children until nine years of age.

While inadequate form perception does not account for the reading failure of a large number of LD youngsters (Senf, 1972; Shankweiler & I. Liberman, 1978; Vellutino, Steger, Moyer, Harding, & Niles, 1977), there may be other sources of difficulty associated with visual perception. Senf (1972) proposed that certain LD children might have inadequate visual information storage systems. These children would have iconic images which are subject either to overly or insufficiently rapid decay.

Ellis and Miles (1977) reported that "dyslexic" children may have an icon which decays too rapidly. The authors designed a recall task in which four to seven digits were displayed tachistopically with exposure time varied. When a visual mask was used after offset of the stimuli, dyslexics were able to recall only two to three digits, on the average, whereas normals could recall four to five. Ellis and Miles noted that a graphic representation of data demonstrated different slopes for dyslexics and normals prior to but not after the 150 msec. point. They hypothesized that the dyslexic youngsters had a problem with visual code store capacity which appears within the first 150 msecs. of processing. Since controversy exists over the adequacy of visual masking procedures (Wildman & Kling, 1978) and the comparability of digit recall and recall involving linguistic material, inferences about the reading process based on these findings must be made with caution.

Inadequate visual information may also be the result of a lack of inhibition of extraneous stimuli (Senf, 1972). LD children may be so stimulus-bound and susceptible to new input, that they are unable to attend selectively to critical features. Ross (1976) noted that selective attention may be delayed in LD children. Samuels and Anderson (1973) concluded that visual recognition memory deficits observed in poor readers may be due, in large part, to poor perceptual learning and a lack of focused attention.

Deficits Which Interfere With Coding. The beginning reader must learn to translate visual symbols from the printed page into a meaningful code. In order to so, the child must make visual-auditory linkages which take into account both item and order information. The more automatic these linkages become, the better able the child is to take in subsequent symbols, integrate them with earlier symbols, and proceed to the next word, phrase, or sentence.

Disabled readers appear to be unable to make these linkages in an efficient manner. On recall and scanning measures utilizing either digits or letters, poor readers generally do not perform as well as their normal peers. Depressed encoding speed (Spring & Capps, 1974), asynchrony in visual and auditory processing (Farnham-Diggory & Gregg, 1975) and lack of prerequisite knowledge of language structure (Shankweiler & I. Liberman, 1976) have been postulated as explanations for the encoding deficiencies observed. In simple terms, if children attach verbal labels too slowly, fail to integrate visual and internal auditory input simultaneously, or lack an anticipatory set for orthographic

or speech patterns, their short-term memory systems will easily be overloaded.

In addition to codes related to specific item information, children need to process specific data about order within a letter sequence to decode words accurately. Doehring's comprehensive analysis of performance on reading and nonreading measures (1968) revealed that disabled readers had particular trouble with tasks that required sequential processing. Noelker and Schumsky (1973) as well as Bakker (1972) also reported that poor readers had trouble retaining order information. However, it is important to note that Mason, Katz, and Wicklund (1975) found that there was only a modest relationship between order memory and standardized reading scores. Mindell (1978) reported no significant relationship between sequence errors made on a word reading task and order for letter strings. Therefore, it is important to keep in mind that while LD children have inadequate sequential processing on certain diagnostic and experimental measures, there is little evidence to support the notion that retarded reading performance is strongly related to this deficiency.

Deficits Which Interfere With Retention and Retrieval. Gibson and Levin (1975) emphasized that, in order to read efficiently, an individual needs to "process textual material in the most economical way he can" (p. 474). If children with reading difficulties fail to use strategies which combine individual elements into larger units, they are putting a substantial strain on their processing capacity.

Various studies which tap memory processes have led to the conclusion that LD children fail to process information efficiently.

were unable to fulfill the task requirements at all and received scores of zero, whereas only two of the good readers demonstrated difficulty with verbal recall tasks because of a lack of letter pattern concepts.

Educational Implications Drawn from Information Processing Theory and Research

Research findings indicate that reading disabled youngsters are easily overloaded when task demands include the need for precise information about critical features, accurate and speedy visual-verbal matches, and utilization of strategies based on knowledge of language structure. In order to minimize these deficiencies, reading instruction for LD children must be constructed with care. Although there are many instructional variables to consider (see Bryant, 1965), three important principles will be highlighted in the following discussion: placing limits on the amount of material to be covered, providing focus or cue salience, and introducing useful strategies for learning.

Limit the Amount of Material. If LD children manifest a range of processing deficiencies, it is logical to assume that learning rate will be affected. In order to provide adequate practice which allows LD children to discriminate critical features and to code information efficiently, it behooves educators to consider the amount of material which the child is expected to process during any specific lesson or sequence of lessons. While there is a temptation to move in a lock-step fashion through published curriculum, it is necessary to do so with extreme caution Good diagnostic-prescriptive teaching for problem learners should address itself to these questions: 1) How much

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time does it take the child to learn, retain, and apply one phonic element or principle? 2) Can the child make rapid and accurate responses to learned elements or principles introduced in the lesson or lesson sequence? 3) If the child is asked to deal with two or more elements simultaneously, does the child confuse the elements in subsequent presentations? 4) How much review does the child need to maintain the skills that are learned? Perhaps answers to these questions will help teachers to set realistic goals related to the amount of material to be covered in a day, week, marking period, or year.

Focusing on What is to be Learned. It is not uncommon in published reading materials to present phonic elements or generalizations in a "discovery" format. Manuals often give linguistic justifications for activities which ask children to infer specific sounds embedded in words or to generate generalizations based on a variety of examplars. Research findings indicate that disabled youngsters may have trouble isolating the "middle sound in 'hat'" for themselves because of an inability to code information swiftly or accurately. As examples are presented, nonhandicapped children may well infer the sound-symbol relationship and apply it in listening, reading, and spelling activities. The disabled youngster, on the other hand, may never be very clear about the visual-auditory match that he or she is expected to make.

Cue salience is an important factor to keep in mind when teaching reading disabled youngsters. While consonant sounds are difficult

to isolate, vowel sounds, the largest source of errors found among beginning readers, are not (Monroe, 1932; Weber, 1970). For vowel sounds, isolating the grapheme-phoneme relationship both in a visual and an auditory format may increase the salience of the match for the learner. The disabled reader needs training in making the visual-auditory match first with the letter(s) alone and then in the context of words. While picture cues and key words may help the learner in initial learning trials, it is crucial that the child be able to respond automatically with the sound when presented with a grapheme, to demonstrate discrimination of this grapheme from others and to produce the sound when the grapheme is embedded in a word.

Teaching Word Attack Strategies. LD children do not seem to apply successful strategies when asked to read novel words. They demonstrate a marked deficiency in their ability to group or cluster letters into common orthographic patterns and, therefore, may subject themselves to overload conditions. It seems prudent to provide for the disabled learner strategies based on language regularities which their normal peers probably infer on their own. Directive teaching of specific strategies can help to compensate for retention and retrieval deficiencies noted in the population.

What are these attack strategies which are consonant with language structure and can be generalized to a variety of words? This question leads naturally to a discussion of the reading task itself within the context of a psycholinguistic perspective.

Understanding the Task: The Psycholinguistic Perspective

From the discussion of information processing, it appears that a child needs to learn about the structure of language in order to read efficiently. Rules and regularities influence the way in which an individual processes text. Are there inherent difficulties involved in translating print into speech? What are the generalizations the child needs to internalize in order to decode words? Although there are no certain answers to these questions, researchers in the areas of speech perception, linguistics, and word perception have collected data which shed light on these issues.

Speech Perception

Speech is a complex code which the human being is able to perceive and to analyze rapidly. A. Liberman, Cooper, Shankweiler, and Studdert-Kennedy (1967) hypothesized that a special auditory decoder exists within the organism which is mediated by motor aspects of sound production.

Inroads have been made in our understanding of speech using spectographs, which are permanent pictures of vocalizations. Spectrographic analysis performed at Haskins Laboratory (A. Liberman, et al., 1967) revealed that single consonant phonemes are actually dependent upon context. As a result of their research, the authors concluded that "a phoneme is an abstract and general type of segment represented in any specific utterance.... that may vary as a function of context" (p. 431). There is no one-to-one correspondence between the actual sound and the perceived phoneme, and phonemes are encoded into units

(i.e., a syllable) around a "vowel-like nucleus" (A. Liberman, 1970, p. 311).

Other researchers have also concluded that the phoneme is not a distinct unit of information. Savin and Bever (1970) measured response time for locating syllables and phonemes in sequences of nonsense syllables. Syllables were recognized faster than phonemes. Warren concluded from his research on phoneme identification that individual speech sounds are not located directly. Rather, they are "inferred" (p. 349) from the whole syllable. Schubert (1975) asserted that larger units are more "perceivable" (p. 126) than smaller units.

Based on findings from speech research, I. Liberman and Shankweiler (Note 3) pointed out various difficulties that arise when a child is asked to decode words. First, segmentation is an unnatural task for the learner. The child perceives spoken words in a unitary fashion, not through individual phonemes. Secondly, when asked to analyze word parts, the beginning reader is dealing with letter sounds that have no perceptual reality. I. Liberman and Shankweiler gave the example of a child attempting to decode the word bag in a letter-by-letter fashion. In actuality, "reading letter-by-letter gives not 'bag,' but 'buhaguh' " (p. 10).

Linguistics

It is often assumed that the English writing system bears little relationship to the speech code. Gibson and Levin (1975) summarized the arguments offered by proponents of this position in the following

statement:

> One often hears that English letter-to-sound correspondences are "chaotic." We can cite the anguish of educators and spelling reformers to show that almost all letters in English have various pronunciations and that sounds can be spelled in various ways. (p. 173)

There is empirical and theoretical support for an alternate position regarding the structure of English. Venezky (1967, 1970) analyzed a corpus of 20,000 words in order to establish regularities which exist in speech-to-print relationships. He concluded that, while single graphemes are generally not closely associated with sound, there are graphic units which do predict the pronunciation of graphemes. These units are generally letter clusters or specific orthographic patterns within words.

The notion that the writing system has a predictable relationship to speech has also received support from Chomsky (1970). His defense of this position is quite different from Venezky's. Chomsky proposed a generative phonology in which the surface structure serves as a clue for the underlying lexical or semantic representation. He argued that "orthography corresponds closely to a significant level of linguistic representation that is....related to sound by general rules" (p. 15). Chomsky admitted that his theory was highly abstract and not directly applicable to reading instruction. However, he recommended that material for beginning readers be highly regular so

that surface phonetics are reliable.

Recent work in linguistics indicates that English orthography is not a hopeless confusion of unpredictable grapheme-phoneme relationships. However, it does appear to be necessary to focus on units which are larger than individual letters in order to exploit these regularities.

Word Perception

Studies which focus on how adults and children perceive and recognize words have added substantial support to the notion that language structure, or "higher-order" regularities, aid the reader in processing textual information. These studies have examined both auditory and visual word perception utilizing match-to-sample and tachistoscopic recognition paradigms.

Gibson and her colleagues (Gibson, Pick, Osser, & Hammond, 1962; Gibson, Osser, & Pick, 1963; Gibson, Bishop, Schiff, & Smith, 1964; Gibson, Shurcliff, & Yonas, 1970) have devoted considerable attention to the role of letter order information in the visual perception of words. Gibson, Pick, Osser, and Hammond (1962) noted differences in an individual's ability to encode pronounceable as opposed to unpronounceable words based on a tachistoscopic presentation of 100 msecs. per word. Even when the researchers switched to a match-to-sample task, skilled readers were able to recognize more pronounceable than unpronounceable nonsense letter strings.

A later study with deaf subjects (Gibson, Shurcliff, & Yonas, 1970) convinced Gibson and her colleagues that pronounceability may

not be the key to structure. Even deaf college students were able to encode more "pronounceable" than "unpronounceable" nonsense words after brief exposures. Orthographic structure would appear to play the key role in processing for these deaf students.

The ability to respond to intraword redundancy inherent in structured letter clusters appears to develop during the early school years. Gibson, Osser, Pick (1963) found that, while first graders were more successful with pronounceable than unpronounceable three-letter strings presented tachistoscopically, only the third grade girls were able to utilize structural regularities in four- and five-letter items.

Samuels and Chen (1971) also found that there was a developmental aspect to the acquisition of word recognition strategies. In their study, college students had more accurate perception of words which were flashed too quickly to read and were better able to use partial cues in items with omitted letters than fourth grade subjects.

Children may in fact use an entirely different set of strategies to recognize words than do adults. On a delayed recognition task using trigrams and quingrams, Marchbanks and Levin (1965) found that the initial consonant was the most frequently used cue for word recognition for kindergarten and first graders. Williams, Blumberg, and Williams (1970) found that adults, on the other hand, used many different letter positions as cues and even relied on general word configurations.

Santa (1976) attempted to locate those letter clusters in words

which are particularly salient to elementary school youngsters. She utilized a set of 60 stimulus cards, each with a CCVCC word (e.g., block) and an accompanying probe ranging from one to five letters. Subjects were asked to decide whether the letters in the probe were in the same order as in the actual word. Those second grade children who were judged to be non-achieving based on an informal reading inventory responded faster to single letters than to any other probe, whereas their achieving peers responded equally quickly to single letters and initial clusters. By fifth grade, achieving youngsters were responding faster to the initial than to the final cluster in words. It would appear that the ability to group letters into clusters and to respond to them as a unit in a left-to-right fashion is related to skilled word recognition.

Kuenne and Williams (1973) examined different auditory recognition cues used by kindergarten through second grade children for identification of CVC (consonant-vowel-consonant) words. Subjects were presented with four blocks in a row and directed to keep their left hand on the first block. The stimulus word was read, followed by three other "choice" words. Children were directed to move their right hand as each of the three "choice" words was read and to lift the block which had a "name" exactly or almost like the "name" of the first block. The cues used were: words with the same single consonant (initial or final position); the same CV or VC pattern; or a complete word reversal. By second grade, 40% of the choices were words containing the same VC pattern and 30% were words containing the same CV pattern as the stimulus word. The

authors noted that children tended to use rhyme as a cue in this aural recognition task.

While Santa (1976) found that the initial cluster was the most salient cue for word recognition, Kuenne and Williams (1973) concluded that the VC pattern at the end of words was the most popular. The fact that the authors used different designs helps to explain this contradiction. More importantly, the mode of presentation may have affected cue salience. Swenson (1975) demonstrated with six to eight-year-old children that cues which children utilize may be task-specific. Using the Kuenne and Williams delayed match-to-sample paradigm with the same five cues in Visual-Visual, Visual-Auditory, Auditory-Visual, and Auditory-Auditory conditions, Swenson found that, with auditory intramodal tasks, children chose an equal number of CV and VC stimuli. On visual intramodal tasks, children tended to match based on the CV pattern.

There are tentative conclusions which can be drawn from the work on word perception. First, the ability to utilize structural cues and to process letter clusters increases with age and reading ability. Secondly, in tasks which require processing of visual stimuli or intermodal material, a strategy which clusters the beginning letters of the word is useful and popular. The rhyme, or final cluster, strategy is also utilized in word recognition, especially in tasks which are entirely auditory.

Reading Research

Fries (1963) applied the conceptualization of language which

emphasizes regularity to reading instruction by advocating the use of spelling patterns for beginning readers. Rather than the traditional letter-by-letter phonics approach, Fries argued that words should be taught in patterns, and, as one pattern is contrasted with another, children will be able to make their own connection between individual graphemes and phonemes. Gough (1975) emphasized that beginning readers need to infer structure on their own:

> The disadvantage of the phonemic system is that you cannot display the correspondences he (the student) must master. . . all we can do is to present the learner with strings of characters, and strings of phonemes, and hope that he can break the code. (p. 27)

The ability to detect structure appears to distinguish good from poor readers. Calfee, Venezky, and Chapman (1969) noted that third graders who demonstrated adequate reading achievement were better able to pronounce predictable patterns in nonsense words than their nonachieving peers. In general, 3rd, 6th, and 11th graders as well as college students who were good readers were more consistent in their responses to predictable patterns than were poor readers. Golinkoff (1974) also found a significant relationship between the ability to respond to predictable patterns and general reading achievement in first and second grade children.

What patterns are children likely to detect in CVC words? Pick (1978) trained 17 children on three lists of single syllable words.

These words were taught by four teachers, and each teacher designed his or her own method. Words were grouped as follows: Day 1--bum, hum, bug, hug; Day 2--rat, fat, ran, fan; Day 3--sip, lip, sid, lid.

After the three days of instruction, children were tested on 18 transfer words, six of which contained the final bigrams in training words (e.g., -um, -ug), and six of which contained the vowels and consonants in the training words but none of the actual bigrams. Pick found that more words which contained the initial bigrams were read correctly than words containing either the final bigrams or rearranged letters. She also noted that an examination of partially correct responses revealed that 26 contained accurate CV responses, while only 10 had correct VC responses.

Fletcher (1973) studied the effect of training with specific spelling patterns on retention of learned items and transfer to novel words. He selected 25 boys and 47 girls from three "moderate ability" first grade classes in a school serving an economically deprived population. Using the Computer Assisted Instruction (CAI) program in beginning reading, he exposed children to four types of patterns (CV, VC, CCV, and VCC) over eight days. Words were divided into the following categories: (1) I--words containing a training CV bigram; (2) F--words containing a training VC bigram; (3) B--words containing both CV and VC training bigrams; and (4) N--words which contained no training bigrams.

Children were posttested on words taught during the program and on transfer words containing the same patterns. Fletcher concluded

that words containing both bigrams (B) and words containing the final bigrams (F) were read significantly better than words containing either the initial bigrams only (I) or no training bigrams (N).

Fletcher's conclusions need to be examined in light of his data. Unfortunately, he did not include any information regarding pretest performance in his description of methodology. Since children were selected from normal first grade classes that were receiving instruction based on a phonics-linguistics series (McCracken & Walcutt, 1963), it is possible that many children already knew the words and/or the patterns prior to training. There is reason to doubt the effectiveness of the training in that transfer of patterns to nonsense words was uniformly low. It is also noteworthy that differences in the percent of I, F, B, and N words read correctly were actually quite small (percentages ranged from 56-66%).

Rubin (1979) examined the degree to which first graders' short term retention of sight words and transfer of spelling patterns were dependent on grouping words by pattern and instructional focus on these patterns. Children in the patterned conditions were exposed to words grouped both by the initial digraph pattern (e.g., sk, cr, and bl) and the final phonogram (e.g., unk, im, and ow). She found that a patterned presentation facilitated recall of single-syllable training words and transfer of the spelling patterns to novel words. Focus on the specific patterns did not significantly improve the children's ability to recall the training words or to transfer the patterns to new words.

While normal children appear to detect structure and to utilize it with novel words, reading disabled children may have trouble doing so unless they receive direct instruction on transfer tasks. Silberman (1964) concluded, based on his study of children in the lowest quartile on a reading readiness measure, that poor readers need practice with a transfer strategy and will not automatically apply learned patterns to novel words. The author prepared a teaching procedure which consisted of words containing four initial consonants and four final bigram patterns. Without direct instruction on how to recombine elements to make new words, these children were unable to read transfer items successfully. With specific training for transfer, they were able to use these elements in novel words.

Fayne (1979) examined the relative effectiveness of various word attack strategies for a reading disabled population. Children in the sample were taught with lessons over a two-day period which provided salient cues, practice until a level of accuracy was reached on CVC (consonant-vowel-consonant) words, and specific transfer training on nonsense syllables. Word attack strategy was varied for the five treatment groups. Practice consisted of synthesis using initial bigrams and final consonants (co-g), initial consonants and final bigrams (c-og), a combination of initial and final bigram training, or letter-by-letter analysis (c-o-g). There were significant differences noted on transfer items in favor of the group taught with the initial bigram-final consonant strategy. This strategy appears to be differentially effective because it both emphasizes left-to-right processing and reduces the number of

units to be synthesized. This finding calls into question popular phonics approaches which emphasize rhyming patterns or phonograms.

Educational Implications Drawn from Psycholinguistic Theories and Research

Psycholinguistic constructs which are applicable to reading instruction can be gleaned from a wide variety of research orientations. Analysis of the speech code (A. Liberman, et al., 1967; Savin & Bever, 1970; Warren, 1971) indicates that the identification of individual phonemes may not be a natural part of speech perception and, therefore, can present difficulties when fluent speakers are asked to apply analysis-synthesis skills to speech-print linkages. Research related to orthographic structure reveals that regularities in English exist if one looks beyond the individual grapheme (Chomsky, 1970; Venezky, 1967, 1970). Both children and adults appear to exploit "higher-order" regularities by clustering individual letters into patterns when they perceive words (Gibson, et al., 1962, 1963, 1964, 1970; Kuenne & Williams, 1973; Samuels & Chen, 1971; Santa, 1976-1977; Swenson, 1975). Children who are able to distinguish patterns and to learn to read words containing patterns can use them when attempting to decode novel words (Fletcher, 1973; Fries, 1963; Pick, 1978). Since the ability to exploit regularities appears to distinguish good from poor readers (Calfee, Venezky, & Chapman, 1969; Golinkoff, 1974), it is likely that reading disabled youngsters require direct instruction utilizing sound word attack strategies in the application of these patterns to novel words (Silberman, 1964).

A Proposal for Evaluating Phonics Methods and Curriculum

There are certain basic questions which need to be asked regarding the value of decoding materials or programs. While none of these questions are unique to this paper, it is necessary to highlight their importance in light of research findings related to information processing and psycholinguistics:

1. Does the program provide adequate focus by isolating and emphasizing grapheme-phoneme relationships where appropriate and by introducing regularities or orthographic patterns?
2. Does the program present manageable amounts of material and allow children to receive enough practice to ensure a high level of speed and accuracy?
3. Does the program include strategies which children can utilize and generalize to a great many other words?

While many programs pay lip service to these crucial issues, few incorporate focus, appropriate unit size, sufficient practice and review, or well-articulated word attack strategies consistently. Two experimental programs carried out at Teachers College, Columbia University, and supported by the Bureau of Education for the Handicapped, U. S. Office of Education, lend support to the efficacy of curriculum materials which operationalize these principles.

Williams (1980) developed a phonics program, entitled The ABD's of Reading, which gives directed training in analysis, blending, grapheme-phoneme correspondences and decoding. Results gleaned from careful

program evaluation are both encouraging and instructive. During Year 1, children trained with the supplementary decoding program based on thorough task analysis and sound instructional principles made significant gains when compared to a control group drawn from the same special education population. However, six-month follow-up testing revealed that gains on decoding measures made by the children in the group were no longer significantly greater than those of the control subjects, probably because classroom teachers did not provide review and practice of the skills taught. The second year of program evaluation documented the general effectiveness of the instruction for acquisition and transfer of skills. It is important to note that, on the average, disabled children in the Year 2 sample took approximately 58 sessions over 18 weeks to learn and to apply the analysis, blending, letter-sound relationships, and decoding of single syllables using only nine letters.

The work of the Basic Reading and Spelling Task Force at Teachers College's Research Institute for the Study of Learning Disabilities (Bryant, Fayne, and Gettinger, Note 1) underlines the importance of adequate instructional time for disabled learners. Reading disabled children provided with systematic practice and review and given a consistent attack strategy, learned over 75% of the words taught and generalized to greater than 60% of new items when they were introduced to one phonic element (medial vowel sound) per week and were given one week of review and integration practice after two elements were learned.

Disabled learners may indeed by casualties of inappropriate teaching, as Bateman (1974) suggests. They are particularly victimized when

teachers feel pressured to "cover" a fixed amount of material. In order to insure that disabled learners receive adequate practice and review, it is necessary to allot heavy doses of teacher time to these youngsters. Without good, directive teaching and constant review, it is unlikely that these underachieving youngsters will be able to compensate for their processing deficiencies.

Reference Notes

1. Bryant, N. D., Fayne, H. R., & Gettinger, M. "LD efficient" instruction in phonics: Applying sound learning principles to remedial teaching. Unpublished manuscript, 1980.

2. Calfee, R. C. Diagnostic evaluation of visual, auditory, and general language factors in pre-readers. Paper presented at a meeting of the American Psychological Association, Honolulu, 1972.

3. Liberman, I. Y., & Shankweiler, D. Steps toward literacy. Report prepared for the President's Commission on Mental Health, November, 1977.

References

Atkinson, R. C., & Schiffrin, R. M. Human memory: A proposed system and its control processes. In K. W. Spence and J. T. Spence (Eds.), The psychology of learning and motivation: Advances in research and theory (Vol. 2). New York: Academic Press, 1968.

Bakker, D. Temporal order in disturbed reading. Bulletin of the Orton Society, 1972, 2, 80-83.

Bateman, B. Educational implications of minimal brain dysfunction. Reading Teacher, 1974, 27, 662-668.

Bender, L. A. Specific reading disability as a maturational lag. Bulletin of the Orton Society, 1957, 7, 9-18.

Benton, A. L. Dyslexia in relation to form perception and directional sense. In J. Money (Ed.), Reading disability: Progress and research needs in dyslexia. Baltimore, Md.: Johns Hopkins Press, 1962.

Black, W. F. Neurological dysfunction and reading disorders. Journal of Learning Disabilities, 1973, 6, 313-316.

Black, W. F. The word explosion in learning disabilities: A notation of literature trends 1962-1972. Journal of Learning Disabilities, 1974, 7, 323-324.

Blank, M., Weider, S., & Bridger, W. Verbal deficiencies in abstract thinking in early reading retardation American Journal of Orthopsychiatry, 1968, 38, 823-834.

Boder, E. Developmental dyslexia: A diagnostic approach based on three atypical reading-spelling patterns. Developmental Medicine and Child Neurology, 1973, 15, 663-687.

Brewer, W. F. Is reading a letter-by-letter process? A discussion of Gough's paper. In H. Singer and R. B. Ruddell (Eds.), Theoretical models and processes of reading. Newark, Del.: International Reading Association, 1976.

Bryant, N. D. Characteristics of dyslexia and their remedial implications. Exceptional Children, 1965, 31, 195-199.

Bryant, N. D, & McLoughlin, J. A. Subject variables: Definition, incidence, characteristics, and correlates. In N. D. Bryant & C. E. Kass (Eds.), Final Report (U.S.O.E. Grant No. OEG-0-71-4425 604, Project No. 127145). Tucson, Arizona: Leadership Training Institute in Learning Disabilities, 1972.

Calfee, R. C., Venezky, R. L., & Chapman, R. S. Pronunciation of synthetic words with predictable and unpredictable letter-sound correspondences (Technical Report 71). Madison, Wisconsin: Wisconsin Research and Development Center for Cognitive Learning, 1969.

Chalfant, J. D., & Scheffelin, M. A. Central processing dysfunction in children: A review of research (NINDS Monograph No. 9, U.S. Public Health Service). Washington, D. C.: U.S. Government Printing Office, 1969.

Chall, J. A decade of research on reading and learning disabilities. In S. J. Samuels (Ed.), What research has to say about reading instruction. Newark, Delaware: International Reading Association, 1978.

Chomsky, N. Phonology and reading. In H. Levin and J. P. Williams (Eds.), Basic studies on reading. New York: Basic Books, 1970.

Clements, S. D. Minimal brain dysfunction in children (NINDS Monograph No. 3, U.S. Public Health Service Publication No. 1415). Washington, D. C.: U.S. Government Printing Office, 1966.

Doehring, D. G. Patterns of impairment in specific reading disability. Bloomington, Indiana: Indiana University Press, 1968.

Ellis, N. C., & Miles, T. R. Dyslexia as a limitation in the ability to process information. Bulletin of the Orton Society, 1977, 27, 72-81.

Farnham-Diggory, S., & Gregg, L. W. Short-term memory function in young readers, Journal of Experimental Child Psychology, 1975, 19, 279-298.

Fayne, H. R. The effect of various methods of word synthesis on the phonics achievement of learning disabled youngsters. Unpublished doctoral dissertation, Columbia University, 1979.

Fletcher, J. D. Transfer from alternative presentations of spelling patterns in initial reading (Technical Report 216). Stanford University, Institute for Mathematical Studies in the Social Sciences, 1973.

Fries, C. Linguistics and reading. New York: Holt, Rinehart, and Winston, 1963.

Gibson, E. J., Bishop, C., Schiff, W., and Smith, J. Comparison of meaningfulness and pronounceability as grouping principles in the perception and retention of verbal material. Journal of Experimental Psychology, 1964, 67, 173-182.

Gibson, E. J., & Levin, H. The psychology of reading. Cambridge, Mass.: MIT Press, 1975.

Gibson, E. J., Osser, H., & Pick, A. A study in the development of grapheme-phoneme correspondences. Journal of Verbal Learning and Verbal Behavior, 1963, 2, 142-146.

Gibson, E. J., Pick, A., Osser, H., & Hammond, M. The role of grapheme-phoneme correspondence in the perception of words. American Journal of Psychology, 1962, 75, 554-570.

Gibson, E. J., Shurcliff, A., & Yonas, A. Utilization of spelling patterns by deaf and hearing subjects. In H. Levin and J. P. Williams (Eds.), Basic studies on reading. New York: Basic Books, 1970.

Golinkoff, R. Children's discrimination of English spelling patterns with redundant auditory information. Paper presented to the American Educational Research Association, Chicago, 1974.

Gough, P. B. One second of reading. In J. F. Kavanaugh and I. G. Mattingly (Eds.), Language by ear and by eye. Cambridge, Mass.: The MIT Press, 1972.

Gough, P. B. The structure of the language. In D. D. Duane and M. B. Rawson, Reading, perception, and language. Baltimore, Md.: York Press, Inc. 1975, 15-39.

Hochberg, J. Attention in perception and reading. In F. A. Young and D. B. Lindsley, Early experience and visual information processing in perceptual and reading disorders. Washington, D. C.: National Academy of Sciences, 1970.

Ilg, F. L., & Ames, L. B. Developmental trends in reading behavior. Journal of Genetic Psychology, 1950, 76, 291-312.

Johnson, D., & Myklebust, H. Learning disabilities: Educational principles and practices. New York: Grune and Stratton, 1967.

Kuenne, J., & Williams, J. P. Auditory recognition cues in the primary grades. Journal of Educational Psychology, 1973, 64, 241-246.

LaBerge, D., & Samuels, J. J. Toward a theory of automatic information processing in reading. Cognitive Psychology, 1974, 6, 293-323.

Liberman, A. M., Cooper, F. S., Shankweiler, D. P., & Studdert-Kennedy, M. Perception of the speech code. Psychological Review, 1967, 74, 431-461.

Liberman, I. Y., Shankweiler, D., Orlando, C., Harris, K. A., & Bell Berti, F. Letter confusions and reversals of sequence in the beginning reader: Implications for Orton's theory of developmental dyslexia. Cortex, 1971, 7, 127-142.

Lyle, J. G., & Goyen, J. Visual recognition, developmental lag, and strephosymbolia in reading retardation. Journal of Abnormal Psychology, 1968, 73, 25-29.

Mackworth, J. F. Some models of the reading process: Learners and skilled readers. In M. Kling, E. B. Davis, and J. J. Geyer (Eds.), The literature of research in reading with emphasis on models. (450E Contract No. OEC-0-70-4790(508), Project No. 0-9030). Ithaca, New York: Cornell University, 1971.

Marchbanks, G., & Levin, H. Cues by which children recognize words. Journal of Educational Psychology, 1965, 56, 257-261.

Mason, J. Questioning the notion of independent processing stages in reading. Journal of Educational Psychology, 1977, 69, 288-297.

Mason, M., Katz, L., & Wicklund, D. A. Immediate spatial order memory and item memory in sixth grade children as a function of reading ability. Journal of Educational Psychology, 1975, 67, 610-616.

Mattis, S., French, J. H., & Rapin, I. Dyslexia in children and young adults: Three independent neuropsychological syndromes. Developmental Medicine and Child Neurology, 1975, 17, 150-163.

McCracken, G., & Walcutt, C. E. Basic reading. Philadelphia, Pa.: J. B. Lippincott, 1963.

Miller, G. A. The magic number seven plus or minus two: Some limits in our capacity for processing information. Psychological Review, 1956, 63, 81-97.

Mindell, P. Dyslexia and sequential order errors in reading. Bulletin of the Orton Society, 1978, 28, 124-141.

Monroe, M. Children who cannot read. Chicago: University of Chicago Press, 1932.

National Advisory Committee on Dyslexia and Related Reading Disorders. Reading disorders in the United States (N.I.H., Department of Health, Education, and Welfare). Chicago: Developmental Learning Materials, 1969.

Nodine, C., & Steurerle, N.L. Development of perceptual and cognitive strategies for differentiating graphemes. Journal of Experimental Psychology, 1973, 97, 158-166.

Noelker, R. W., & Schumsky, D. A. Memory for sequence, form, and position as related to the identification of reading retardates. Journal of Educational Psychology, 1973, 64, 122-125.

Orton, J. T. Reading, writing, and speech problems in children. New York: Norton, 1937.

Pick, A. D. Perception in the acquisition of reading. In F. B. Murray and J. J. Pikulski (Eds.), The acquisition of reading: Cognitive, linguistic, and perceptual prerequisites. Baltimore, Md.: University Park Press, 1978.

Ross, A. O. Psychological aspects of learning disabilities and reading disorders. New York: McGraw-Hill, 1976.

Rubin, E. C. Teaching sight words to beginning readers: The effect of emphasizing spelling patterns. Unpublished doctoral dissertation, Columbia University, 1979.

Rumelhart, D. E. An introduction to human information processing. New York: John Wiley, 1977.

Samuels, S. J. Success and failure in learning to read: A critique of the research. Reading Research Quarterly, 1973, 8, 200-239.

Samuels, S. J., & Anderson, R. H. Visual recognition memory, paired-associate learning and reading achievement. Journal of Educational Psychology, 1973, 65, 160-167.

Samuels, S. J., & Chen, C. C. Comparison of word recognition strategies of adults and children. In Frank P. Greene, Reading: The Right to Participate - Twentieth Yearbook of the National Reading Conference, 1971, 20, 73-77.

Santa, C. M. Spelling patterns and the development of flexible word recognition strategies. Reading Research Quarterly, 1976, 12, 125-144.

Savin, H. B., & Bever, T. G. The nonperceptual reality of the phoneme. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 295-302.

Schubert, E. D. The role of auditory perception in language processing. In D. D. Duane and M. B. Rawson. Reading, perception and language. Baltimore, Md.: York Press, Inc., 1975.

Senf, G. M. An information-integration theory and its application to normal reading acquisition and reading disability. In N. D. Bryant and C. E. Kass, Final Report (USOE Grant No. OEGO-71-4425604, Project No. 127145), Tucson, Arizona: Leadership Training Institute in Learning Disabilities, 1972.

Shankweiler, D., & Liberman, I. Y. Exploring the relations between reading and speech. In R. M. Knights and D. J. Bakker (Eds.), The neuropsychology of learning disabilities: Theoretical approaches. Baltimore, Md.: University Park Press, 1976.

Shankweiler, D., & Liberman, I.Y. Is there a distinctive pattern of reading behavior in dyslexia? Bulletin of the Orton Society, 1978, 28, 114-123.

Silberman, H. F. Exploratory research on a beginning reading program. Santa Monica, Calif.: System Development Corporation, 1964.

Silver, A. A., & Hagin, R. Specific reading disability: Delineation of the syndrome and relationship to cerebral dominance. Comparative Psychiatry, 1960, 1, 126-134.

Simon. H. A. On the development of the processor. In S. Farnham-Diggory (Ed.), Information processing in children. New York, New York: Academic Press, 1972.

Smith, F. Understanding reading. New York: Holt, Rinehart and Winston, 1971.

Sperling, G. Short-term memory, long-term memory, and scanning in the processing of visual information. In F. A. Young and

D. B. Lindsley (Eds.), Early experience and visual information processing in perceptual and reading disorders. Washington, D. C.: National Academy of Sciences, 1970.

Spring, C., & Capps, C. Encoding speed, rehearsal, and probed recall of dyslexic boys. Journal of Educational Psychology, 1974, 66, 780-786.

Swenson, I. Word recognition cues used in matching verbal stimuli within and between auditory and visual modalities. Journal of Educational Psychology, 1975, 67, 409-415.

Taylor, S. E., Frackenpohl, H., & Pettee, J. L. Grade level norms for the components of the fundamental reading skill (EDL Research and Information Bulletin No. 3). Huntington, N. Y.: Educational Developmental Laboratories, Inc., 1960.

Tinker, M. A. Recent studies of eye-movements in reading. Psychological Bulletin, 1958, 55, 215-231.

Vellutino, F. R., Steger, J. A., & Kandel, G. Reading disability: An investigation of the perceptual deficit hypothesis. Cortex, 1972, 8, 106-118.

Vellutino, F. R., Steger, B., Moyer, S., Harding, C., & Niles, T. Has the perceptual deficit hypothesis led us astray? Journal of Learning Disabilities, 1977, 10, 375-385.

Venezky, R. L. English orthography: Its graphical structure and its relation to sound. Reading Research Quarterly, 1967, 2, 75-106.

Venezky, R. L. Regularity in reading and spelling. In H. Levin and J. P. Williams (Eds.). Basic studies on reading. New York: Basic Books, 1970.

Warren, R. M. Identification times for phonemic components of graded complexity and for spelling of speech. Perception and Psychophysics, 1971, 9, 345-349.

Weber, R. A. A linguistic analysis of first-grade reading errors. Reading Research Quarterly, 1970, 5, 427-451.

Wildman, D. M., & Kling, M. Semantic, syntactic, and spatial anticipation in reading. Reading Research Quarterly, 1978, 14, 128-164.

Williams, J. Teaching decoding with an emphasis on phoneme analysis and phoneme blending. Journal of Educational Psychology, 1980, 72, 1-15.

Williams, J. P., Blumberg, E. L., & Williams, D. Cues used in visual word recognition. Journal of Educational Psychology, 1970, 61, 310-315.

Wolfe, L. S. Differential factors in specific reading: II. Audition, vision, verbal association, and adjustment. Journal of Genetic Psychology, 1941, 58, 57-70.