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ABSTRACT

The lengthy annotations in this bibliography of recent research on visual perception and its relation to reading are classified in four main groupings: (1) development of perceptio. of complex forms and attention to significant details, (2) the ability to perceive visual form in relation to reading, (3) perception of letters and words, and (4) sequential memory and sequential grapheme-phoneme correspondence. Works listed have been selected from well-known psychological and educational journals and from a few books. The items within the bibliography are placed in a logical order, that is, the annotations are so arranged as to relate to one another and to the sectional introductions. (Author/TO)

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# VISUAL PERCEPTION AND ITS RELATION TO READING

*An Annotated Bibliography*

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Revised 1973

Ramon Ross, *General Editor*

CONTENTS



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## INTRODUCTION

Although many of the topics covered in this bibliography are the same as those appearing in earlier bibliographies, there are some new and important developments. It appears from the studies analyzed that the difficulty experienced by young children in understanding complex forms may be associated with the inability to select the significant features which characterize essential form or meaning while disregarding minor or irrelevant details. Such a difficulty may prevent young children from abstracting the fundamental characteristics of letters and the letter groups which make up words and may hinder them in learning to read.

Certain young children seem to experience these difficulties to a greater extent than do others. But the studies described show that older children, even when backward in reading, may possess little inferiority to normal readers in average scores on tests of visual perception. These average scores, however, often obtained by children who are only slightly retarded in reading, should not cloud the fact that a few children, probably severely retarded, exhibit gross perceptual deficiencies [see clinical studies of Crosby and Liston, 1969]. Only by calculating frequency distributions of errors (not done in any of the experimental studies cited) would it be possible to demonstrate whether there are some older children whose reading retardation is essentially associated with deficiencies in the visual perception of form.

It seems possible that the most important achievement made by children as they learn to read is the recognition of particular letter groups rather than of isolated letters. The important investigations of this process, especially those by Gibson and colleagues, were cited in earlier bibliographies, and are repeated and added to here. The shapes of letters are learned at a fairly early age, but reading cannot become fluent until rules have been acquired for spelling groups of commonly associated letters. There is a stronger emphasis on the difficulty for children in 1) remembering correct order of letters in printed words and in 2) associating this spatial order with temporal order of phonemes in spoken words. Backward readers appear to exhibit general deficiency in sequential memory and matching, even at a considerable age, which may be the fundamental factor in severe reading disability.

The studies reported in this bibliography are summarized more fully than in earlier bibliographies. They are also classified differently, the current classification appearing to be the most appropriate for the recent publications, mainly those dating 1968-1972; though, as noted, some important papers from earlier bibliographies are also included. Works have been selected from well-known psychological and educational journals, plus from a few books. The latter are likely to be readily available except perhaps *Specific Reading Disability*, edited by Bakker and Satz; however, libraries should be encouraged to obtain this book.

The reader will find items within the bibliography placed in a logical, rather than an alphabetical, order: that is, the annotations are so arranged as to relate to one another and to the sectional introductions.

M.V.

## DEVELOPMENT OF PERCEPTION OF COMPLEX FORMS AND ATTENTION TO SIGNIFICANT DETAILS

It seems that children as young as 5 or 6 are not affected in learning to read by inadequacy in the perception of simple forms and that training with the latter has little effect. But the abilities to analyze these complex forms to detect significant details and to reconstruct forms from their parts may be deficient in children of any age. It is possible that this deficiency may be linked with inability to direct attention appropriately to significant details.

BECK, R., and W. TALKINGTON. "Frostig Training With Head Start Children," *Perceptual and Motor Skills,* 30 (1970), 521-522.

The first of two groups containing 15 Head Start children with average age just over 5 years and average IQ of 80 was trained for 20 minutes per day for 7 months on the Frostig Horne visual perception materials. The second group was given the normal Head Start type of activity. The first group showed greater average gain on the Frostig tests than did the second but the only significant difference between them on subtests was for position in space. Both groups improved about equally on the Peabody Picture Vocabulary test.

GREENBERG, J. W. "Synthesis and Analysis of Visually Perceived Forms by Young Children," *Perceptual and Motor Skills,* 34 (1972), 735-741.

80 kindergarten and first grade children of 5 to 7.5 years were required to 1) find the parts in fairly simple whole figures. 2) decide which of four figures could be constructed from parts shown previously, and 3) decide which of our groups of lines could be used to construct a whole figure. There were positive and significant correlations for all ages among the three tasks of analysis, synthesis, and constructive synthesis. Analysis was performed more correctly than synthesis. In the better performances there was more efficient and complete exploration of the figures, with greater attention to direction and relative size.

REED, S. K., and A. J. ANGARAN. "Structural Models and Embedded-figure Difficulty for Normal and Retarded Children," *Perceptual and Motor Skills,* 35 (1972), 155-164.

80 children, 20 in each age group of 6 to 7, 8 to 10, and 10 to 12 and 20 mentally retarded children of 11 to 16 years with IQs averaging 60, were required to trace simple figures embedded in complex ones. Mean response times decreased with age and were longer in the mentally retarded children than in even the youngest normal children. The times also increased with complexity of figures. The most significant correlations of response times were with the intricity of the complex figures and the number of contours

shared by all figures. These sources of difficulty affected the mentally subnormal and the youngest normal children to a greater extent than the older normal children, possibly through inefficiency of scanning strategies.

MACKWORTH, N. S., and J. S. BRUNER. "How Adults and Children Search and Recognize Pictures," *Human Development*, 13 (1970), 149-158.

Groups of adults and 6-year-old children were required to look at and recognize pictures of objects in a series ranging from blurred to clearly focused while eye movements were recorded.

The adults exhibited long eye movements about the field to detect the areas of high information content and then focused on them, while sometimes making further long movements to relate widely separated details. The children were much less systematic in scanning. They made few long movements but wandered about the field in small steps, sometimes passing over principal features. Sometimes the children appeared to eye one place, apparently reluctant to leave it. Thus, they did not deploy attention between general content and specific details. The children lacked precision in aiming, were slow in processing perceptual information, failed both to detect relevant features and to pass over irrelevant ones, and were unable to integrate features in order to arrive at the meaning of the picture. Thus, they were slower than adults in recognizing the more blurred pictures.

The children showed somewhat the same type of eye movement in reading whereas the adults were much quicker and more regular. It may, therefore, be that a real difficulty in learning to read is directing attention systematically toward the relevant aspects of the text.

## THE ABILITY TO PERCEIVE VISUAL FORM IN RELATION TO READING

**There is some disagreement** as to whether in older children reading retardation is associated with inability to perceive forms other than letters. The degree of relationship may vary with the type and complexity of the material. Memory tasks are more affected than are tasks involving only immediate perception.

The Bender test, using mainly the Koppitz system of scoring particular categories of error, is used extensively for investigating perceptual deficits which relate to reading retardation. The relationship seems to appear for only a limited number of these Koppitz categories and only in younger children; however, Bender (1970) states that it is the overall nature of the reproductions rather than the isolated categories which is important and that, furthermore, severely disordered reproductions may be obtained from severely retarded clinical cases.

BRUININKS, R. H. "Auditory and Visual Perceptual Skills Related to Reading Performance of Disadvantaged Boys," *Perceptual and Motor Skills*, 29 (1969), 179-186.

105 Negro boys of mean age 8.7 years and mean IQ 90 were given reading, auditory, and visual perceptual skills tests. All correlations between scores on the tests were low, but the correlations were significant for four auditory tests and two visual tests – embedded figures and perceptual closure. The correlation of reading with verbal intelligence was higher than any of the others, which were reduced when IQ was held constant. The correlations of reading with the matching of auditory and visual sequences were not significant, possibly because this test was too difficult for most of the boys. It was concluded that visual perceptual skills contribute little by comparison with intelligence in reading by boys of this age and IQ range. It would appear, however, that, as in other studies, performance on the embedded figures test had some significance for reading.

STUART, I. "Perceptual Style and Reading Ability," *Perceptual and Motor Skills*, 24 (1967), 135-138.

47 children in grades seven and eight, being above average in reading (average grades score 9.5), made significantly higher scores on the Witkin embedded figures test than did 36 children below average in reading (average grade score 4.4).

LEIDER, A. B. "Relationship of Visual Perception to Word Discrimination," in H. M. Robinson and H. K. Smith (Eds.), *Clinical Studies in Reading, III*, Supplemental Educational Monograph, 97 (1968), 104-108.

70 children, aged 8.5 to 10.5 with intelligence in the normal range but an average grade reading score of only 5.4, were given three tests of strength of closure: 1) drawing missing lines in patterns of increasing complexity, 2) detecting the reversal of the whole or a part of one of each pair in a series of pictures, and 3) selecting two identical pictures from a set of nine. Tests one and two correlated, as with reading achievement, but three did not. One and two also showed high correlations with mental age. Thus, intelligence may have had more significance for reading than had strength of closure.

LYLE, J. G., and J. GOYEN. "Visual Recognition, Developmental Lag, and Strephosymbolia in Reading Retardation," *Journal of Applied Social Psychology*, 73 (1968), 25-29.

Ten 7-year-olds retarded in reading by at least 9 months and ten 9-year-olds retarded by at least 18 months, were compared with matched normal readers on immediate and delayed recognition of the following, previously presented tachistoscopically: 15 letters of the alphabet; 15 shapes, simpler in form than letters; and 15 line drawings of outlines of words. There were correlations of 0.5-0.6 between scores on these tests and scores on a test of word recognition. The retarded readers were inferior to the normal readers on all of these tests, but this inferiority was less in the older children. It was suggested that the developmental lag seen in the younger had largely disappeared in the older.

However, the degree of reading retardation appears insufficient to warrant any reliable conclusions; there is no evidence of strephosymbolia.

LYLE, J. G. "Reading Retardation and Reversal Tendency: A Factorial Study," *Child Development*, 40 (1969), 833-843.

18 boys, 6.75 to 12.5 years of age with average intelligence, were selected from each of the six primary grades. Half were retarded in reading, from one-half year in grade one to three years in grade six. All children were given tests of reading and writing reversals, spelling, Memory-for-Designs (Graham and Kendall), WISC, arithmetic, finger agnosia, and lateral dominance. Correlations of scores were submitted to a principal components analysis and other factorial measures. The first factor extracted showed high loadings on reading, letter and sequence reversals in reading, and letter reversals in writing (which decreased with increasing age) and a moderate loading on Memory-for-Designs, scored to a considerable extent for reversals. The factor was claimed to be related to perceptual and perceptuomotor distortion.

But it could be argued that these tests depend mainly on perception and reproduction of sequential order.

VAN MEEL, J. M., C. A. J. VLEK, and R. M. BRUIJEL. "Some Characteristics of Information Processing in Children with Learning Difficulties," in D. J. Bakker and P. Satz (Eds.), *Specific Reading Disability.* Rotterdam University Press, 1970, 97-114.

Three groups of 10 children each, aged 7 to 9, 9 to 10.5, and 10.5 to 12, respectively, who were severely retarded in reading and writing, were matched with three groups of normal readers. They were required to match six patterns, projected tachistoscopically, against one of a set of patterns which differed from the standard in two to five dimensions; the number of alternatives in the set equaled the number of dimensions of difference. Discrimination in terms of the amount of information processed improved with age. For normal readers in the two older age groups discrimination also increased with the number of dimensions; but for the youngest age group of normal readers and for the retarded readers it leveled off with more than two dimensions. Older retarded readers were less capable of perceiving and remembering more complex form relationships.

BECKER, J. T. "Spatial Orientation and Visual Discrimination," *Perceptual and Motor Skills,* 31 (1970), 943-946.

64 children of average age 6 with normal intelligence were placed in two groups, one making four or more errors of spatial orientation on the Bender test and the other making one or no errors. The children were then required to match standard words against four variables containing the same letters in different orders. The first group performed significantly worse than the second. Thus, it appeared that inaccurate spatial orientation in Bender test reproductions was related to inferiority in perception of order of letters in words.

SABATINO, D. A., and J. E. YSSELDYKE. "Effects of Extraneous 'Background' on Visual-perceptual Performance of Readers and Nonreaders," *Perceptual and Motor Skills,* 35 (1972), 323-328.

From 342 children, aged 6.5 to 12.5 years, of normal intelligence who had been graded below average on the Berry Perceptual test, a group of 199 normal readers and a group of 143 poor readers were selected on the basis of reading comprehension and word recognition test scores. They were presented individually with the Bender test, one figure at a time. There were no significant differences between normal and poor readers on Koppitz scores either with direct copying or in reproduction from memory; but when the figures were embedded in meaningless backgrounds of lines and dots, or were printed in white on black backgrounds with certain parts obscured, poor readers performed significantly worse than normal readers.

It is possible that the lack of difference in direct and memory reproduction

resulted both from the selection of children who were all poor in visual shape perception and from the method adopted of presenting one Bender test figure at a time.

WEDELL, K., and L. E. HORNE. "Some Aspects of Perceptuo-motor Disability in 5-1/2-year-old Children," *British Journal of Educational Psychology*, 39 (1969), 174-182.

From 150 children of 5.5 years were selected 20 obtaining the highest scores on the Bender test (Koppitz scoring) and 20 obtaining the lowest scores. The candidates were required to identify six simple patterns from transformations, to trace the patterns, to copy them by drawing, and to copy them with plasticine strips. The children were tested a year and a half later with copying by drawing, spelling, and sentence copying tasks. The high scorers on the Bender test were significantly superior than the low scorers on all the initial tests except copying by drawing and on all the follow-up tests. It was concluded that the low scorers were not deficient on all the components of the Bender test but were impaired in the spatial organization of voluntary movement.

This conclusion suggests that the low scorers could not control their hand movements in such a way as to produce correct Bender reproductions. It is difficult to see what evidence there is for this conclusion since these children were also inferior in identifying and in tracing. It seems more probable that their perception of spatial organization was inadequate.

NIELSEN, H. H., and K. RINGE. "Visuo-perceptive and Visuo-motor Performance of Children with Reading Disabilities," *Scandinavian Journal of Psychology*, 10 (1969), 225-231.

20 Danish children, aged 9 to 10 with normal intelligence and in remedial reading classes, were matched with 20 normal readers. The former obtained significantly higher scores than the latter on the Bender test, Koppitz scoring; but of the Koppitz categories, only rotation showed a significant difference. There were no significant differences on the Draw-a-Man and Frostig tests. It is probable that the Bender and the other perceptual tests do not differentiate good and poor readers at this age.

OBRZUT, J. E., H. D. TAYLOR, and R. C. THWEATT. "Reexamination of Koppitz' Developmental Bender Scoring System," *Perceptual and Motor Skills*, 34 (1972), 279-282.

289 children, aged 6 to 12 in grades one, three, and six, were given the Bender test individually and also tests of word recognition and understanding paragraph meaning. The correlations between the test scores were too small for prediction of reading achievement from the Bender test; correlations be-

tween total Koppitz scores and scores on the two reading tests were low, of the order of 0.3. No Koppitz item discriminated between good and poor readers at all ages; the most discriminative were rotation and integration. The number of discriminating items decreased with age.

BENDER, L. "Use of the Visual Motor Gestalt Test in the Diagnosis of Learning Disabilities," *Journal of Special Education*, 4 (1970), 29-39.

The author deprecated the scoring of discrete items on the Bender test and maintained that the whole set of figures should be treated as an integrated group. Exemplifying her argument by several case histories, she concludes that the following characteristics appear in order of maturation: 1) control of circular movement; 2) figure-ground differentiation; 3) and 4) correct horizontal and vertical orientation, including the arrangement of the figures on the page; 5) correct diagonal orientation; and 6) differentiation and separation of figures and their parts and correct relationship of parts to wholes. The later characteristics in particular tended to show primitiveness when there was a maturational lag, such as occurs in dyslexic children.

CROSBY, R. M. N., with R. A. LISTON. *Reading and the Dyslexic Child.* London: Souvenir Press, 1969. (First published as *The Waysiders.* New York: Delacorte Press, 1968.)

Numerous case histories are cited of dyslexic children, with and without neurological impairment, who produced severely disordered Bender test reproductions. The illustrations of these are useful in showing how such children may perform this test.

GREDLEY, G. R. "Severe Reading Disability – Some Important Correlates," in J. F. Reid (Ed.), *Reading and Its Problems.* London: Ward Lock Educational, 1972, 142-160.

This article provides both a useful summary of investigations into perceptual deficits found in dyslexic children and an assessment of their significance. Many reports on investigations not generally available are included. It is emphasized that visual perceptual ability operates most strongly in the early stages of learning to read and that this deficiency is not the sole factor producing dyslexia but combines with other deficiencies.

## PERCEPTION OF LETTERS AND WORDS

Many studies have been performed by Gibson and colleagues on the discrimination and confusedness of letters and shapes similar to letters. Even quite young children, according to testers, are able to extract the invariant characteristics of letters and letter groups and discriminate these from unimportant variable characteristics. However, this task is more difficult to do from memory than in immediate perception. At first Gibson thought that certain letter groups were readily recognized because they were pronounceable, but later she concluded that children acquired and utilized rules of spelling of familiar letter combinations.

Numerous studies have also been made of the tendency to confuse similar words. It appears that little attention is given to similarity of shape of the words, but much more confusion occurs when words have identical first or last letters. Thus, it appears that children tend to recognize words in the first place from certain outstanding letters. The evidence as to confusion between words with the same letters in reversed order is inconclusive. But studies cited in the next section indicate that the perception and remembering of sequential order of letters in words may be important in learning to read.

GIBSON, E. J. et al. "A Developmental Study of the Discrimination of Letter-like Forms," *Journal of Comparative and Physiological Psychology*, 55 (1962), 897-906.

167 children aged 4 to 8 were each required to select 12 shapes from among 12 transformations: from line to curve or vice versa; from a complete line to a broken line; by rotation and reversal; and by slanting, as in perspective. Mean errors decreased from 58 percent at 4 years to 20 percent at 8 years but with considerable differences between types of transformation. Errors of break and close were few throughout. Errors of line and curve and of rotation and reversal decreased greatly from 4 to 8 years. Errors of perspective slant were high throughout.

The younger children, who could not read but were familiar with letters, were tested in the same way with 12 capital letters and similar transformations of each. Errors were fewer but of the same types. and their frequencies correlated highly with those for letter-like forms.

It should be noted that, although an important experiment, it relates to the discrimination of forms and letters presented simultaneously with their variants whereas in reading, children are required to identify from memory letters which may be presented with minor variations, usually slighter than those of the foregoing transformations.

TRIESCHMANN, R. B. "Undifferentiated Handedness and Perceptual Development in Children with Reading Problems," *Perceptual and Motor Skills*, 27 (1968), 1123-1134.

60 boys aged 7 to 9 of normal intelligence, half of whom scored above and half below grade placement in reading, were required to match the standard Gibson letter-like forms against the transformations in delayed recognition. The retarded readers made significantly more errors than the normal readers, especially of rotation, reversal, and perspective. But even in normal readers these types of errors were fairly frequent at this age because matching from memory, and not in immediate perception, was employed.

GIBSON, E. J., F. SCHAPIRO, and A. YONAS. "Confusion Matrices for Graphic Patterns Obtained with a Latency Measure," in H. Levin, E. J. Gibson, and J. J. Gibson (Eds.), *The Analysis of Reading Skill.* Final Report, Project No. 5-1213, U.S. Department of Health, Education, and Welfare, 1968, 76-96.

Groups of 96 adults and 60 7-year-olds were presented with 9 capital letters in pairs and 9 shapes similar to the letter-like forms of Gibson, et al, 1962. The various shapes contained somewhat the same features as the letter pairs. Subjects were required to say whether the two members of a pair were the same. The latency of responses and the number of errors were measured; the two measures correlated. Pairs differing in many features were more quickly and accurately detected than were those with many similar features. The children were slower than the adults but utilized much the same distinguishing features: curved vs. straight lines; diagonal vs. vertical vs. horizontal lines; intersecting lines; and closed vs. open curves. The children, however, discriminated among diagonal lines less readily than did the adults and, therefore, tended to confuse *M* with *N* and *M* with *W*. It was concluded that differentiation of letters depends principally on distinguishing features.

It is not possible to infer whether the same conclusions are applicable to lowercase letters, which are more important in learning to read.

GIBSON, E. J., H. OSSER, and A. D. PICK. "A Study of the Development of Grapheme-phoneme Correspondences," *Journal of Verbal Learning and Verbal Behavior*, 2 (1963), 142-146.

Two groups of 24 children each – one group at the end of the first grade and the other at the end of the third grade – were presented tachistoscopically with 3- and 5-letter words and pronounceable and unpronounceable 3-, 4-, and 5-letter pseudowords (nonsense words), all in capital letters. In all cases more words than pseudowords of the same length and more pronounceable words than unpronounceable pseudowords were read and spelled correctly. First grade children, however, could read only the 3-letter pseudowords. It

was concluded that even first graders had acquired some grapheme-phoneme associations in pronounceable groups, irrespective of their inclusion in words. These associations were more highly developed in the third grade children.

GIBSON, E. J., R. SHURCLIFF, and A. YONAS. "Utilization of Spelling Patterns by Deaf and Hearing Students," in H. Levin, E. J. Gibson, and J. J. Gibson (Eds.), *The Analysis of Reading Skill.* Final Report, Project No. 5-1213. U.S. Department of Health, Education, and Welfare, 1968, 14-38.

Pseudowords of 4 to 8 capital letters, varying in ease of pronounceableness, were presented tachistoscopically to 34 deaf and 34 audient adult students. Ease of pronounceableness was correlated with the number of errors in much the same way for the deaf as for the audient students. Length of pseudowords was also a significant factor, but digram and trigram frequencies were not significant to any great extent. It was concluded that familiar rules of spelling are operative in producing easily perceptible "chunks" of letters. These rules had been acquired by the deaf with actual instruction in them.

It should be noted that in this experiment the reading of presumably fluent adults was governed by spelling rules rather than by pronounceableness of phoneme combinations. But it could be that audient children, who commonly learn to read at an earlier age than deaf children, do utilize familiar phoneme combinations.

GIBSON, E. J. "The Ontogeny of Reading," *American Psychologist,* 25 (1970), 136-143.

This is an excellent paper, summarizing and commenting on the learning-to-read investigations performed by Gibson and colleagues; it should be studied by all those interested in children's reading.

In a new study, it was shown that digrams embodying common spelling patterns, such as *ng, ea, ch,* had been acquired by few kindergarten children but by half of a group of first grade children, with improvement ensuing up to the third grade. These children were able to sort words into categories corresponding to the different digrams. One group of first grade children was given preliminary instructions telling them which digrams would appear in the words. A second group was told that some of the same pairs of letters would appear in the words but not which letters; and a third group was given no instructions. The first group learned to sort quickly and the third group, slowly. The second group did badly at first but soon learned to perform as well as the first group; and in a post-test, the second group performed better than the first. It was concluded that the second group was capable of searching for invariant spelling patterns in words even without knowing beforehand the letters involved.

TIMKO, H. G. "Configuration as a Cue in the Word Recognition of Beginning Readers," *Journal of Experimental Education*, 39 (1970), 68-69.

40 first grade children were required to match trigrams of lowercase letters in delayed recognition. Trigrams with the same first letter were most often confused, followed by those with the same last letter; but there was no confusion of general shape as constituted by ascending and descending letters.

WILLIAMS, J. P., E. L. BLUMBERG, and D. V. WILLIAMS. "Cues Used in Visual Word Recognition," *Journal of Educational Psychology*, 61 (1970), 310-315.

17 kindergarten and 15 first grade children, who had had no instruction in reading or letter recognition, were required to match pseudowords of 3 and 5 lowercase letters against groups of pseudowords which matched the former in general form or had the same letter somewhere. The kindergarten children showed no consistent cue selection in matching. The first grade children matched predominantly by means of the first letter and then the last, but seldom employed overall shape.

TIMKO, H. G. "Letter Position in Trigram Discrimination by Beginning Readers," *Perceptual and Motor Skills*, 35 (1972), 153-154.

31 first grade children, in the first month of the school year, were required to match trigrams of lowercase letters, in delayed recognition, against one of four alternatives, three of which contained the same letters in a different order. Reversed (mirror-image) alternatives were chosen significantly less often than other orders of letters. Thus, mirror-image reversals appear to produce less difficulty for beginning readers than do other types of difference in ordering of letters.

BONSALL, C., and R. L. DORNBUSH. "Visual Perception and Reading Ability," *Journal of Educational Psychology*, 60 (1969), 294-299.

Three groups of 10 normal and 10 retarded readers each, were selected from grades two, four, and six. In grade two, retardation averaged 1.2 grade norms; in grade four, 3.1; in grade six, 3.6. The children were required to discriminate tachistoscopically between pairs of words and pseudowords of 4 lowercase letters and between the same combinations of letters in reversed order. Performance improved with age, but there were no significant differences between normal and retarded readers. It was concluded that discrimination of reversed order is not relevant to reading ability at these ages.

It should be noted that reversal of order of letters in reading and writing may appear in younger children with severe reading disability although it is uncommon among older ones.

## SEQUENTIAL MEMORY AND SEQUENTIAL GRAPHEME-PHONEME CORRESPONDENCE

It appears that young children may lack the ability to search the field systematically and, hence, to report items in correct sequential order (probably due to incapacity to direct attention, noted in the first section). But deficiencies in memory for order of items in sequences may be more significant and persist to a later age. Both spatial and temporal order are important.

The correspondence between spatial order of letters in printed words and temporal order of phonemes in spoken words may present particular difficulty. Young children may be deficient in ability to match spatial and temporal order in series of meaningless stimuli, and backward readers may exhibit the same deficiency until a later age. Some investigators consider that matching depends on the use of words to describe verbally the grouping of items in sequences, but unfortunately there seems to be no direct evidence of association between difficulties in cross-modal matching of meaningless stimuli and inferiority in remembering order of letters in words.

GOTTSCHALK, J., M. P. BRYDEN, and M. S. RABINOVITCH. "Spatial Organization of Children's Responses to a Pictorial Display," *Child Development*, 35 (1964), 811-815.

63 children aged 3.3 to 6.3 years were required to name 20 familiar objects, pictures of which were arranged in 5 columns and 4 rows. The order of report was seldom systematic in the younger children but became better organized with increase in age, when report began at one of the four corners of the display. A few of the older children reported from left to right and from top to bottom, in order of reading; some had actually begun to read. It was concluded that systematic order in scanning does not develop until 4 to 5 years and that scanning from left to right and top to bottom might be a consequence of learning to read. It should be noted, however, that the children's actual reading achievement was not ascertained.

BAKKER, J. D. "Temporal Order, Perception, and Reading Retardation," in D. J. Bakker and P. Satz (Eds.), *Specific Reading Disability*. Rotterdam University Press, 1970, 81-96.

Descriptions are given of 3 unpublished investigations of sequential memory in backward readers. In the first, groups of 30 boys, age 7, and 26 boys, age 10, from normal primary schools were divided into above median score and below median score on a reading test. They were presented with temporal sequences of meaningful and meaningless figures and required to report the order of these subsequently. Among the younger boys, but not the older, good readers gave significantly more correct responses than poor readers with

meaningful but not with meaningless figures. Thus, it appears that verbalized sequential memory for figures is significantly related to reading at age 7 but not at age 10.

In the second experiment, 10 boys and 10 girls from normal primary schools were randomly selected at each year from ages 7 to 11; and 15 boys with an average reading retardation of 3.5 years from schools for children with learning difficulties were selected at each year from ages 9 to 13. Temporal sequences of 3 letters were presented in the visual, auditory, and haptic modes; and the children were required to report their order subsequently. The normal readers improved in accuracy of report up to the age of 8 or 9 and then leveled off; the retarded readers, showing an average lag of about 3 years, improved throughout but were significantly inferior to the normal at all ages and in each sensory mode. Among the normal readers, girls performed better than boys at 7 to 8 years but not thereafter.

In the third experiment, 30 children of 7 years were placed in two groups according to whether they made above or below average numbers of errors in remembering the temporal sequential order of letters and meaningful figures. In reading, the former made about four times as many errors of order of letters and words as the below average ones although other errors were about the same in the two groups. Thus, it appears that inferiority in remembering temporal sequences is associated with inability to order letters correctly in reading.

DOEHRING, D. G. *Patterns of Impairment in Specific Reading Disability.* Bloomington, Indiana: Indiana University Press, 1968.

39 boys aged 10 to 14, of normal intelligence but retarded in reading by 2.8 years, were matched with 39 normal readers, given a large number of tests, and submitted to neurological examination. After their case histories were studied, 79 measures were obtained. The retarded readers were inferior to the normal on most tasks related to reading and spelling although they did not show any excess of reversals. These boys were not deficient in the perception and recall of letter and number series but were inferior in the rapid location and reproduction of them, in appreciation of rhythms, and in the task of sequential ordering which required them to connect scattered numbered circles in numerical order. The test scores were factor analyzed, and the chief factor of reading-spelling deficit was found to be related to measures of visual and auditory sequential processing. Some cases showed greater visual than language deficits in reading and others, the reverse; but in general there was an interaction of visual and verbal disabilities. It was concluded that the fundamental deficiency in retarded readers is inability to deal with a chain of associated events while keeping in mind the characteristics of the entire sequence.

This is an important and thorough study which indicates the fundamental nature of the defects likely to be encountered in older, severely backward readers. It is possible that the absence of specific visual and auditory defects and of reversals in reading was due to age, for even though retarded, the children had outgrown these; whereas their inferiority in sequential processing remained.

GOODNOW, J. J. "Matching Auditory and Visual Series: Modality Problem or Translation Problem?" *Child Development,* 42 (1971), 1187-1201.

Kindergarten children of good intelligence were found to be unable to choose which of two series of dots matched a sequence of taps although the children were slightly more proficient in reproducing the sequence of taps by tapping. The kindergarten children and some first and second grade children also found it difficult to reproduce patterns of taps in patterns of dots, and particularly to reproduce the auditory intervals by visual spaces; some kindergarten children made pauses while drawing their dots. Even harder was producing a sequence of taps to match a series of dots although performance improved between the beginning and the end of the second grade. Some of these children spaced out their taps spatially along the table. Thus, there was difficulty in the control of order and in recognizing the correspondence between spatial and temporal intervals. It could also be inferred that it was the transposition of temporal to spatial order, and still more of spatial to temporal order, which gave rise to difficulties in children of these ages.

KLAPPER, Z. S., and H. G. BIRCH. "Developmental Course of Temporal Patterning in Vision and Audition," *Perceptual and Motor Skills,* 32 (1971), 547-555.

196 children, aged 3 to 11, were presented visually with sequences of successive flashes of light and auditorily with the same sequences of successions of clicks to be matched subsequently against one of a set of visual and auditory sequences, respectively. At 3 years, children could not perform these tasks, but they began to comprehend them at 4 years, although competence was slight. It increased steadily from 4 to 10 years. Visual sequences were less well matched than auditory sequences, possibly because children are more familiar with auditory than with visual temporal sequences. The correlations between the two scores were low and not significant. It thus appears that the mechanisms involved in information handling of this type are modality specific.

KAHN, D., and H. G. BIRCH. "Development of Auditory-visual Integration and Reading Achievement," *Perceptual and Motor Skills,* 27 (1968), 459-468.

350 children in grades two to six were required to match sequences of taps against 1 of a set of 3 dot patterns presented subsequently. The 10 highest

and 10 lowest scorers were also required to match dot patterns against 1 of 3 presented subsequently and to reproduce tapped rhythms. Auditory-visual matching improved with age and correlated significantly with reading achievement even when IQ was held constant. But the differences between the high and low scorers on the visual-visual and auditory-auditory tests were not significant. Thus, it was concluded that all the children were capable of performing these tasks. The children were required subsequently to describe how they had performed the auditory-visual task. Although the amount of verbalization employed increased with age, it was not associated with auditory-visual performance; thus good performance did not depend on ability to verbalize and to give verbal labels to the items of the sequences.

BLANK, M., M. S. WEIDER, and W. H. BRIDGER. "Verbal Deficiencies in Abstract Thinking in Early Reading Retardation," *American Journal of Orthopsychiatry*, 38 (1968), 823-835.

12 retarded readers, aged 6.4 to 7.3 with normal intelligence, were matched against 12 normal readers. The mean score of the retarded readers on a word recognition test was 1.5, and 2.7 for the normal readers. The subjects were required to select visual spatial patterns that matched. They also matched temporal sequences of lights and dot patterns and reproduced sequences of taps. They had to describe the temporal sequences verbally. The retarded readers performed no worse than the normal on the visual spatial patterns nor in matching dot patterns or reproducing rhythms of taps; but they were inferior in matching dot patterns against temporal sequences of lights, which they all reported as coding verbally. The retarded readers were inferior in labeling temporal sequences and describing them verbally, tending particularly to omit the pauses which spaced out the temporal sequences. It was concluded that it is abstract verbal coding of temporal patterns which is deficient in the retarded readers, not cross-modal auditory-visual matching.

It is not clear why the results of this experiment differ from those of the previously cited experiment on the effects of verbal labeling; the number of subjects, however, was rather small.

CASHDAN, A. "Backward Readers – Research on Auditory-visual Integration," in J. F. Reid (Ed.), *Reading – Problems and Practices.* London: Ward Lock Educational, 1972, 166-185.

Cashdan reports on an experiment carried out by a research student, who selected a group of 22 children, 9 years of age, with average reading age of 6.5 years, and matched them for age, sex, socioeconomic status, and nonverbal intelligence against 22 good readers. The children were required to match sequences of auditory taps against dot patterns presented subsequently. Half the children in each group were "instructed"; that is, the tester gave a verbal

description of the auditory sequences, such as "That was 2 taps and then 2 taps," before exposing the dot patterns. The instructed and uninstructed good readers performed equally well. The instructed poor readers performed less well than the good readers, but the uninstructed did even worse. It was thus concluded that the main difficulty of the poor readers was in attending to and labeling rhythms, rather than in auditory-visual integration as such.

VERNON, M. D. *Reading and Its Difficulties: A Psychological Study.* New York: Cambridge University Press, 1971.

This book includes discussions of research work up to 1970 on the development of visual perception and its relation to reading, the perception and remembering of words, letters and sequential grapheme-phoneme correspondence, and the disorders of perception in dyslexic children.

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