VISUAL DISCRIMINATION OF ALPHABET LETTERS BY PRE-SCHOOL CHILDREN

by

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B.A., University of British Columbia, 1967

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in the Department of
EDUCATIONAL PSYCHOLOGY

We accept this thesis as conforming to the
required standard

THE UNIVERSITY OF BRITISH COLUMBIA
September, 1970

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ABSTRACT

The purpose of the present study was to ascertain from the research literature on alphabet legibility and geometric form discrimination what minimum number and nature of changes could be made to the letters b, d, p and q to increase the ability of preschool children to discriminate vertical, horizontal and rotational changes in orientation of the letters.

In accordance with the research evidence the stem of each letter was replaced by a solid black, right-angle triangle. For each letter the smallest angle of the triangle was uppermost, the right-angle was in the bottom left-hand corner, and a small white circle was imbedded in the right-angle. The base of the triangle was equal in width to the diameter of the eye of the letters.

To test the hypothesis that for preschool children horizontal, vertical and rotational changes in orientation of the modified letters would be more discriminable than identical orientation changes of the standard letters a four-to-one match to sample format was used. In this format one stimulus letter was to be matched with an identical letter contained within a matrix of three letters each depicting a different orientation of the stimulus letter. Kindergarten children between the ages of 4.6 and 5.6 were selected in terms of their performance on two screening tests. Thirty-six children were included in the sample with 18 subjects in each treatment group.

One screening test used simple geometric shapes to assess the child's fundamental understanding of the concept of

similarity, and his ability to respond adequately to the four-to-one match to sample format. The second screening and training test reinforced the child verbally and with candy to attend to orientation cues; the subject was required to manually reorient a response figure to match in sequence a number of sample figures each of which represented one of the three alternative orientations.

The subjects were then given an error base-rate test of twenty-four, four-to-one match to sample formats comprising all permutations of the standard letters b, d, p and q. In accordance with their scores on this test (total number of correct discriminations) subjects were assigned by the randomized blocks design to the control and experimental groups. For the treatment, the control group was given the pretest again while the experimental group was given a test in identical format using the modified characters.

Statistical analysis of the gain scores (number of correct discriminations on the treatment test minus number of correct discriminations on the error base-rate test) indicated that the modified letters significantly improved discrimination of orientational changes at the .025 level of significance, and that no significant difference existed between the performance of males and females.

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ACKNOWLEDGEMENTS

I wish to acknowledge the readily accessible, constructive, and friendly guidance of the members of my committee, Dr. J. Conry (Chairman), Dr. H. M. Covell, and Dr. R. Conry.

DEDICATION

This thesis is dedicated to my mentors (Mr. and Mrs.) Geoffrey and Christine Benny whose undaunted pursuit and sharing of knowledge shall always be an inspiration to me.

David Bain

CHAPTER I

INTRODUCTION TO THE PROBLEM

The ability to read well is fundamental to progress in formal academic learning. Although "one of the most basic features of a reading program is the ability to discriminate the letters of the alphabet (Blair, 1969)," "reversal errors in letter discrimination persist until at least seven years of age (Hall, 1968)," in many cases following two years of schooling. For some children, unable to learn to read through conventional teaching methods, the problems of letter confusion and reversal may continue for a much longer period of time and frequently the resulting frustration is reflected in other areas of the child's life. One of the major problems confronting the child beginning to read concerns discrimination of the letters b, d, p and q which as Money (1966) has shown are the most directionally confounded letters of the alphabet.

The first controlled experiments concerning the relative legibility of the letters of the alphabet were conducted in 1885 (Sanford, 1888). Considerable data related to the perception of alphabetic forms has been accumulated since that time. The sans serif font has been adopted to conform to the style of print by which children are commonly taught. Apart from this change, however, little use has been made of the research evidence to increase the discriminability of the letters of the alphabet.

The thesis of the following discussion is that there is sufficient evidence in the literature to indicate that minimal

temporary changes can be made to increase the discriminability of the letters b, d, p, and q in their introduction to kindergarten and primary level children. Further, that these changes are such that once they have caused improvement in discrimination of the letters, the changes may be progressively and systematically decreased permitting the letters to conform to their conventional form.

REVIEW OF THE LITERATURE

Characteristics of Letters of Type

Familiarity with the characteristics of letters of type is essential to understanding some of the problems inherent in a study of this kind. The following definitions have been summarized from Zachrisson (1965) and Bigelow (1967).

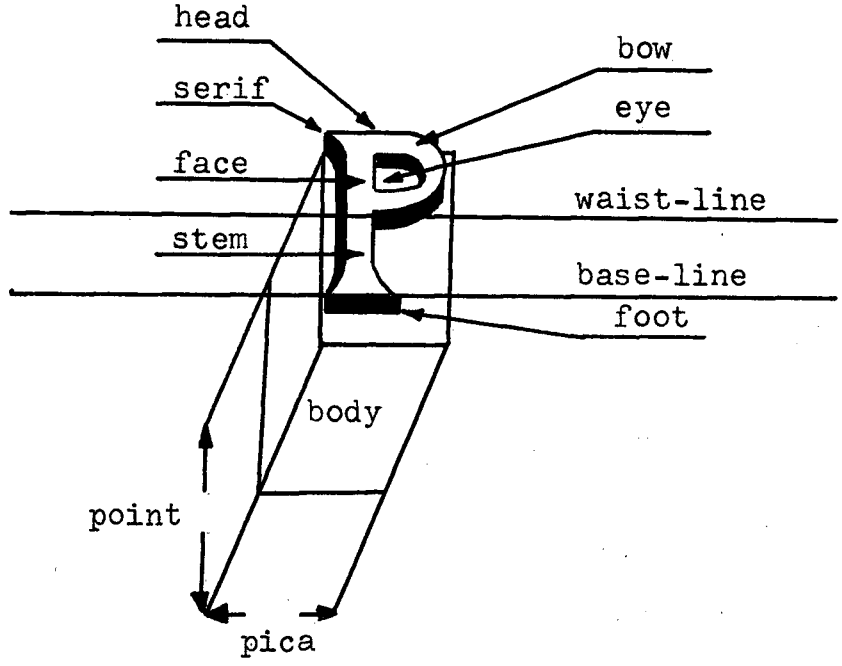


FIG. 1: Characteristics of Letters of Type

face - the surface of a piece of type that imprints ink.

waist line - horizontal line slightly above mathematical centre of the face or stem.

stem - vertical member from base-line to head.

ascender - that part of the stem rising above the waist line.

descender - that part of the stem falling below the base line.

bow - curved member enclosing open area or eye.

stroke - width of stem or bow.

serif - finishing flair at head and/or foot of stem; may be triangular, curved or straight line.

sans serif - type without serif.

body - metal or wooden base upon which type is seated and which limits maximum size of the letter.

point - vertical length of the body; 72 points = 1 inch.

pica - horizontal width of the body; 6 pica = 1 inch.

Note: point and pica refer to the length and width of the body and not to the actual size of the letter. There are types that have a larger design in 10-point than others have in 12-point (Zachrisson, 1965).

font - all the characters in one size and type family.

Roman - classification of types with thick and thin strokes (verticals are generally thick while horizontals are thin; diagonal strokes thicken as they move to the right and thin as they move to the left; may or may not have serifs).

Gothic - classification of types with uniform face (horizontal, vertical and diagonal strokes have equal width; usually without serif).

Classification of Errors

The confusion of b, d, p and q, the most directionally confounded letters of the alphabet (Money, 1966), is reflected in the various titles that have been used to describe the phenomena. For example, Hendrickson (1962) discusses inversions; Popp (1964) referred to horizontal, vertical and diagonal disorientations; Money (1966) examined push-pull and left-right mirror rotations, while Blair (1969) described rotation and reversal transformations,....

The direction of the change in orientation--vertical, horizontal, clockwise or counter-clockwise--should be precisely and consistently described for clearer understanding of the processes involved and the possible remediation that might be made.

The following definition of terms is proposed:

Standard	d	p	q	b	Disorientations	Name
Product	q	b	d	p	180° Up or Down	Vertical Disorientation
	b	q	p	d	180° Lt. or Right	Horizontal Disorientation
	p	d	b	q	180° Clockwise or Counterclockwise	Rotational Disorientation

FIG. 2: Classification of Orientation Errors

Of the three types of disorientations the horizontal q to p or p to q, and d to b or b to d are the most common (Money, 1966). Davidson (1935) in a study of 5-6 year old children found the following error rates for b, d, p and q confusions:

horizontal 79-88%, vertical 26-33%, and rotational 33-43%. Blair (1969) suggests that although the types of errors and their relative frequency of occurrence have remained constant over the past forty years the total number of errors has decreased appreciably.

Etiology of the Problem

The origin of the disorientations has been variously ascribed.

1. Orton (1928) suggests that disorientations might be caused by a lack of cerebral dominance (cited in Davidson, 1935). Dearborn (1929) and Munro (1932) believed that the perceptual problems were associated with left handedness and eyedness. Hillerick (1963, in Karraker, 1968) found that "older subjects (age not reported) from non-clinical populations typically do not demonstrate any significant relationships of reading disability and lateral dominance." Karraker (1968) using an adaptation of the Harris Test of Lateral Dominance with children aged 5.5-6.6 found that lateral dominance was not related to discrimination learning of the letters "b" and "d".

2. Some authors have suggested that speech, hearing or neurological impairment or a lack of neural maturity may be sources of the problem (Hildreth, 1932; Ilg, 1950, cited in Hall, 1968).

3. Hall (1962) suggested that the problem might be attributed to an insufficient understanding of the concept of similarity or sameness, and in 1968 concluded from his experiments that the understanding of sameness was more important than the attention factor.

4. Hendrickson (1962) suggested that preschool and early school age children lacked left and right as meaningful directional labels in their vocabularies.

5. Hendrickson further postulated that with preschool or primary children there was a failure to focus sufficient attention or to recognize the importance of changes in orientation inspite of the ability to discriminate these changes. His experimentation with kindergarten children in pretraining them to attend to the directional differences between the letters b and d facilitated learning the names of these letters in a paired associates task.

The research has thus far failed to confirm that any specific organic, neurological or perceptual anomaly is responsible for the difficulties experienced by many young children in discriminating orientation changes in alphabet letters.

The Laws of Object and Directional Constancy

Perhaps the most plausible explanation for the phenomena has been offered by Money (1966) and Alexander (1967) who suggest that the pre-reading child has not adequately learned to use the perceptual laws of object and directional constancy.

The Law of Object Constancy "The pre-reader learns during all the years of his pre-school experience that any object has the same name, meaning or symbolic value regardless of changes in its directional orientation or rotation in space, and despite the addition, removal, or translocation or camouflage of component parts.

Later the child must learn that this law does not fully apply to the letters of the alphabet and that a new law must be learned."

The Law of Directional Constancy "Letters of the same shape have the same symbolic value only if their directional orientation is identical." The three types of disorientations described above are not permitted. However, there are exceptions such as "x" and "o" that can be rotated in any direction without change in identity, while the letters S, V, B and H can be rotated in some directions but not in others. In addition to the exceptions there are other sources of confusion such as upper and lower case letters, differences in font style and print versus cursive type.

Legibility Studies

Numerous studies, principally by Tinker (1963) and Zachrisson (1965), have been conducted on the relative legibility of various types of print. These researches, primarily with adults, have employed three different experimental techniques to establish error rates of recognition: (a) varying the distance between the subject and the letter stimulus, (b) varying the interval of tachistoscopic presentation of the letter stimulus, and (c) presenting the stimulus to the periphery of the subject's vision.

A number of variables have been studied in these experiments to ascertain which factors most affect legibility.

1. Size of type. Sanford in 1888 wrote that legibility would be favoured by enlarging the size and increasing the differences of the letters. McNamara (1953) stated that the size of type affects speed of reading, but that speed is not an important characteristic of reading below the fourth grade. Tinker (1963) discovered that lower case printing is much more legible than all capital printing,

however, individual capital letters are more legible than lower case letters in terms of visibility at a distance. Lower case letters are more differentiated in form than upper case letters, have more distinguishing characteristics, and are more readily recognized. Dechant (1964) reports that "the best evidence indicates that the size of type should be between 14 and 18 point in grade one and between 12 and 14 point in grades two and three...." Hall (1968) found no difference between pica (typewriter) and larger primary type and concluded that letter size is not an important factor in kindergarten.

2. Kinds of type. Studies have generally indicated that Roman is more legible than italic type (Tinker, 1928: Russell, 1961), and bookprint is more readable than typewriter print (Russell, 1961). Vernon (1963) in studying geometric forms suggested that such characteristics as angularity as contrasted with smoothness or flatness appears to be most important for the perception of a figure by young children. Money (1966) reporting on a multidimensional analysis of a confusion matrix generated from matching activities of four year old children showed that letters having curved and straight lines or oblique and slanted lines have priority in the discriminal process.

3. Leading. Leading refers to the spaces between letters within a word. For grade one, using 14-18 point type, 4-6 point leading is recommended (Paterson and Miles, 1940; in Dechant, 1964).

4. Simplicity of outline. Sanford (1888) stated that legibility

is favored by simplicity of outline (confirmed by Tinker, 1963) and concentration of differentiating features upon a single aspect.

5. Serifs. Too heavy or too long a serif should be avoided at the top and bottom ends of double strokes as in h and u. With letters such as a, s, and z short triangular serifs would simplify the letter outlines (Tinker, 1963). Zachrisson (1965) reports that one often meets with the assumption that sans serif types in general are less legible than the old face groups (with serif), however, a review of seven experiments fails to demonstrate the benefit of serifs in terms of legibility, reading speed or error rate. Zachrisson in ten of his own experiments showed no significant difference in legibility between old face and sans serif in grades one and four.

6. Stroke size. With most of the letters breadth is more of an advantage than length, other things being equal, for it gives visibility to their internal spaces (Sanford, 1888). Letters recognized the least on tachistoscopic presentation were those with greatest lightness of face (Tinker, 1928). Light face is more legible than bold face (Russell, 1961). There is no advantage in having one part of a stroke thicker than another; the tendency to use hair lines should be strongly condemned (Tinker, 1963). One of the primary stimulus determinants of the detection threshold is the area of the target; in general, the greater the area the lower the threshold (Dember, 1965).

7. Area of white spaces. The white space as in H or the eye in

p influences legibility; other things considered, the greater the enclosed area--the greater the legibility (Tinker, 1963).

8. Distinguishing characteristics. It is ironic that in at least eight studies from 1885 to Tinker, 1963, the most legible letters for adults with an average correlation of .62 are: k, d, q, b, p, m and w, while the letters of least legibility are c, e, i, n, l. Tinker stated that the letters of greatest legibility are those most marked with distinguishing characteristics, and that the next most important attributes of letters are (a) area of enclosed white space and (b) the size of type.

Studies of Geometric Form Discrimination

A number of studies of letter-like, regular or irregular geometric forms have revealed some important facts related to visual discrimination.

1. Ghent (1961) confirmed Hebb's theory that children do not perceive the whole of an object but rather perceive it in parts beginning with a focal point and scanning downward.

2. Ghent further discovered that symmetric geometric figures with a broad open or closed base and a distinct rounded or pointed apex were considered to be right-side-up by 4-5 year olds and vice-versa when the apex pointed downward. The highest amount of agreement for vertical orientation was for an equilateral triangle.

3. Vernon (1963) in reporting on a number of studies made the

following statements:

(a) Figures in strong contrast to the background tend to attract one's eye.

(b) Variation, surprise and incongruity are also likely to attract attention; subjects spend more time looking at incongruous items than at others and in looking at irregular figures among a series of regular ones.

(c) In each of a number of studies Vernon found that an observer's perception of the field or of any aspect of it may be made more rapidly and accurately in so far as his attention is directed toward it. The more narrowly and specifically attention is directed the greater the improvement in accuracy of perception.

4. A study by Fitts reported in Uhr showed that superior performance in discrimination was evident with vertically oriented, bilaterally symmetrical figures as opposed to horizontally oriented figures; subjects show greater facility in responding concurrently to two stimuli that are symmetrical about a vertical axis.

5. Wohlwill (1968) confirmed Ghent's (1961) hypothesis regarding the vertical directionality of broad based,pointed forms and in addition he noted that the presence of an internal focussing detail in essentially non-directional figures increased the amount of agreement in estimating their directionality.

Developmental Aspects of the Problem

In combination, the results obtained from many experiments

have illuminated the developmental aspects of learning and of using the laws of visual discrimination as described above. Davidson (1935) postulated the following stages of orientational confusion: (a) confusion b with d and p with q, (b) confusion b with d, but not p with q, (c) confusion b with d although it is recognized that they face in different directions, and finally (d) recognition that b and d are actually different letters. Vernon (1963) in studying geometric forms discovered that two year old children can discriminate triangles of different shapes when the difference is fairly marked. Hendrickson (1962) found that children observed up-down inversions (vertical disorientations) as early as three years of age, while left-right inversions by contrast were inconsistently responded to as late as five years of age. Ghent (1961) in studying 4-5 year old children discovered that they consistently respond to the orientation of regular or irregular geometric forms as right side up or upside down. Vernon (1963) suggested that the ability to match a number of geometric shapes such as diamonds, triangles, trapezoids and irregular quadrilaterals appears to develop about four years of age. Ghent (1961) found that if the focal point of a figure at which 4-5 year old children begin their downward scanning is not located in the upper portion the figure is considered to be upside down. Gibson (1962) discovered that 40 per cent of the errors made by four year old children were rotations and reversals when four different types of transformations were studied. Hall (1968) stated that reversal errors in letter discrimination persist until at least seven years of age particularly

in copying. Finally, it has been confirmed by Davidson (1935), Alexander and Money (1967), and Blair (1969) that there is no difference in error rate for lower case letter discrimination between sexes in kindergarten or nursery children although in grade one the error rate is higher for boys than girls.

A Review of Popular Primer Letter Types

The Initial Teaching Alphabet. Inspite of the amount of evidence regarding the process of visual discrimination of alphabet forms amassed since Cattell in 1885, no apparently beneficial temporary or permanent changes have been made to reduce the perceptual confusions of the alphabet. In fact, the few changes that have been made appear to be contrary to the research evidence. Consider for example Pitman's Initial Teaching Alphabet (I.T.A.). The characters are basically of the Times Roman classification characterised by thick and thin stroke lines and hair lines. The vertical and diagonal members are uniformly thick while the curvilinear members thin as they approach either the right or left. All letters with a thick vertical or diagonal stroke have either one or two triangular serifs at either head and/or base.

The I.T.A. in differing from the standard twenty-six letter alphabet has an additional eighteen symbols most of which are formed by the joining of two letter symbols as in th ; there is no letter q .

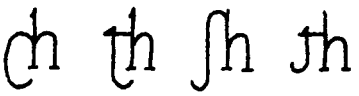
A review of the literature has not revealed that the I.T.A. symbols have been tested for legibility. Examination of the letters would seem to indicate that legibility has not been a

consideration in their design.

1. As Tinker (1963) has pointed out, the tendency to use hair lines should be strongly condemned. For example, when a hair line is used for the horizontal member of "e" the probability is increased that the figure will be confused with "o" or "c".

2. When the letter "A" is in the form "ɑ" rather than that of "a" there is a strong possibility that it will be confused with "o".

3. Tinker (1963) and other experimenters including Sanford (1888) have emphasized that a distinguishing characteristic is one of the most important features of letter discrimination. The following figures appear to emphasize similarity rather than differences:

(a)  (b)  (c) 

4. The figures above also appear to favour complexity as does "ŋ" rather than simplicity as advocated by most researchers.

5. The triangular serifs on the I.T.A. letters such as those on the "h" would also appear to increase confusion as with "b".

One can imagine that if confusibility is high among complex figures printed in a standardised type, the rate of confusion will be much higher when the letters are depicted in chalk by a careless teacher.

The letters b, d, p, and q in the I.T.A. alphabet are not merely different orientations of the same figure. The stem of the letter g (Standard Times Roman) has a lengthy tail that

curves upward to the left and is unlikely to be confused with the other letters. The letters b, d, and p differ not only in their orientation, but also in the number of serifs each letter has: the "b" has only one serif to the left of the head; the "d" has two serifs, one to the left of the head and one to the right at the base of the stem; the "p" has three serifs, one to the left of the head and one on each side of the base of the stem. In each case the serifs are small and triangular and as the experimental evidence (Zachrisson, 1965, seventeen studies) indicates they would make no significant difference to legibility.

Words in Color. Gattegno and Hineman in discussing Words in Color (Money, 1966) directly address themselves to the problem in stating that "b, d, p, and q are confused because the shapes differ only by asymmetry and symmetry usually serves to integrate parts rather than provide drastic distinctions." In Words in Color the letters are separately introduced in the above order and in different colors; "p" is brown, "d" is dark green, "q" is gold or aqua depending upon its sound.

The type used in Words in Color corresponds fairly closely to the Futura demi-bold condensed italic characterized by equal thickness of stroke on the horizontal, vertical and diagonal members. There is a very slight narrowing of the stroke where curvilinear members insert into the stem. The eye of the letters b, d, p and q are oval shaped; the vertical length is greatest. These four letters differ in color and orientation only.

Some of the characteristics of Words in Color are not in

accord with the experimental evidence. (a) According to Tinker (1928) and Russell (1961) studies have generally indicated that Roman is more legible than italic type. (b) Tinker (1963) states that other things being equal the greater the enclosed area the greater the legibility. The condensed form of Words in Color reduces the size of the open area, (c) Vernon (1963) suggests that the greater the color gradient between figure and ground the greater the discrimination of the figure. Words in Color, however, is of a variety of colors against a common black background and the legibility is thus decreased in proportion to the reduction of the color gradient.

Type Common to Canadian Primers. According to Covell (1966) the style of print suggested by a majority of the Departments of Education in Canada in their script writing curricula has been selected for use in the primer See Me Go. Examination reveals that this type is of the Gothic family, sans serif, with equal stroke width on vertical, horizontal and diagonal members. The type may be further classified as Futura Light characterized by a relatively narrow stroke width with a circular eye and bow. The same character in different orientations is used for the letters b, d, p and q. The stem length of these letters is 3/16 of an inch; the diameter of the bow is 2/16 of an inch and the stem rises only 1/16 of an inch above the bow.

Bigelow (1967) recommended that the diameter of the bow should be slightly less than half the length of the stem. In view of this recommendation the length of the stem in the above type should be extended for optimum discrimination.

CHAPTER II

STATEMENT OF THE PROBLEM

A review of the research literature indicates that for pre-school kindergarten or nursery children the most confusing letters of the alphabet are b, d, p and q, and that there are a number of attributes common to other letters of the alphabet that make them less subject to confusion.

The object of the present study was to incorporate those attributes contributing to maximum discriminability into a temporary modification of the letters b, d, p and q suitable in form for introduction to kindergarten children, and minimally modified in accord with the principles of programmed learning so that the modifications might be systematically faded as the children were progressively taught to discriminate the letters in the conventional form.

MODIFICATION OF THE LETTERS b, d, p AND q

The modified form of the letters was as follows:

FIG 3: Modification of the letters b, d, p and g.

The modified symbols incorporate the following attributes demonstrated by the research evidence to contribute to maximum discriminability.

1. (a) Angularity as contrasted with smoothness or flatness; curved and straight lines or oblique and slanted lines assist young children in the perception and discrimination of geometric figures (Money, 1966).

   (b) A triangular figure with a broad base and a distinct apex in the highest position is perceived to be upright by pre-school children (Ghent, 1961).

Thus, in the above figures the stem has been expanded to a triangle to combine curved, straight and slanted lines while the apex of the triangle is always in the highest position.

2. (a) The use of distinguishing characteristics (Tinker,1963),

   (b) The concentration of differentiating features upon a single aspect (Tinker, 1963),

   (c) The inclusion of an internal focussing detail (Wohlwill, 1968), and

   (d) The narrow focussing of attention to specific discriminating details (Vernon, 1963).

Each aspect improves the rapidity and accuracy of perception. Therefore, in the above figures a small internal white circle in contrast to the solid black stem has been located to draw attention to the ninety degree angle of the triangle that is always oriented in the same manner to deter horizontal or

rotational disorientations. Further, in terms of the research evidence it is likely that both the apex of the triangle and the white dot will be perceived of as two constantly located foci of attention in relation to which the eye of the figure is positioned; thus, the likelihood of horizontal, vertical and rotational disorientations may be further reduced.

3. (a) The contrast or incongruity of a figure within a series of figures (Vernon, 1963),

(b) The contrast of a figure against its ground (Vernon, 1963), and

(c) The largeness of the area of the figure (Dember, 1965); each characteristic influences the speed and accuracy of perception. Therefore, in the above figures a large, bold black stem against a white background has been chosen.

4. Other considerations in modifying the letters to provide maximum discrimination to kindergarten children are:

(a) A large white area within the eyes (Tinker, 1963) has been achieved through the use of circular eyes accentuated by a perimeter of even stroke width;

(b) The style of the conventional type to which the modifications have been made and to which the modified form could possibly be returned is that most common to Canadian primers --Gothic style, Future Light (Covell, 1966) with a minor modification in that the length of the stem has been increased to twice the diameter of the bow (Bigelow, 1967);

(c) The maximum size of print recommended for kindergarten

or grade one children--18-point--has been adopted (Dechant, 1964);

(d) The base of the triangle corresponds to the diameter of the bow and is 2/16 of an inch wide to provide an approximately bilateral symmetry about a vertically oriented figure;

(e) The enclosed white dot is 3/64 of an inch in diameter;

(f) If a child is able to learn to discriminate the modified form of the letters more rapidly and accurately than with the conventional form of the letters the modifications are such that they can be systematically faded by progressively making the base of the triangle smaller and smaller as the child is taught to discriminate the conventional form.

STATEMENT OF HYPOTHESIS

It was hypothesized that kindergarten children (a) between the ages of 4.6 and 5.6 (b) who had a fundamental understanding of the concept of similarity and (c) who were able to respond satisfactorily to a match-to-sample format (containing one stimulus and one matching figure within four response choices) would make significantly fewer errors, at the .05 level, in matching the letters d, b, p and q each with itself (a) if the subjects had been previously reinforced to attend to vertical, horizontal or rotational changes in orientation and (b) if the triangular stemmed letters were used, than they would make using the Futura Light Gothic type when each type was (a) 18-point, (b) bold black against a white fine-grain mat and (c) the length of the stem was twice the diameter of the eye.

CHAPTER III

METHOD OF EXPERIMENTATION

SELECTION OF SUBJECTS

In the research of Ghent (1961), Hendrickson (1962), Wohlwill (1964), Popp (1964), Karraker (1968), Hall (1968) and Blair (1969) the average ages studied ranged from 4.9 to 5.6 years, males and females undifferentiated. The average number of children per treatment group obtained from preschool kindergartens and nurseries was twenty.

In the present study fifty-two children from ages 4.6 to 5.6 with six months or more of typical kindergarten experience were selected by the pretests. Five of these children obtained a score greater than twenty out of twenty-four on the error base-rate test and were eliminated from the sample because their gain scores on the treatment test could be expected to exceed the maximum score possible. Seven children were randomly eliminated from the sample to obtain the desired total of forty subjects who were assigned to the control and experimental groups by the randomized blocks design (described under statistical analysis). Three of these subjects were unavailable for the treatment test. The block partners for two of these subjects were eliminated from the sample in accordance with the rules for the randomized blocks design. The treatment test score for one control female was predicted by regression analysis (see statistical methods). In the final analysis there were thirty-six subjects, eighteen males and

eighteen females with an equal number of each sex in the control and experimental groups. Only two children failed the pretests.

The subjects were selected from four different kindergartens located within the working and middle class areas and the university of British Columbia district so as to provide a broad sampling of the average preschool child.

TESTING FORMAT AND PROCEDURES

Many experimenters who have tested preschool children have used the match to sample format in which the matching stimulus was contained within a number of different but similar response alternatives. Popp (1964), Blair (1969), Hendrickson (1962) and Wohlwill (1968) used a two response choice format; Ghent (1961) used ten response choices; Smith (1928) used 26 response alternatives, while Davidson (1935) and Hall (1968) required a match of five identical letters within a forty letter matrix.

Thus, on three of the four tests used in the present study a match to sample format was used with one matching stimulus within a matrix of four response alternatives.

Initial Screening Test

Part One of the initial screening test (Appendix A) in accord with the hypothesis selected subjects in terms of (a) their ability to respond satisfactorily to a four choice match to sample format, and (b) a fundamental understanding of the concept of similarity.

The test was organized in the following manner. A circle, square, cross and triangle, each of eighteen point type, were presented to the subject in individual frames for a match to sample response. The first three frames consisted of two response choices; the second three frames each had three response choices, while the following eight frames had four response choices each. For each frame the stimulus used and the order of its corresponding response choices was random.

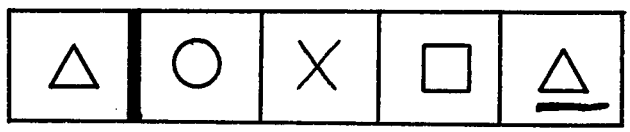


FIGURE 4: Example of a Four Choice Match-to-Sample Frame

The test was administered individually and for each frame the subject was required to underline the matching response choice as in the diagram above. If an incorrect choice was made in the first six frames, the subject was immediately informed of his error, and the correct response was indicated by the examiner. Verbal reinforcement was provided for correct responses. In each case, only the initial response was recorded. To qualify for further testing, subjects must have responded correctly to at least six of the eight, four-choice frames. No reinforcement or feedback was provided for performance on the eight qualifying

frames.

Initial Screening Test, Part 2. (Appendix A) This test, in accord with the hypothesis, was designed to introduce, focus and reinforce the subject's attention to vertical, horizontal and rotational changes in orientation. Considerable study was made to select a stimulus that would fulfill the following requirements of this section of the screening test.

(a) The stimulus had to be such that its orientation could be changed in a vertical, horizontal or rotational manner while each of its other characteristics remained the same.

(b) The stimulus and its orientations had to be more familiar, meaningful and discriminable to the subject than the letters b, d, p and q; orientation cues must be obvious and familiar.

(c) The stimulus had to be as simple as possible in design and dissimilar to either the standard or the modified letters b, d, p and q in order not to bias the subjects later responses on the treatment tests in favour of either the standard or modified form of the letters.

(d) The stimulus and the testing task had to be such as to focus the subject's attention on relevant cues of orientation and permit the examiner to provide feedback and reinforcement to the subject for responding in the required manner.

Extensive examination revealed that very few stimuli would

fulfill all of these requirements. Children learn at an early age to discriminate the various orientations of shoes and cups. However, the shoe is too complex a stimulus to accurately represent graphically. It is too difficult to depict the very subtle orientation cues of a shoe that a child--through familiarity--is apparently able to perceive. A cup, like many other stimuli, may be simply depicted, but its characteristics are too similar in nature to the letter stimuli. An upright cup for example is not unlike a p or q, while upside down it is similar to a d or b. Some familiar objects such as a tooth or hair brush, a comb or a spoon can not be suitably represented in each of the different orientations.

The requirements would seem to be fulfilled--as much as possible--by the depiction of a simple profile of a man's face with well marked orientation cues.

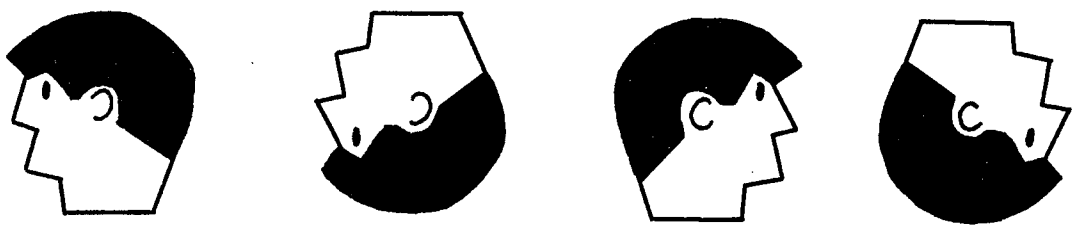


FIGURE 5: One-to-One Match-to-Sample Stimuli

Children are familiar with a human profile, and the changes in its orientation are meaningful to them. However, since the profile is considerably more complex in detail than the letters

b, d, p and q, it might be more difficult in a four choice format to discriminate changes in orientation of the profile than it would be to discriminate those of the letter stimuli. To simplify the task, to focus the child's attention on relevant orientation cues, and to permit immediate feedback and reinforcement, a one-to-one match to sample format was selected.

A sheet of white paper, eight and one-half by eleven inches, with eight one-inch high profiles, each representing either a vertical, horizontal or rotational change in orientation was presented individually to each subject. On each presentation only one profile was visible. The child was required to match the orientation of the stimulus profile by manually reorienting a response card. This card, of clear plastic, had a black border surrounding a profile that was identical to the stimulus profile. The response profile was equally visible from both sides of the response card (Appendix A). Each time that the response card was presented to the subject, it was vertically oriented with the face pointing toward the subject; in this manner, it was in a different orientation to that of the stimulus profile.

The child was directed to "make the picture (the response card) look the same as this picture (the stimulus profile) and to tell the examiner when he was finished." The examiner then informed the subject as to whether his response was right or wrong. If the response was not correct, the examiner said, "No, in this picture (stimulus) the hair is up (or down), or the nose points this way or that way--make this picture look the same as this one." All children continued to manipulate the response

card until it was properly oriented, they were then rewarded verbally and with a small, readily consumed candy.

Base-Rate Test

Subjects who reached criterion on part one and who eventually matched all profiles on part two of the initial screening test were individually presented with the base-rate test (Appendix A). This test was used to establish a basic error rate for each subject in discriminating various orientations of the standard letters b, d, p and q in 18-point type in twenty-four, four-to-one match to sample frames. There were six frames for each stimulus figure representing all permutations of the four letters. For each frame the subject was required to underline the response letter that matched the stimulus letter.

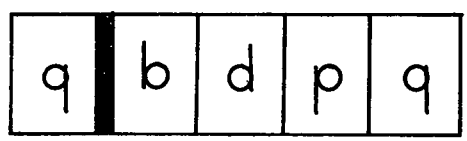


FIGURE 6: Example of a Four-to-One Error Base-Rate Testing Frame

The subjects were not provided with any feedback or reinforcement for their responses. In the case where a subject changed his response, only his first response was recorded. The score for each test was the total number of correct discriminations.

In terms of their total scores on this test, subjects were assigned to homogeneous groups and then randomly into the experimental and control groups as per the randomised blocks design (see statistical procedures).

Experimental Test

All subjects were selected and assigned to either the experimental or the control groups in terms of the total number of correct discriminations they made on the error base-rate test. Since a period of one week or more intervened between the error base-rate and the treatment tests, both the experimental and the control subjects were individually provided with a refresher experience. The refresher immediately preceded the treatment tests and was comprised of four frames of both parts one and two of the initial screening tests. This experience was designed to re-familiarize the subjects with the four-to-one response choice format, and to reinforce them again for attending to orientation cues. The same testing procedures were used here as previously.

Following the refresher experience the control subjects were individually given an additional twenty-four frames of the standard letters identical to the error base-rate test. The experimental group was presented with a test identical to that of the control group except that the modified symbols were used in place of the standard letters. No feedback or reinforcement was provided for the subjects' responses to these tests. If the subject corrected his response, only his first response was scored. The

total score for each test was the total number of correct discriminations.

CHAPTER IV

STATISTICAL PROCEDURES AND RESULTS

RANDOMIZED BLOCKS DESIGN

Assignment of the subjects to the control and experimental groups in terms of their scores on the base-rate test (total number of correct discriminations) followed the methods prescribed for the randomized blocks design as described by Edwards (1968).

1. Subjects were rank ordered from low to high scores obtained on the error base-rate test.

2. The rank-ordered distribution of forty subjects was then divided into twenty blocks of two subjects each.

3. The subjects within each of the twenty blocks were then randomly assigned to the control and experimental groups (one subject from each block to each group with a total of twenty subjects per group).

4. Where a subject was not available for the treatment retesting, as previously described, both he and his block partner were eliminated from the sample. In the final analysis there were thirty-six subjects divided in two's into eighteen blocks.

According to Edwards, subjects assigned to experimental and control groups by the above method "will be more homogeneous on their response to the dependent variable in the absence of treatment effects than subjects selected completely at random." Also,

he states that "by taking into account the differences existing between blocks in the analysis of variance it is anticipated that a smaller error mean square will be obtained for the same number of observations than if a randomized group design had been used (Edwards, p. 155-156, 1968)."

GAIN SCORES

In each of the following analyses the term gain score is defined as the total number of correct discriminations on the treatment test (control or experimental) minus the total number of correct discriminations on the error base-rate test. A gain score was calculated for each subject. For control group subjects gain scores were calculated as the difference between the total number of correct discriminations on two administrations of the same test. For the experimental subjects, gain scores were calculated from the scores obtained on two different tests. The error base-rate test used standard letters of the alphabet while the experimental test, although identical in all other respects, used the modified characters.

Generally gain scores are calculated as the difference between the total number of correct responses obtained on a pretest and on a post test. These tests are either identical or parallel to each other. Usually the subject is presented with a treatment experience that intervenes between the two tests and the gain score is calculated to indicate the effect of the treatment on subsequent performance--the post test.

The present experiment is not directly concerned with the subject's performance following the treatment, but rather during the treatment. The experimental test using the modified symbols acts as both the treatment experience and the post test. The hypothesis states that discrimination of the letters b, d, p and q will be more accurate when the modified characters are used than when the standard letters are used. Thus, in the present experiment, it was justified to calculate a gain score by subtracting the total number of correct discriminations obtained when the standard symbols were used from the total number of correct responses obtained when the modified symbols were used.

REGRESSION ANALYSIS

To predict the treatment score for a control female, unavailable for retesting, the U.B.C. 360 computer program TRIP (triangular regression package) was employed. The pre-, post-, and gain score data was used in the INMSDIC and the SIMREG subroutines. From the first routine partial correlation coefficients, means and standard deviations were obtained, and from the second routine a simple regression equation in the form $\hat{y} = a + bX$ was computed from the correlation array.

DATA ANALYSIS

Analysis of Variance of the treatment and blocks effect was tested by Dr. Seong S. Lee's adaptation to the U.B.C. 360 computer of the BMD08V analysis of variance program for any hierarchical design

with equal cell sizes. Experimental and control gain scores over eighteen blocks or levels were analysed in the complete factorial model where both blocks and treatments are independent variables influencing the dependent variable, gain score.

TABLE I

SUMMARY OF TREATMENT-BLOCKS

ANALYSIS OF VARIANCE

Score of Variance	Sum of Squares	d.f.	MS	F
Treatments	121.00	1	121.00	7.53
Blocks	234.22	17	13.78	
Treatment x Blocks	273.00	17	16.06	
TOTAL	628.22	35		

Analysis of these results shows that the treatment effect is significant ($\alpha < .05$).

The data from Table II is summarized in the graph in Figure 7. Examination of the graph reveals that there is an apparent block effect.

The gain scores for the experimental and control groups were pooled to obtain an average gain score for each of the nine pairs of blocks. Inspection of the graph reveals that a slightly higher average gain was made by control and experimental subjects who had obtained the lowest scores on the pretest (blocks 1-6).

It would appear that practice with either the standard or the modified letters had resulted in improvement in discrimination

TABLE II

EXPERIMENTAL AND CONTROL GAIN SCORES

OVER BLOCKS AND PAIRS OF BLOCKS;

AVERAGE GAIN SCORES EXPERIMENTAL AND CONTROL

Blocks	Gain Scores Exp.	Cont.	Pairs of Blocks	Gain Scores Exp.	Cont.	Average Gain Scores Exp. + Cont.
1	6.0	3.0				
2	6.0	3.0	1,2	6.0	3.0	4.5
3	8.0	0.0				
4	0.0	1.0	3,4	4.0	0.5	2.25
5	9.0	6.0				
6	-2.0	0.0	5,6	3.5	3.0	3.25
7	-2.0	0.0				
8	-2.0	2.0	7,8	-2.0	1.0	-0.5
9	1.0	-4.0				
10	11.0	-1.0	9,10	6.0	-2.5	1.75
11	8.0	-3.0				
12	1.0	-4.0	11,12	4.5	-3.5	0.5
13	1.0	-1.0				
14	9.0	-3.0	13,14	5.0	-2.0	1.5
15	1.0	-2.0				
16	-1.0	7.0	15,16	0.0	2.5	1.25
17	7.0	-3.0				
18	4.0	-2.0	17,18	5.5	-2.5	1.5

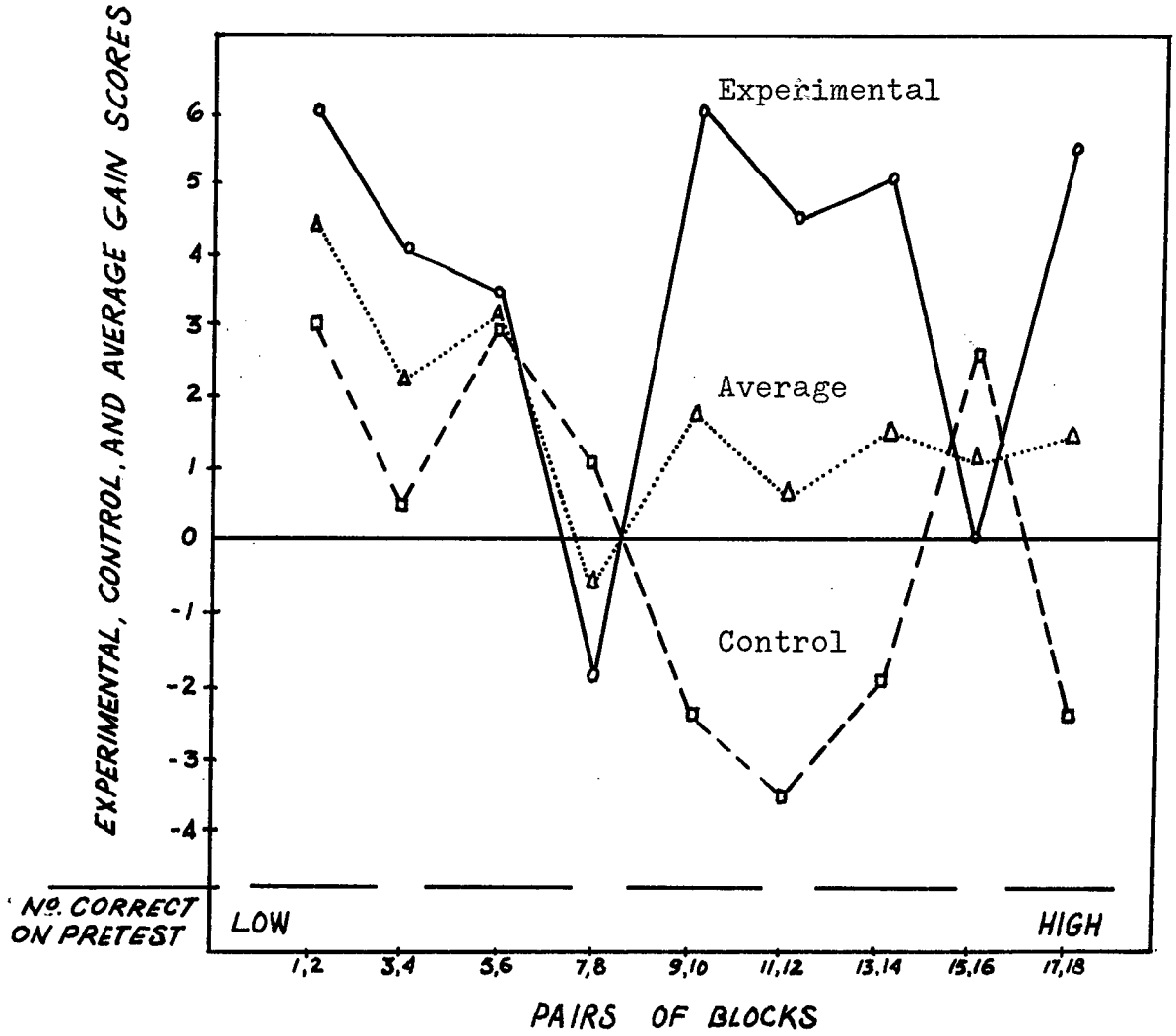


FIGURE 7: Experimental, Control, and Average Gain Score Means over Pairs of Blocks

by these subjects. In blocks 1-4 the experimental subjects using the modified symbols have improved two to four times as much as the control subjects.

At least part of the gain for both experimental and control subjects in blocks 1-6 might be explained by the regression to the mean effect where subjects who score at the extremes of a test tend to have scores closer to the mean when retested on the same or a parallel test. The regression effect might also explain, at least in part, why the control subjects in blocks 17 and 18 obtained an average gain score of minus three points on the post test. The same explanation, however, will not hold for the experimental subjects in the blocks 17 and 18 who averaged a gain of plus 5.5 points on the post test.

The fact that the experimental scores in blocks 17 and 18 do not regress to the mean, plus the fact that while the experimental subjects in blocks 9-14 show a high positive gain the control subjects in the same blocks show a low negative gain would seem to indicate that at least one other factor is having a differential effect upon control and experimental subjects. The novelty of the modified characters or the lack of novelty of the standard letters may account for this differential effect.

No apparent explanation can be found to explain either the negative or zero experimental gains in respectively the 7, 8 and 15, 16 blocks, nor the positive gain by the control subjects in blocks 15 and 16.

In conclusion, it may be stated that the regression effect is most pronounced for experimental and control subjects in

blocks 1-6, and for the control subjects in blocks 17 and 18. Practice with either the standard or the modified symbols may account for the gains in blocks 1-6. It appears that the novelty of the modified symbols and the lack of novelty of the standard symbols may account in part for the vastly differential effect on control and experimental subjects in blocks 9-14 and in blocks 17 and 18. In any case, it is apparent that the interaction of the various factors involved have had a differential effect at various pretest achievement levels and have essentially divided the sample into several distinct subgroups.

Analysis of Covariance. A simple t-test was calculated to test the difference between males and females on the pretest, and in accordance with previous studies (Davidson, 1935; Alexander and Money, 1960; and Blair, 1969). No significant difference was found at the .05 level.

As a final analysis of the effects of treatment and sex upon gain scores the post-test means were adjusted for differences in pretest means using the U.B.C. implementation of the BMDX69 Multivariate Analysis of Variance and Covariance computer program using the factorial with replications design. In this design, treatment (control and experimental) and sex are the independent variables with gain score the dependent variable with nine replications within each cell.

Again the F-value for treatment after adjustment for pretest differences is significant at the .025 level, while the effects of sex and the interaction between treatment and sex is

not significant at the .25 level. Thus, it may be stated that the performance of both males and females was improved through the use of the modified symbols, and that there was no significant difference between the performance of males and females whether they were in the control or experimental groups.

TABLE III

EFFECTS OF TREATMENT AND SEX UPON POST TEST SCORES;

SUMMARY ANALYSIS OF COVARIANCE

Source of Variance	Sum of Squares	d.f.	MS	F
Treatment	122.09	1	122.09	7.96*
Sex	16.80	1	16.80	1.10
Treatment x Sex	2.78	1	2.78	0.18
Replications (T x S)	475.26	31	15.33	
Covariate	416.96	1	416.96	27.20
TOTAL	1033.89	35		

r_{xy} = .63 where X = pretest (covariate)

Y = post test

* $\alpha < .05$

TABLE IV

CELL MEANS AND ADJUSTED MEANS

	Cell Means		Mean	Adjusted Means		Mean
	Males	Females		Males	Females	
Experimental	16.22	14.11	15.16	16.08	14.16	15.12
Control	11.89	10.89	11.39	11.84	11.03	11.44
Mean	14.05	12.50		13.96	12.59	

CHAPTER V

DISCUSSION AND CONCLUSIONS

From the results of the statistical analyses it may be concluded in accordance with the limitations stated in the hypothesis that the average kindergarten child, male or female, between the ages of 4.6 and 5.6 made significantly fewer errors in discriminating the letters b, d, p and q when the modified characters were used than when the standard letters were used.

Control and experimental subjects were selected by pretests. The first test assessed their fundamental understanding of the concept of similarity and their ability to respond satisfactorily to a four-to-one, match-to-sample format. This format contained one stimulus and one matching figure within four response alternatives each depicting either a horizontal, vertical, or rotational change in orientation of the stimulus figure. The second test comprised a testing-training experience in which the subject was reinforced for attending to orientation cues as he manually reoriented a response figure to match variously oriented stimulus figures. A third test, the error base-rate test, used the four-to-one, match-to-sample format to establish base-line error rate for each subject discriminating the letters b, d, p and q. In terms of scores obtained on the error base-rate test subjects were assigned to the control or the experimental groups by the randomized blocks design.

The treatment for the control group comprised a readministration of the error base-rate test. The treatment for the

experimental group was identical to the control treatment except that the modified symbols were used.

The standard letters were Futura Light Gothic type, 18-point, bold black against a white fine-grain mat. The length of the stem was extended to twice the diameter of the eye. The modified letters were identical to the standard letters except for the stem. The stem of the modified letters was a solid black, right-angle triangle with the smallest angle in the highest position, the right-angle was in the lower left-hand corner, and the base of the triangle was equal to the diameter of the eye of the letter. A small white circle was imbedded in the ninety-degree angle.

It was further apparent from the analysis that there was an apparent block effect that divides the sample into several sub-groups. A regression effect is apparent for experimental and control subjects who had obtained low scores on the error base-rate test, and for control subjects who had obtained high scores on the error base-rate test. Practice with either the standard or the modified symbols may account for the gains among previously low scoring subjects. The novelty of the modified symbols and the lack of novelty of the standard symbols may account in part for the vastly differential effect upon control and experimental subjects within the middle and upper range of blocks. No significant difference existed between the performance of males and females on either the pretest or the post test.

RESERVATIONS IN INTERPRETATION, AND IMPLICATIONS FOR FURTHER RESEARCH

Before the modified symbols can be adopted in any educational, remedial or preventitive measure there are several considerations that must be made.

1. Vernon (1963) reported that figure-ground contrast, and serial variation or incongruity of visual stimuli focussed one's attention upon the contrasting or novel stimulus. Hendrickson (1962) emphasized the importance of attention in the discriminal process of detecting directional differences in the letters b,d,p and q. Although no measurements were taken it was apparent during the treatment tests that subjects given the modified symbols focussed their attention more fully upon the task and had a longer latency of response than subjects using the standard letters. Thus, the question must be asked what possible role did the factors (a) discriminating attributes of the modified symbols, (b) boredom with repeated use of the standard symbols, and (c) novelty of the modified symbols, individually contribute to the significant gain score on the retest using the modified symbols?

2. Were the modified symbols perceived of by the subjects as modified letters of the alphabet? If the answer is no, could children be taught to perceive them as such? If so, could learning with the modified symbols be transferred to the use of the

standard letters through the method recommended--progressive shortening of the base of the triangle?

3. Is the design of the modified symbols such as to promote maximum positive change to the greatest number and variety of subjects? Should the width of the base of the triangle, or the diameter of the imbedded dot be changed?

4. Can the task involving discrimination of letters within a four-to-one multiple choice format be generalized to the discrimination of the modified symbols within the context of a word? Would their be a confounding effect from or upon adjacent letters?

5. Two children were eliminated by part I of the pretest. They failed to reach the criterion of six or more correct discriminations out of the eight qualifying frames of four response alternatives each. Apparently these children either did not have sufficient understanding of the concept of "sameness" and/or were unable to respond to the four-to-one match to sample matrix. It would seem likely that children in this category would have the greatest difficulty in discriminating orientational changes and future research should certainly focus upon remediating their problems.

These questions and others can obviously be answered only through further research. As mentioned earlier a review of the literature has not revealed that such study has been conducted

upon the I.T.A. or the Words in Color alphabets. When considering the number of problems that learning to read presents to a young child, and that the ability to read well is fundamental to progress in the formal academic process--further research of this nature is certainly mandatory.

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JACKSON, S. Implimentation of the U.C.L.A. BMDX69 Multivariate Analysis of Variance and Covariance Program on the U.B.C. 360 Computer.

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APPENDIX A

INSTRUMENTS

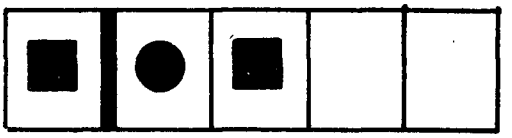
Initial Screening Test Part I

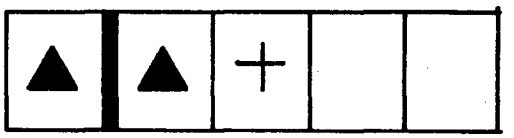
Initial Screening Test Part II

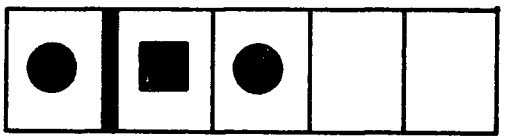
Error Base-Rate and Control Treatment Test

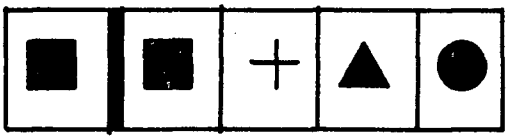
Experimental Treatment Test

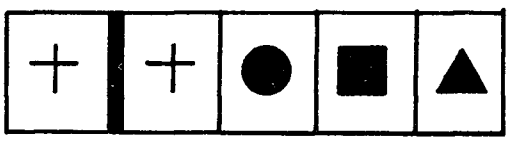
INITIAL SCREENING TEST PT. 1

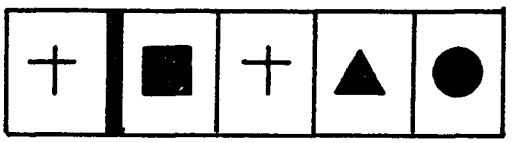
1 

2 

3 

8 

9 

10 

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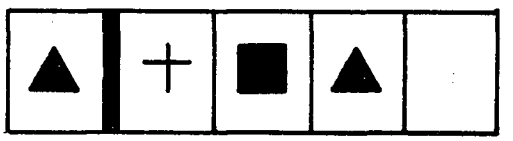
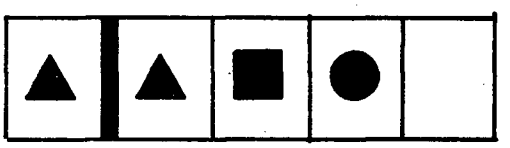
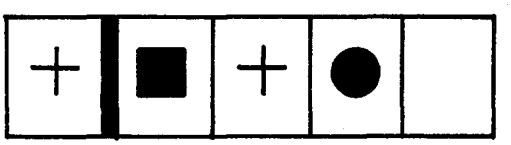
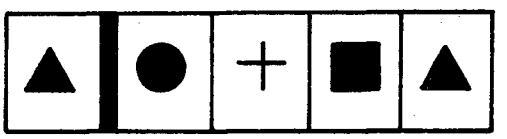
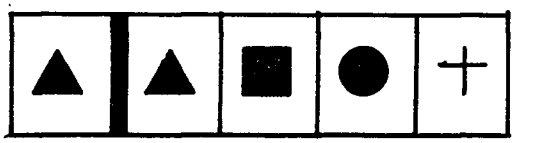
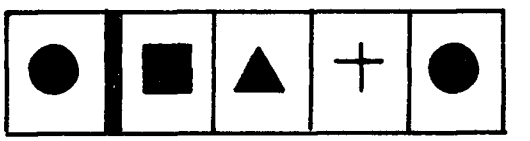
4 

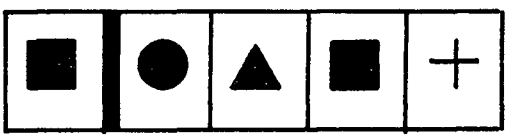
5 

6 

7 

11 

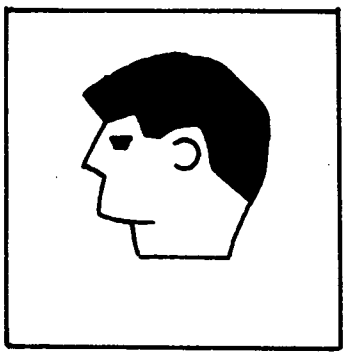
12 

13 

14 

NAME _____ AGE _:_ SEX ___ SCHOOL _____

INITIAL SCREENING TEST PART 11



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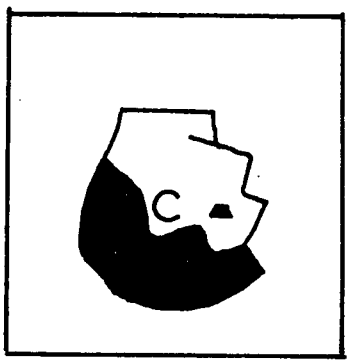

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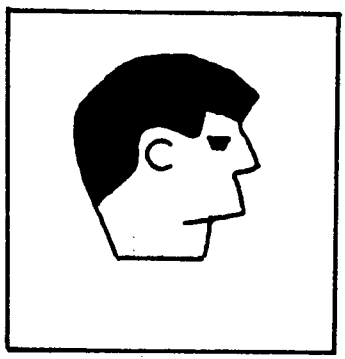

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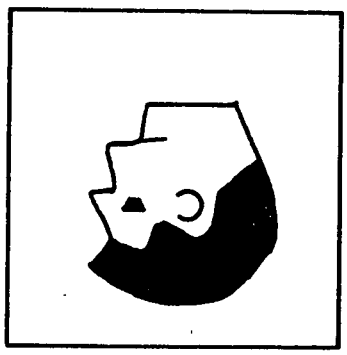

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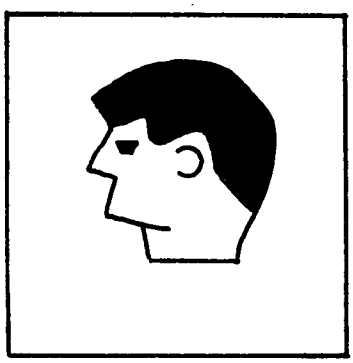

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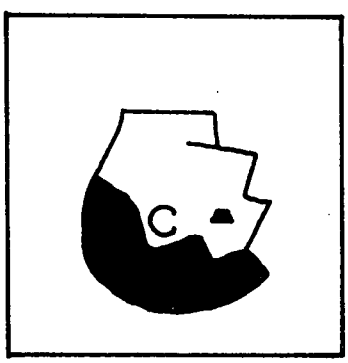

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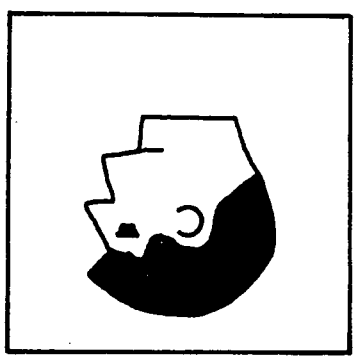


8.

ERROR BASE-RATE TEST & CONTROL TREATMENT

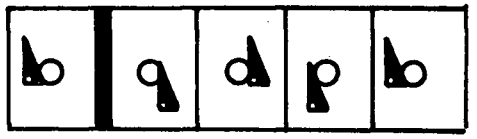
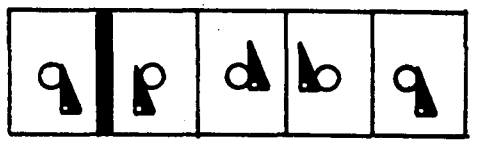
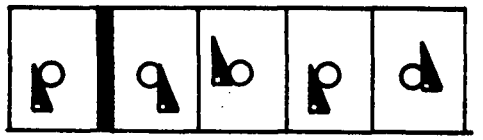
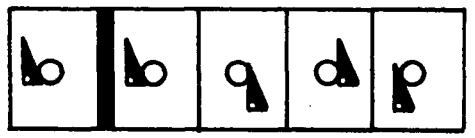
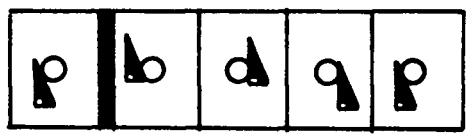
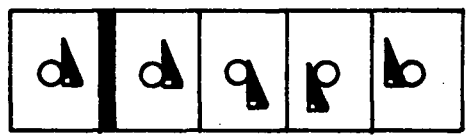
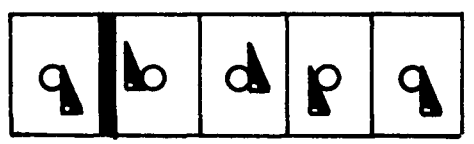
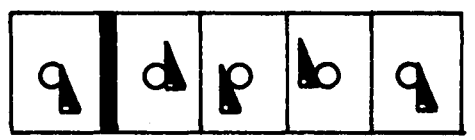
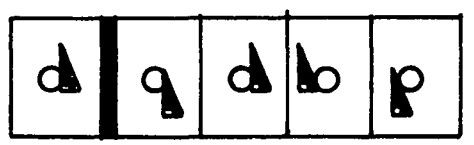
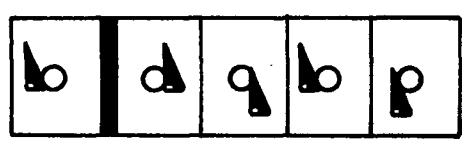
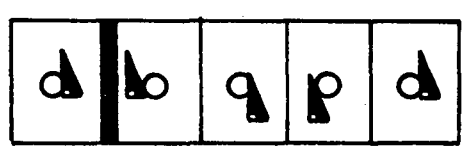
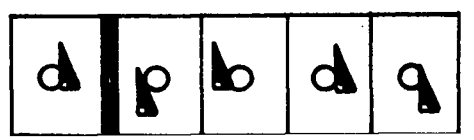
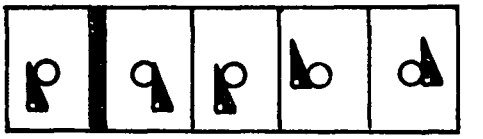
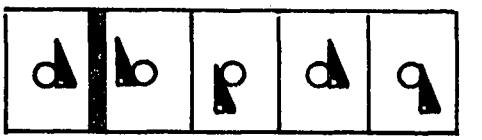
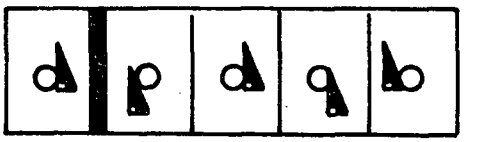
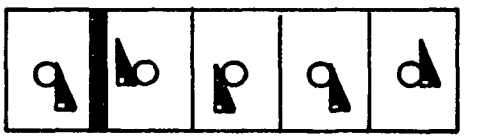
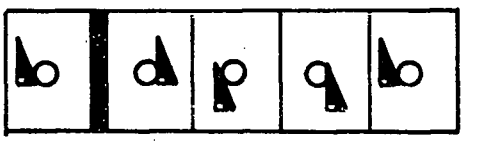
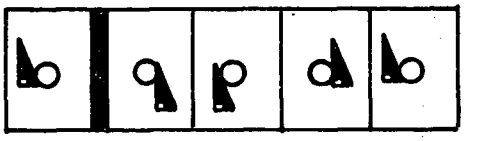
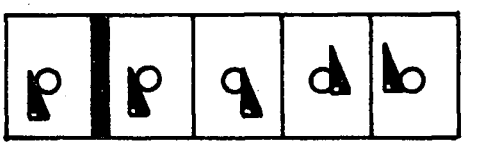
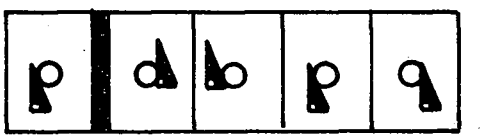
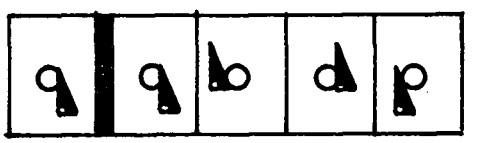
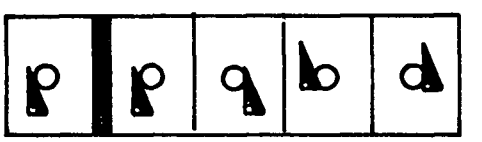
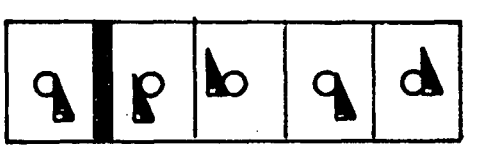
NAME_____ AGE_____ SEX_____ SCHOOL_____

CROSS-OUT EITHER:

1.	b	q	d	p	b		13	p	q	p	b	d
2.	q	p	d	b	q		14	d	b	p	d	q
3.	p	q	b	p	d		15	d	p	d	q	b
4.	b	b	q	d	p		16	q	b	p	q	d
5	p	b	d	q	p		17	b	d	p	q	b
6.	d	d	q	p	b		18	b	q	p	d	b
7.	q	b	d	p	q		19	p	p	q	d	b
8.	q	d	p	b	q		20	p	d	b	p	q
9.	d	q	d	b	p		21	q	q	b	d	p
10	b	d	q	b	p		22	p	p	q	b	d
11.	d	b	q	p	d		23	q	p	b	q	d
12	d	p	b	d	q		24	b	d	b	q	p

EXPERIMENTAL TREATMENT TEST

NAME_____ AGE_____ SEX_____ SCHOOL_____

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 
10. 
11. 
12. 
13. 
14. 
15. 
16. 
17. 
18. 
19. 
20. 
21. 
22. 
23. 
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