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ABSTRACT

Reading requires the synthesis of auditory and visual skills and therefore involves almost all of the brain. Stages of reading include prereading skills (requiring an adequate spoken vocabulary), the ability to name letters and pictures, good memory for spoken sentences, and manual dexterity in copying patterns. Learning to read involves the ability to link the separate phonemes in a word with printed material. For most children, an auditory method is better than a visual one for teaching reading. Skilled reading depends on knowledge of word probabilities in speech and is characterized by the ability to transfer visual input into comprehension without the intervention of the speech system. The collaboration of the two sides of the brain is required for skilled reading. Poor readers may reflect right brain superiority and be more adapt at visuo-spatially oriented disciplines. (Author/KS)

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Abstract.

Information Processing Models of Reading. A Developmental Approach.

Jane F. Mackworth.

Objective: Discusses models in terms of research, mental growth, required skills and cerebral processes.

Basic Premise: Reading requires the synthesis of auditory and visual skills, and therefore inolves almost all the brain.

Sources: A wide range of books and journals was consulted.

Stages of Reading: Prereading skills require an adequate spoken vocabulary, the ability to name letters and pictures, good memory for spoken sentences and manual dexterity in copying patterns. Learning to read involves the ability to link the separate phonemes in a word with the printed material. An auditory method is better than a visual one for teaching the majority of children.

Skilled reading depends on knowledge of word probabilities in speech. It consists largely in confirming guesses. The skilled reader may go directly from the visual input to comprehension, without the intervention of the speech system.

Brain Processes: Reading requires the collaboration of the two sides of the brain, since the left brain deals with speech, and the right brain is more skilled with visuo-spatial material. Poor readers may have right brain superiority, being skilled in such arts as architecture, painting, sculpture, photography, and mechanical design. Higher mathematical ability and music may also be related to the right brain.

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Information Processing Models of Reading

A Developmental Approach.

Jane F. Mackworth

Reading is an integrative activity that involves the whole brain, including the left and right hemispheres and the brainstem activities of attention and alertness. The ability to relate the printed word with the spoken word seems to be different from either the auditory or visual skills. The skilled reader can eliminate the actual sounding out of words, and may go directly from visual patterns of words to meaning. He must, however, process many words into speech motor programs (Liberman, Cooper, Shankweiler, and Studdert-Kennedy, 1967). (21). High speed reading consists largely of selecting the important words, since printed text is highly redundant. Thus Goodman (1970) (15) has spoken of the psycholinguistic guessing game. However, the child must learn the whole process of linking the printed word to the spoken word.

Detailed accounts of models may be found in "Theoretical Models and Processes of Reading" (Singer and Rudell, 1970) (30), and in "The Literature of Research in Reading, with Emphasis on Models", (Davis, F.B. 1971) (11). Since models are based on research, this paper will attempt a synthesis of some recent research which has clarified our understanding of the reading process. The following topics will be discussed:

I. PRE-READING SKILLS

II. LEARNING TO READ

III. SKILLED READING

IV. CEREBRAL HEMISPHERES AND READING DIFFICULTIES.

I. PRE-READING SKILLS

Reading readiness depends on a basic set of pre-reading skills. The most important is language ability. Jansky and de Hirsch (1972) (18) carried out a comprehensive study of pre-reading skills. They tested 347 children towards the end of Kindergarten, and then retested them at the end of Grade 2. Out of nineteen tests that were given in the Kindergarten, five were found to be most predictive of reading performance in Grade 2. The five tests, in descending order of their contribution to reading performance, were:

1. Letter naming Range 5 yr olds: 10-50% errors
2. Picture naming
3. Gates Word Matching
4. Bender Motor Gestalt
5. Sentence memory (Binet).

This battery identified three out of four children who failed in Grade 2, and three out of four who succeeded. Jansky identified the following skills required for learning to read from the above tests; they are listed in decreasing order of their contribution to reading:

a) Oral language
b) Verbal pattern matching (spoken or written)
c) Visuo-motor organization
d) Verbal pattern memory.

The findings therefore form a model of pre-reading skills. The young child needs a well-developed skill in spoken language, as well as the ability to store and recover visuo-spatial information, including visual patterns of letters and words, with particular emphasis on left-right orientation. These two basic skills involve both brain hemispheres. In addition, the child needs the motor skills of speech and writing, since he learns the shape of the letters and words as much by copying as by reading. He also needs the ability to direct and maintain attention.

II. LEARNING TO READ.

Bateman (1969) (2) also made a study of the relation between pre-reading and reading skills. She divided Kindergarten children into groups according to their performance on the visual and auditory subtests of the Illinois Test of Psycholinguistic Abilities (ITPA). The average child scored nine months higher on the auditory tests than on the visual tests of memory. Half of the auditory group and half of the visual group were given training in Grade I by an auditory method (the Lippincott Program) and the other two halves were taught by a visual method (the Scott, Foresman Program).

Bateman found that the auditory children learned more rapidly than the visual children, and that auditory training was superior to visual training for all groups. She concluded that children who prefer the visual modality are handicapped in reading, and that all children should be taught by an auditory method.

Until a child can isolate a phoneme within a spoken word, he is unable to match the spoken word with the printed one. The phoneme is the smallest unit of speech: for example, the word "tin" contains three phonemes but only one syllable. Liberman, Shankweiler, Fischer and Carter (1974) (22) have shown that phoneme segmentation is more difficult than syllable segmentation, and is perfected later, between 5 and 7 years of age. The child becomes aware of the elements of speech as he relates them to the printed word. The visual child may achieve the ability to hear and isolate the phoneme somewhat later than the auditory child.

Any model of learning to read must be founded upon spoken language, with special emphasis on the ability to hear and record the sequences of phonemes within a spoken word. This

sequencing ability is often defective in the poor reader. He may reverse the order of letters within a printed word. The severely handicapped child may even reverse syllables within a spoken word, (Clarke, 1974) (9). Boder (1971) (4) reported that 63% of poor slide readers are unable to hear the separate phonemes and to code them into the visual patterns of the printed word. These children usually have good visual ability. The prognosis for children who have both visual and auditory difficulties is very poor. Zigmond (1969) (33) found that poor readers were inferior to normals on all of the eleven auditory tests that they took, but only one of the four visual tests differentiated between the groups. This one was the digit-symbol test, which Zigmond regarded as a symbolic process.

Thus it is legitimate to regard reading as the process of coding the printed symbols into spoken words. The learner must memorize the relation between the spoken and the printed word; this relationship is a cross-modal one between sound and sight. Myklebust (1971) (27) has reported that syllabication (for example: "match-ing") is the skill that distinguishes most strongly between normal and severely handicapped children. Poor readers have difficulty in matching temporal patterns with spatial ones, even when both are visual, as with flashes of light and dot patterns, (Blank and Bridger, 1967) (3). Bryden (1972) (7) found a high correlation between matching skills and reading ability for poor readers, but not with good readers.

Fisher and Rubenstein (1975a and b) (13,14) have shown slide that when children are given visual and auditory tasks (pictures and spoken words), skill in integrating the modalities increases with age from Grades I through V. However, this improvement shows a decreasing relationship with the ability to process visual or auditory material individually as the children grow older. Cross-modal integration

seems to be a skill separate from the skills of auditory or visual processing.

Poor readers often have inadequate pronunciation, possibly due to an inability to hear the separate sounds in words. Chall (1967) (8) found that speech training in sequencing aided by manual pointing helps many poor readers. Such children may also have an inadequate visual representation of the printed word in memory. They may be unable to recognize that a printed word is spelled incorrectly (Mackworth and Mackworth, 1974a) (23). They may also be unable to notice that two words sound differently when only the order of the letters distinguishes the two words, (for example: loaf-foal). (Mackworth and Mackworth, 1974b), (24), (Mackworth, 1975)(25).

The child who has difficulty in reading due to environmental deficiencies can usually be brought up to normal standards, but the child whose brain is different from those of his peers may never achieve the normal standards of reading, although he may be able to learn enough to function in the working world. He may, however, excel in other directions.

Research has shown that there is little benefit for the poor reader in working with visuo-perceptual programs or with physical exercises. These skills do not help him to read better. (O'Donnell, 1968(28), Hammill, 1972 (16), Martin,1973, (26), Dubois and Brown,1973(12)). The Hartmans (1973)(17) have pointed out that the task-oriented approach is now becoming more popular. Reading must be taught by reading experience. It is a highly specific skill.

Thus learning to read requires the ability to hear and understand the sounds of speech and to record them mentally in the correct order. The pupil must learn to relate the shapes and sounds of letters, progressing to the relation between the printed word

and its sound. The ability to translate a temporal sequence into a spatial one is a vital part of learning to read.

III. SKILLED READING.

The skilled reader does not need to pay attention to every letter or even to every word. Indeed, he does not need to translate all the words into speech, spoken or silent. Much of his speed comes from the ability to go straight from the visual input to the meaning. This ability is related to prediction. Crosby and Liston (1968) (10) presented a series of models that show how the development of reading skill involves a progressive simplification of the reading process. The initial level contains the whole process, from the visual input through motor speech and hearing to final comprehension: "How can I know what I said until I hear it?" With increasing skill, the actual sounding out is eliminated, and the reader goes from the motor programs of speech to the recognition of meaning. In skilled reading the reader may leap from visual recognition of the printed word to comprehension.

This ability to comprehend the written word without coding it into speech patterns arises from the reader's knowledge of language probability. He can guess with considerable accuracy what will come next, since he has already an understanding of what the material is describing. His reading consists largely of confirming his guesses by matching the printed word to a stored visual pattern already activated. Goodman (1970) (15) and Smith (1971 (31), 1973, (32)) have argued that skilled reading means the reduction of uncertainty about the meaning of the text. Without the cognitive understanding that the reader brings to the text, no amount of knowing how to code the printed word into sound will help the reader to understand what

he has read. It is possible to teach someone to sound out Chinese symbols without understanding a word.

The visual input is the basic process in reading. The brain can learn to recognize the meaning hidden in the most bizarre transformations of print (Kolers and Perkins, 1975 (20)). Posner, Lewis and Conrad (1972) (29) have shown that there are at least three separate stages in recognition of letters and words by adults. The physical match normally takes place most rapidly; it is affected by visual confusion, decay and rotation. The visual code preserves the actual spatial organization. The name match is affected by acoustic confusion with other stored names. It shows a left to right processing order. When the physical match is more difficult, as with rotation, the name match may occur first. The rule match involves the recognition that two items fall into the same category, such as "living things"; it normally takes longer than the name match. Boies (1971) (5) found that physical matches of letters are unimpaired even when the patient is aphasic.

Smith (1973)(32) pointed out that there is a trade-off between visual and non-visual information in reading. When the reader understands what he is reading, he needs to pay minimal attention to the process of converting the visual symbols into silent speech. He needs to recognize only a letter or two in a predicted word to verify his guess. Thus he usually fails to notice misprints, unless he is specifically looking for them. Even young readers can get the sense of a passage from a few key words, and often "read" words that are not on the printed page, but make sense.

I. CEREBRAL HEMISPHERES AND READING DIFFICULTIES.

The differentiation of the left and right sides of the brain is unique to humans. The left hemisphere usually contains

the speech center, and also controls the skilled right hand. The right hemisphere deals with visuo-spatial activities, such as matching a printed letter with its memory image. Klatzky (1970)(19) projected letters to the right and left hemispheres; the subject was asked to decide if the letter matched one in a set that had been shown previously. Reaction times were fastest when the letters were processed by the right hemisphere. Damage to the right brain may also interfere with the ability to return the eyes accurately to the beginning of the next line.

Many children with inadequate lateralization may have difficulty with verbal skills. Bryden (1970)(6) reported that boys with opposite lateralization of speech and motor functions may show a significantly higher proportion of poor readers than those with normal lateralization. Inadequate lateralization may cause reversals of letters and even syllables. Many boys with reading problems may perform well on spatial tasks. Bannatyne (1973)(1) found that such children did well on Picture Completion, Block Design and Object Assembly tests of the WISC. Many famous creative people have been left-handed. They may excel in painting, photography, sculpture, music, and higher mathematics, all of which appear to be right brain skills.

Mackworth and Mackworth (1974b)(24) found that there was no difference between good and poor readers in the ability to identify pictorial details by pointing; both groups showed a wide range of skill. When however students were asked to relate a simple word to a complex picture, the poor readers took longer than the good ones to decide that the word was not related to the picture.

Conclusions.

Reading involves the integration of many different parts of the brain. The young learner must be able to hear and

memorize the sounds and sequences of speech, and then he can learn to translate the printed symbols into the spoken word. This complex integration involves the spatial skills of the right brain as well as the sequencing ability of the left brain. Adult skilled reading makes less use of the inner speech mechanism, and more use of the ability to predict what will come next. The question "What is reading?" can only be answered by another question: "Who is reading what for what purpose?"

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