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A PROGRAM FOR GRAPHEME DISCRIMINATION FOR
PRESCHOOL CHILDREN.

University of Arizona, Ph.D., 1971
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1971
A PROGRAM FOR GRAPHEME DISCRIMINATION
FOR PRESCHOOL CHILDREN

by
Billie Jeanne Underwood

A Dissertation Submitted to the Faculty of the
DEPARTMENT OF PSYCHOLOGY
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1971
I hereby recommend that this dissertation prepared under my direction by Billie J. Underwood entitled A Program for Grapheme Discrimination for Preschool Children be accepted as fulfilling the dissertation requirement of the degree of Doctor of Philosophy.

Wayne K. Carroll  8/31/70
Dissertation Director  Date

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SIGNED: Billie J. Underwood
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ABSTRACT

Visual discrimination has been said to be a prerequisite skill to reading and many authorities have declared that training in visual discrimination should be a part of an early reading program. Studies have shown, however, that some alphabet letters are not easily discriminated by young children and the differentiation of four such difficult graphemes, b, d, p, and q, has been selected as the criterion task in this study.

Nineteen children were given a paper-and-pencil test to assess their ability to correctly discriminate the graphemes. Ten children, on the basis of their low scores on this pretest, became participants in a machine training program.

The characteristic feature which differentiates these graphemes from each other is their left-right directionality. The training program featured a series of stimuli graduated from gross directional differences to more subtle ones. In the first series the stimulus was a vertical line from the middle of which projected an arrow pointing to left or right. In the next series the arrow became an oval and this was replaced by a circle. The discrimination was made as an oddity response; the correct stimulus was the odd one in a row of non-odd. For example, in the first series it might be a left-pointing arrow in an array of right-pointing ones. Progress through the program phases
was contingent upon reaching a criterion in the previous phase. Four errors resulted in repeating a prior phase.

Criterion tests consisted of the correct discrimination of \( b \) from \( d \), \( p \) from \( q \), \( b \) from \( q \), and \( d \) from \( p \). All these phases were programmed on cards placed in a simple teaching machine. A correct selection from stimuli in an upper row of windows was followed by the child's pulling of a lever which opened a window in a lower row. Through this window the child saw a colored seal—flowers, animals, sports figures, etc.

Eight of the ten children who took part in this training program performed successfully on the criterion tests. Six of these children chose correctly 90% of the time on a machine retest given a week after they finished training.

However, only four of these children could perform to criterion on a paper-and-pencil posttest. Two children performed more poorly than on their pretest; one stayed the same; one made some improvement. One of the two children who experienced difficulties in the training program made all correct choices on the posttest; the other child improved.

A study of the data yielded implications for improving the program. These included the possibility of adding color to the cards as a stimulus cue toward errorless acquisition. This would also increase the number of cards to prevent sequence effect if a phase needed repetition. The adoption of generalization and motivation procedures was discussed as being important instructional objectives.
The low cost and uncomplicated operation of the teaching machine itself prompted the suggestion of its use with this and other programs in preschool settings.
INTRODUCTION AND REVIEW OF THE LITERATURE

Many authorities feel that a major factor contributing to readiness for beginning reading is visual discrimination and that developing visual discrimination should be one of the major objectives of beginning instruction in reading (Betts 1954, Gates and Boeker 1923, McKee 1948). Studies comparing abilities in visual discrimination with later reading achievement most frequently report significant correlations (Gates and Boeker 1923, Henig 1949, Kottmeyer 1947).

Several studies have compared the effectiveness of letter discrimination training with other methods. Sixty kindergarten children served as subjects in a comparison of letter training and word training which evaluated both the mean number of trials to criterion of both experimental groups and also the number of trials to learn a criterion list as a transfer test. The letter-trained group was superior in the transfer task (Jeffrey and Samuels 1967). However, letter training had been combined with phonic blend training and both are considered to be prerequisite skills. In an earlier study, the same experimenters (Samuels and Jeffrey 1966) used an artificial alphabet in a paired-associate learning task with kindergarten children and concluded that training which forces attention to each letter is less likely to lead to subsequent reading errors than training which permits the child to identify words on a single feature. They felt that the child should learn to attend to all the letters in a word.
King (1964) gave 138 six-year-olds different kinds of visual discrimination training prior to learning a common list of words on a reading task. She found that matching all of the single letters which were components of the words to be learned later in the reading task was superior to training in matching the same words.

In another study, a delayed-recognition task was used to assess the cues by which children recognize words. They found that specific letters and not overall shape formed the basis of recognition. The first letter was the most important cue; the second, the next most important (Marchbanks and Levin 1965).

Burkholder (1968) developed a set of exercises to increase perceptual speed as part of a program to improve underlying perceptual and cognitive skills in retarded readers. After the three month training period, the children in the experimental group showed significantly greater gains in many reading allied skills.

First grade pupils were given fourteen tests of visual perception at the beginning of the school year, a reading test in December, and another form of the reading test in May. After ten weeks, half of the group received tachistoscopic form training. Goins (1958) found a significant correlation between several of the perceptual tests and the reading tests. However, although the tachistoscopic training appeared to increase competence in certain aspects of visual perception, it did not seem to influence progress in learning to read.

Not all graphemes are easily discriminated by young children. Smith (1928) tested first grade children on a letter matching task
and reported that $b$, $p$, $q$, $d$, $r$, $h$, $f$, $i$, $j$, and $n$ were most often responded to with an incorrect match. Davidson (1935) used a matching test to identify the alphabet letters which were most confusing to young children. She found that the letters $d$, $b$, $p$, and $q$ were especially difficult to differentiate for almost all the kindergarten children and a smaller but substantially large percentage of first grade pupils were confused. It was not until a chronological age (CA) of 7 1/2 years was reached that 50% of the pupils of any age level were able to select $d$, $q$, $p$, and $b$ without error. She noted that the most difficult letters to discriminate are pairs of letters that are the reversals of each other; the next most difficult are the upside down inversions. She concluded that the increase in ability to discriminate letters comes with increasing mental maturity and experience.

Popp (1966) designed a study to measure the confusability of pairs of graphemes in a simple matching task for five-year-old children. Her results seemed to substantiate those of Davidson's; confusions arose from reversals and rotations ($p-q$, $b-d$, $b-q$, $d-p$, $b-p$, $n-u$). Formal similarity appeared to be another source of confusion, that is, the proportion of similar or identical lines contained in both graphemes, as in $i-i$, $h-y$, and $h-n$.

Studies such as these have indicated to some authorities that improvement in letter discrimination with age is a function of maturational processes. Ilg and Ames (1950) stated that the reversal errors are of interest in indicating how far the child has developed in his reading ability.
An article which apparently substantiated the strong matura-
tional component in this discrimination difficulty is that of Rudel and Teuber (1963) who found that their four-year-old subjects failed to respond differentially to rectangles inclined obliquely to left or right. However, Jeffrey (1966) repeated their study but used two experimental groups in a training procedure. The first experimental group had stimuli with arrowheads presented successively with buttons which they were to push to indicate the direction of the arrowhead. The second group also had successive presentation but the lines did not have arrowheads. The control group was given just the test task, as in the Rudel and Teuber study. The first experimental group was more effective than the second and only the two experimental groups met the criterion. He said that the difference in performance of the two experimental groups demonstrated that slight changes in testing procedures make a considerable difference in the likelihood that a four-year-old child can learn to respond differentially to oblique lines. He added that the success of these subjects on their test task indicates that many children may become capable of performing "impossible" discriminations when they are given appropriate pre-
training.

In an earlier study, Jeffrey (1958) set for his four-year-old subjects the experimental task of labelling left and right stimuli appropriately. The treatment of learning to press buttons oriented in the direction to which stick figures were pointing was found to be significantly effective on subsequent learning to apply labels.
Hendrickson and Muehl (1962) assessed the effect of attention and motor response pretraining on learning to discriminate b and d in kindergarten children and found that pretraining in attending to the directional differences between b and d facilitated learning names for these same letters in a paired-associate transfer task. They felt that this provides additional evidence that a left-right inversion can be identified considerably before Davidson's normative age of 7 1/2. They suggested caution in the application of readiness concepts when these concepts are used to prescribe appropriate age levels at which children can optimally learn a particular task. They added that age norms derived from tests built to assess a given skill level provide no certain evidence as to what age the skill might first be taught and learned provided the learning conditions were effectively arranged.

These studies which used motor responses suggest that the crucial variable is attentional. Goins (1959) offered the possibility that young children are unable to remember small details of shape such as in alphabet letters for several reasons. Some of these may include: (1) they do not realize which of the details are important, (2) they see separate letters as whole and cannot break them into distinguishable parts, and (3) they do not see the importance in how the shape is oriented.

Caldwell and Hall (1969) argued that while attention to stimuli is obviously a necessary condition for correct performance on discrimination tasks, these tasks have typically been inadequately analyzed. They reviewed the Davidson data and challenged her
interpretation on the basis of an inadequate analysis of the criterion task. When a child marked a d and the standard was a b he might have done so because the letters were indistinguishable to him or because by his definition of same and different this reversal was immaterial. Just as three-dimensional objects go by the same name regardless of their orientation, so would two-dimensional graphemes for the subject unless he had learned a new concept of same and different for this type of stimulus. Using a criterion task similar to Davidson's, they used three groups. An experimental group was given a training task in which orientation was irrelevant; a second experimental group learned a concept of same and different which was inappropriate for the criterion task; a third group was given correct information regarding the relevance of orientation with two-dimensional graphemes. Both of the other groups made two to four times as many confusions of d, b, g, and p as did the group which had received training in appropriate orientation. They stated that, at the very least, the results indicate that kindergarten children are able to discriminate the letters b, d, p, and g. These results were also interpreted as illustrating the role of the appropriateness of the subject's concept of same and different rather than perceptual ability and/or attentional factors.

An important part of the Caldwell and Hall study was the use of feedback to the subjects of the correctness of their responses; an overlay procedure effectively gave them that knowledge. Hildreth (1932) was an advocate of the maturational component in the ability to correctly discriminate letters yet she suggested that there was also
some indication that subjects in her study who had had the least help from parents or teachers showed the most tendency to make reversals. She indicated that to such children the letter probably looked as satisfactory one way as another and since they had learned nothing to the contrary the discrimination was not made.

Gibson et al. (1962) studied the development of the ability to visually discriminate a set of letter-like forms, in children four through eight years of age, and related the types of errors made to certain critical features of the forms. They found that the visual discrimination of the forms, using a matching procedure which requires a judgment of same or different, improves from ages four to eight. The results suggest that what is learned are the features or dimensions of difference which are critical for differentiating letters. The authors hypothesized that some of the subjects' previous experience with solid objects could transfer to the new discrimination task; solid objects also have invariant qualities and distinctive features. However, some aspects of the task, such as perspective transformations, reversals and rotations, and changes of line to curve, were highly confusing to the younger children because such transformations are not distinctive features for object identification. The two latter types of errors drop markedly as the children learn to read, perhaps because the children develop a sensitivity to these distinctive features. Errors on perspective transformations decrease only slightly; perspective transformations apparently are not critical for letter identification.
Gibson (1968) described an experiment designed by Anne D. Pick to compare two hypotheses about the perceptual learning involved when a child comes to discriminate graphemes by detecting their distinctive features. One has been called a "schema" or "prototype" hypothesis, the basis of which is a model or memory image previously stored of each letter and built up by repeated experience of visual presentations. In the other hypothesis it is assumed that the child learns by discovering how the forms differ and then easily transfers this knowledge to new letter-like figures. In Pick's experiment all the subjects were presented with initially confusable letter-like forms and trained to discriminate between them. In the transfer stage the subjects were divided into three groups. One group was given sets of stimuli to discriminate which varied in new dimensions from the same standards as in the training stage. A second group was given sets of stimuli which deviated from new standards, but in the same dimensions of difference discriminated in training. A control group was given both new standards and new dimensions of difference to discriminate. Both experimental groups performed significantly better than the control group, but the group which had familiar transformations of new standards performed significantly better than the group given new transformations of old standards. Gibson inferred from these results that, while children probably do learn prototypes of letter shapes, these are not the original basis for differentiation.

The most relevant kind of training for discrimination is practice which provides experience with the characteristic differences
which distinguish graphemes. Evidence for transfer from such experiences to reading is inconclusive, but if instead of the typical matching geometric shapes and pictures, variables were used which were significant for letter discrimination these should have greater potential transfer value. Gates (1926) found only low correlation between discrimination of geometric figures and reading ability; Vernon (1959) declared that learning to discriminate shapes from one another has little effect on learning to discriminate letters and words. Fries (1962) suggested that the first set of recognition responses to be developed should be those for the letters of the alphabet and that the form of recognition should be identification of an alphabet letter when presented with contrasting shapes. The identification of contrasting letters should be practiced until the child responds to the significant features automatically.

With the reappraisal of the restriction of maturation on children's readiness to begin such instruction, it appears that many children can and should begin reading much earlier than first grade. Durkin (1963) reported a longitudinal study of children who could read before they entered first grade. Fifteen early readers who had intelligence quotients (IQs) of 120 or less were found to have profited from their early starts. She concluded that the lower the child's IQ the greater seems to be the advantage of starting this reading early. She added further that it might mean that slower children need to start earlier in order to give them more time for learning.

A recurrent criticism to the teaching of reading to young children has been based on the possibility of eye damage. Holmes (1968)
reviewed the literature and found little scientific evidence to substantiate the theory that early use in fine visual discrimination leads to any abuse of the children's eyes.

The emphasis on prereading learning environment highlights the possibility that many children approach the task of reading with a deficient background; that due to living under marginal economic conditions they are lacking in the skills which are prerequisite to reading itself.

Ninety kindergarten children in Phoenix, Arizona served as subjects in a verbal discrimination study by Wheelock and Silvaroli (1967). The children were given a pre and post test for discrimination of I, T, F, and E. Children in the group designated as having higher economic status performed significantly better in the initial test. All the subjects were taught a differential motor response and given verbal instructions which called attention to significant features of the letters. There was a significant difference from pre to post test in the ability to make the discriminations, favoring the experimental group. The children from the lower socioeconomic class appeared to profit most from the training.

Scholnick, Osler, and Katzenellenbogen (1968) investigated discrimination learning and concept identification in disadvantaged and middle-class children and found that performance in concept attainment is facilitated by prior experience in discrimination learning which involves the component attributes. The degree of facilitation is related to the similarity between the discrimination and concept tasks.
They found that the low social status child showed a deficiency in performance on simple discrimination tasks but was not handicapped in the more complex problems. Their conclusion was that the enriched experience of middle-class children results in greater familiarity with stimulus material used in discrimination tasks.

Headstart emphasis on a great deal of work with books is one instance of the attempt to give to this segment of our population the experiences which middle-class children have in abundance. Bijou (1963), in his discussion of the functional analysis approach to reading, suggested a search into processes underlying retardation for the specific deficits and he included the economically deprived in the category of those who are retarded due to limited behavioral repertoires. The functional analytic approach focusses on the training of new repertoires and Bijou felt that the development of programmed perceptual and conceptual material for kindergarten and first graders will be helpful to all children and that more practice and smaller steps could be used for those children with specific areas of deficiency.

Reading appears to have components which lend themselves to this approach. Skinner (1957) made a distinction between formal repertoires and thematic repertoires. In a formal repertoire there is point-to-point correspondence between stimulus and response, as in imitating, reading, and copying. In thematic or mediated repertoires, responses are controlled by common sets of variables, but without formal correspondence, as in responding appropriately to a question
with a meaningful answer. Formal repertoires are the less complex of the two to study and have received the most work in operant analysis.

The purpose of this study is to determine which critical features of alphabet letters are difficult for a child to differentiate and to develop a training program which will aid the child in overcoming that difficulty. This program will feature practice on a series of problems. If the program is successful, the child will demonstrate increasing facility in discrimination as he proceeds through the series. This ability to improve in discriminative ability from one problem to another, the interproblem improvement, the learning-to-learn, has been called a learning set.

**Learning Set Formation**

Harlow (1949) studied the effect of the learning of a single problem on the learning of subsequent problems and demonstrated that rhesus monkeys learn to solve a series of discrimination problems with increasing facility. If six-trial nonspatial discrimination problems were used, the learning of the early problems took place slowly and the learning curve is typical of "trial-and-error" learning. The early learning curve is positively accelerated and continuous. But as successive problems are given, these later problems are learned rapidly or immediately and the resulting learning curve is discontinuous, with a rapid component from Trial 1 to Trial 2 and a slow component from Trials 2 to 6. Performance changes in this interproblem learning from chance to perfection or near perfection in a single trial and subsequent errors are insignificant.
The most striking phenomenon associated with learning set (LS) formation is the change in problem difficulty following multiple-problem practice. Early problems are learned slowly but after LS formation the same kind of problem is solved immediately. In a discussion of human learning set formation, Harlow (1959) said that "the behavior of the human being is not to be understood in terms of the results of single learning situations but rather in terms of the changes which are effected through multiple, though comparable, learning problems" (p. 51).

Learning set formation represents a particular type of transfer of training, the transfer between many problems of a single class rather than between problems of disparate classes or transfer between a few problems of a single class. The procedure which Harlow adopted is also different from other transfer-of-training models. Instead of training subjects to mastery over a narrow range of problems he ran each problem for a limited number of trials and analyzed the learning of relatively large blocks of problems. This application to concept formation is discussed by Harlow (1959); he concluded that unlimited training on a single problem would produce no significant concept formation. With increased practice on a single problem, generalization tendencies should decrease, lessening the possibility of concept formation. It is his hypothesis that all concepts such as triangularity, middle-sizedness, number, and smoothness, for example, evolve only from learning set formation.
There have been many investigations into the relationship between mental age (MA) and learning set performance in normal and retarded children (Ellis and Sloan 1959; Girardeau 1959; Harter 1965, 1967; Hill 1962; House 1964a, 1964b; Kaufman and Peterson 1958; Koch and Meyer 1959; Martin and Blum 1960; Penn, Lindberg, and Wohlhueter 1969; Stevenson and Swartz 1968). Their data indicated that discrimination learning set formation depends upon intellectual development. Harter's (1965) conclusion reflects the results of other studies. Whatever the actual mechanism involved in LS formation, there is general agreement that such learning involves complex processes such as the ability to generalize, transfer information from one problem to another, and form conclusions. It was clear that both IQ and MA had independent effects on the speed with which LS was acquired. Both IQ and MA influence the number of problems required before an abrupt acceleration to criterion. CA predicted LS formation to the extent that it is positively correlated with MA and not negatively correlated with IQ.

The learning set formation chosen for this study is that of oddity which has been chosen for the visual discrimination training because the emphasis in oddity learning is not on the stimuli themselves but on the relationship between them. This is similar to the necessity in the task of differentiation of graphemes for the child to see not just the individual letter but which of its features distinguish it from the others.
Oddity Learning

Harlow, Meyer, and Settlage (1951) defined the oddity problem as a representative example of a multiple-sign problem in which there is ambiguous reward of two or more cues on single trials. On a single oddity problem, position, specific stimulus object, and oddity may all be reinforced. It is only through a series of trials that the relationship between the odd (different) and non-odd (same) stimuli is revealed through consistent reinforcement. Oddity may be form, size, color, orientation, or pattern.

In a review of comparative studies in simple oddity learning, Strong and Hedges (1966) revealed differences in methodology in oddity experiments. The number of stimulus objects has ranged from 3 to 352; the number of simultaneously presented objects from 3 to 12; the number of trials or problems from 1 to 12 or until learned. They also pointed out that improvement over problems may merely indicate learning set for object-quality discrimination and only a high first-trial percentage correct on new problems indicates true oddity learning.

Many studies deal with oddity and developmental level (Harter 1965; Hayes, Thompson, and Hayes 1953; Hill 1962, 1965a, 1965b; Lipsitt and Serunian 1963; Martin and Blum 1960; Strong 1966). Representative of some of the findings of the developmental studies are those of Gollin and Shirk (1966). In their oddity-problem study, three-year-old children failed 58.3% of the time to meet criterion; older children failed 33.3% of the time. The difference was significant. Hill (1962)
concluded that the youngest age level for the solution of the oddity problem probably falls between the third and sixth year. Strong (1966) offered the suggestion that after a certain age, probably between five and seven, a new approach develops in which the first tendency is to choose the odd object and the solution is immediately apparent. Oddity is present as a concept and must be reinforced only once for it to become associated with the problems.

Martin and Blum (1960) found a significant sex difference in favor of boys and a significant sex and age interaction in sensitivity to stimulus cues.

Lipsitt and Serunian (1963) suggested that the ease or difficulty of the oddity problem might be a function of the stimulus and motivation parameters which affect discrimination learning generally. They outlined research questions which might delineate these variables: stimulus-similarity continuum; extensions to other stimulus dimensions; the effectiveness of various kinds of pretraining experience; and the effect of different reinforcement and motivational factors.

In an oddity learning experiment with young children, Strong (1965) contrasted the use of three-dimensional stimuli and two dimensional stimuli. A modified Wisconsin General Test Apparatus (WGTA) which used three dimensional stimuli was contrasted with a Primate Automatic Testing Apparatus-Key (PATA-K) which used two dimensional stimuli otherwise identical to those of the WGTA. They found that for three and four-year-old children the WGTA produced a
significantly greater number of subjects reaching criterion than did the PATA-K. There was no significant difference between the two apparatuses for five and six-year-olds. Lipsitt and LoLordo (1963), in a color-oddity problem study with fourth graders, studied the interactive effect of stress and stimulus difficulty. Easy stimuli were those which differed greatly; difficult stimuli were those which were similar. A significant interaction between Trials and Difficulty revealed that learning differed for the easy and difficult conditions, the rate of learning apparently being greater for the easy condition.

The sequence of easy and hard discrimination trials was varied by House and Zeaman (1960). They used two different training sequences of easy-to-hard discrimination trials and compared them for efficiency with a training sequence of hard discrimination trials only. Their subjects were mentally retarded children. The hard-discrimination group was trained with pattern stimuli differing in color and form. One easy-to-hard group was first trained to criterion with a pair of object stimuli before pattern training; there were identically relevant cues for object and pattern. The second easy-to-hard group was trained on both objects and patterns but color and form were different in them. Both easy-to-hard sequences were more effective as measured by total trials to learn a hard discrimination. Identical relevant cues facilitated the task.

In a discrimination-learning set problem, not oddity, Katz (1967) varied the difficulty level of two discriminanda, difficulty level being determined by the number of stimulus attributes common to
them. Two stimuli which differed grossly in size, color, and shape represented a simple discrimination; two stimuli which differed in only one dimension constituted a difficult discrimination. She used three types of training sequences: (1) a simple to progressively more difficult, (2) a simple with an abrupt shift to difficult, and (3) beginning and continuing with a difficult discrimination. She concluded that the type and sequence of discrimination problem used may influence the rate of LS acquisition but that this is not a simple effect as she found the groups differed only in the shape of the learning curves, not in performance on the criterion task. All the experimental subjects performed significantly better on the transfer task than did a control group with no training. She felt that the problem sequence seemed to affect the performance of low IQ subjects more than those subjects of normal intelligence; consistency of problem type appeared to the most effective sequence. She noted that despite the clear relevance of learning set to education practice, not enough research has been along the lines of how the difficulty of the discrimination problems affects the rate of acquisition; what are the most efficacious methods of stimuli presentation and programming; and what kinds of testing conditions give rise to long-range retention. Her study is unique in its use of a test of long-range retention six months after the original task; the trained groups showed faster learning than the control groups.

Martin and Blum (1961) found in an oddity experiment that the range of difficulty for mentally normal and subnormal boys and girls in choosing the odd one of three objects varied according to the
definition of oddity in the problem. Size was the most easily
discriminated, then color and form; the most difficult to discriminate
was an odd stimulus which differed in spatial orientation.

Using three sets of wooden blocks with all combinations of
black and white, large and small, and three forms (square, circle,
and inverted triangle), Lubker and Spiker (1966) studied the effects
of irrelevant stimulus dimension in both three and four-position
oddity problems. Their subjects were third and fourth grade children.
Their results indicated that the number of irrelevant nonspatial
dimensions present on a setting adversely affected the children's
performance. The evidence suggested that in the early stages of
learning the number of identical stimuli present on a trial affected
the rate of learning, but this was not statistically significant.
Assessing the effect of perceptual distinctiveness in oddity-problem-
solving, Gollin, Saravo, and Salten (1967) tested children in a
5-stimulus condition (four non-odd) and in a 3-stimulus condition
(two non-odd). They found that kindergarten children's performance in
the 5-stimulus condition was superior to their performance in the
3-stimulus condition. There was no difference between conditions for
either preschool or second-grade children. They hypothesized that
the cognitive behavior of young children is strongly dependent upon
the perceptual saliency of the field so that problems are more easily
solved by kindergarteners if the stimuli are distinctive. They found
that their second-grade subjects learned the problem under both con-
ditions, apparently because they had developed a conceptual approach
with less reliance upon perceptual cues. Almost none of their preschool subjects learned the problem under either condition. This age group was evidently unable to shift to the odd cue when confronted with the reinforcement contingencies.

Another methodological variable which has been examined is stimulus presentation. Saravo and Gollin (1969) suggested that young children may have difficulty learning the oddity problem because the procedure often involves the presentation of an odd stimulus on one trial which had been non-odd on the previous trial, constituting a reversal. Since investigators have found that ease of reversal learning appears to be related to ontogenetic and phylogenetic status (Gollin 1964; Kendler, Kendler, and Wells 1960; Saravo and Kolodny 1969), Saravo and Gollin suggested that the effects of developmental levels and task variables may have been on the reversal component of the problem, not on the oddity response per se. They found that a two-pair reversal shift procedure was more difficult than a non-reversal for their subjects. They used a random oddity reversal task (with different odd objects) but stated that the successive reversal oddity task is equally confounded. Perhaps previous studies using either random reversal or successive reversal tasks may have had confounding effects of cue perseveration, obscuring results of oddity learning.

Strong (1965) suggested that in the successive reversal procedure the problem is solved on object-quality discrimination rather than oddity. He found that additional one-trial problems were necessary for his subjects before the oddity principle was firmly grasped.
House (1964a) compared the successive reversal method with the random method and found that no subject in the successive method got the first reversal trial right, always choosing the previously odd stimulus. Yet more subjects in that group met the criterion. Only one of the ten subjects trained on the random method met the criterion. She offered the explanation that repeated trials with the same stimulus objects, until criterion, served to increase the probability that the subject would attend to the relevant dimension. Repeated reversal trials in which the non-odd object was used as the odd one, again to criterion, served to retard tendencies to approach a specific stimulus.

A study by Saravo and Kolodny (1969) showed that though there was initial negative transfer for their subjects in the reversal-shift condition, performance on reversals improved as their oddity learning set improved.

The possibility exists that children's responses in oddity problems have reflected vocabulary differences rather than conceptual differences. Scott (1964) found that retarded children were able to respond to questions of sameness, but not difference. Saravo and Gollin (1969) included a verbal designation task in which the children were asked how they knew where the candy was and with new stimuli told to point to the one which was (1) the same as, (2) different from, or (3) not the same as the stimulus the experimenter held. Analysis revealed that correctly identifying the different object was the most difficult, not the same was intermediate in difficulty, while same as was the easiest to identify. Fifty-three percent of the six-year-olds were able to verbalize the solution of the oddity problem, while only
two four-year-old subjects and one three-year-old could verbalize the solution. However, since the oddity solution was achieved by four-year-olds and nonverbalizing six-year-old subjects, the authors concluded that verbal ability was not a prerequisite nor did it mediate solution of the problem.

In a transposition study, Reese (1966) offered the possibility that preliminary training with verbal labelling serves to clarify for the child what it is that he is supposed to do and if he learned during pretraining that his behavior was supposed to be under verbal control, then exerting that control would be seen as pleasing the experimenter and thus would arise a relationship between mediation and reward that was previously unobserved by the child.

Etzel (1969) studied the oddity problem in two populations. One which was described as a middle-class population passed the initial pretest at 90% or better when they were told to "push the button under the different picture." Only 23% of the Headstart children met this criterion. When the term "not-like" was substituted for "different" in the instructions more children from both populations were able to pass the test. The total for each population, then, was 68% of the middle-class and 60% of the Headstart. The author pointed out that the initial advantage of the middle-class group was almost eliminated by a change in the instructions; that is, with this change from "different" to "not-like" the two groups were almost comparable in the number that passed the pretest.
An aspect of discrimination learning which has concerned many investigators is transfer and there is often a measure of the child's performance when new stimuli are introduced or new responses are required.

Kurtz (1955) found, in a paired-associates learning task, that transfer of discrimination training from one task to a second task was positive when the stimuli were distinguished by the same property in both tasks and that transfer would be negative when the stimuli were distinguished by different properties in the two tasks. His explanation for this transfer was based on an observing-response formulation of discrimination learning. According to this formulation, an individual may learn to react to similar stimuli with an observational response which results in more distinctive stimulation from the stimuli to be discriminated; this response may become selectively associated with a discriminative cue. When the stimuli are similar the discriminative cue will usually be a gross, readily perceived property common to the two while the cues made distinct by the observing responses will be more subtle distinguishing properties. Because of their stimulus connections, observing responses learned in one discrimination problem will tend to generalize to subsequent problems using stimuli with similar gross characteristics, whether or not the distinguishing properties are the same.

It had been assumed that subjects with well-established oddity response would be able to respond correctly given any discrimination difference. However, House (1964b) found that subjects with an oddity
performance nearly 100% correct for large differences did very poorly with smaller differences. She questioned whether the subjects failed to observe differences in size on certain trials although able to do so or did they observe the difference but fail to make correct instrumental responses on some trials? Generalization theory would support the second explanation in terms of the generalization of the instrumental habit of approaching the odd stimulus. The gradient of excitation spreading from positive to negative cues would result in interference which increases as the two cues become closer along the same-different continuum. Attention theory would support the first explanation in that adequate discrimination requires attending to the relevant dimension and choosing the correct cue of that dimension; the relevant dimension was probably not attended to. She added two possibilities: that the probability of observing a difference is directly related to the size of the difference and that observing responses for absolute size differ from those for relative size.

Bijou (1966) found, in his study of right-left form concepts in young children that once a mirror-image was discriminated from a non-mirror image, there was no assurance that this discrimination would be maintained when the forms were rotated and when additional mirror-images were displayed among the matches.

The effect of a verbal labelling response on transfer was studied by Strang (1968). In a pretest, he determined that his four-year-old children were able to make an up-down rotation frequently; the right-left reversal discrimination was made infrequently. He gave
all the subjects a series of thirty randomly arranged bd and bb slides after a period of pretraining in which there were four groups: (1) one in which the subjects were shown directionality of the bd and bb stimuli and told to make a verbal discrimination response, (2) one in which subjects were shown the direction and told to make a directional consistent motor response followed by a verbal response, (3) one in which the subject made verbal discrimination responses without a demonstration of the letter's directionality, and (4) one in which the subjects were shown the direction and told to make a direct motor response. Both of the first two groups acquired a reversal discrimination and the subjects with only the verbal response did as well as those which had both the motor and verbal response. In a test of transfer, the subjects who had learned the motor response did not transfer without further training to another discrimination task which included the same stimuli but required differential key pressing. The subjects with verbal labelling demonstrated perfect transfer. Also, a higher percentage of those subjects who acquired labelling discrimination of bd and bb generalized to a pq and pp discrimination.

Component Analysis

The general design of this study is based on a learning set formation with the concept of oddity to be learned by young children. Harlow's learning set formation is one in which subjects gain ever-increasing facility over a series of trials in solving comparable problems in less time and with fewer errors. This learning-to-learn
could be considered to be interproblem transfer, a positive transfer of "method" rather than "content."

However, Harlow (1959) stressed the comparability of the problems in the learning set formation. The problems in this study will vary from the usual procedure in that the problems will be similar but the sequence will range from easier to more difficult. In this respect, the concept of learning set resembles that of Gagne (1965). He does not equate learning set with transfer per se; instead learning sets are considered to be mediators of positive transfer. They might be referred to as intra-class learning sets. Gagne and Paradise (1961) said:

Attainment of any given learning set is dependent on recallability of certain subordinate learning sets, instructions defining the stimuli and goal of the new task, and integration by the learner of subordinate learning sets into the solution of the new task. Subordinate learning sets are conceived as having the function of mediating positive transfer to higher level learning sets through the hierarchy, and ultimately to the final task (p. 16).

The procedure by which this hierarchy is identified is known as component analysis (Gagne 1965). The analysis begins with a statement of the terminal objective, a description of the behaviors which the subject is to exhibit if he performs the task successfully. Once this objective is clearly defined, a subordinate set of subtopics is delineated, each as an individual learning act. Each of these subtopics in turn is studied to determine which skills would be necessary for successful performance. The analysis continues until each prerequisite capability the subject must have has been identified.
The learning model of Gagne resembles findings of other investigators that learning is more efficient when training in a difficult discrimination is preceded by training in similar but easier discriminations than when all training is given in the difficult discrimination alone (Hively 1966, Lawrence 1952, North 1959, Spiker 1959). Hively (1966) suggested that a program of successive discriminations makes it more likely for subjects to observe relevant stimuli and Ehrenfreund (1948) demonstrated that whether or not discrimination training produced a cumulative effect of increased efficiency depends upon whether or not the experiment is designed so that subjects are likely to observe the relevant stimuli.

These studies which have been reviewed have, for the most part, been conducted to test hypotheses about the effect of specified variables and have yielded valuable information about these variables in discrimination learning in children. However, researchers who have tried to develop teaching materials have found that this type of traditional experiment does not yield such material.

Silberman and Carter (1965) described research they conducted on computer-based instruction, and related that their greatest problem was the lack of instructional material. This prompted them to conduct a series of studies in designing better instructional material which at first took the form of traditional hypothesis-testing experiments. However, the findings from these studies led them to believe that before the influence of apparently potent variables can be observed, highly effective materials must be developed and these could not be
produced by hypothesis-testing. They used, instead, a technique called tutorial engineering in which a set of teaching materials was tried with one child at a time. When the child seemed to be having trouble the program was halted and different remedial methods were tried. When the problems appeared to be eased, the effective remedy was recorded. This process of tutorial modification was continued until a sufficient number of tutorial changes was recorded to warrant a major revision to the material. The revised version of the program was then tried on other children.

These data were then collected and analyzed for consistencies and patterns. This analysis resulted in three hypotheses about how to improve materials:

1. The gap hypothesis refers to the gap which occurs when a skill is omitted which is prerequisite to the criterion program.

2. The irrelevancy hypothesis refers to the desirability of eliminating an item which was unrelated to the criterion test.

3. The mastery hypothesis refers to the necessary requirement that each section must be mastered before the next section is tried.

Gilbert (1960) described the procedure by which an experimenter develops a program designed to teach a skill:

Get yourself one student. I repeat, one student. You are about to perform an experiment in which you are permitted no degrees of freedom. . . . Once you have discovered an efficient program for one student, you will have described the gross anatomy of the most generally useful program (p. 479).
Summary of Research Findings

A majority of reading authorities concurred that visual discrimination of graphemes is a prerequisite skill to reading and many studies indicated that the detection of the critical features which differentiate alphabet letters is important in such discrimination.

A training program in which one critical feature, as stimulus, is identified as different from an array of other stimuli which are identical to each other is similar to an oddity-problem. The ability to attend to the relevant relationship which exists among the odd and non-odd stimuli has been studied extensively in children's oddity-problem-learning. These studies have been characterized by their findings of the development of a learning set; through practice, later problems in a training series were solved in fewer trials and with fewer errors.

Certain findings from oddity-problem-learning experiments seem to be especially pertinent to an attempt to develop a training program which will aid in the acquisition of an oddity response. These include: (1) the increase in perceptual saliency with the increase in the number of non-odd stimuli, (2) the importance of the child's understanding of same and different, and (3) the effectiveness of presenting the same odd stimulus in successive trials in eliciting attention to the relevant dimension.

The analysis of the terminal task into component skills is suggested by a model with another interpretation of learning set. This model stressed the efficiency of training on successively more difficult discriminations.
The attempt of this study is to develop a program of materials for teaching visual discrimination through the employment of variables found relevant in discrimination learning experiments but the development of the program was not carried out in the usual psychological experimental fashion. Investigators have found that training materials are best developed, not through hypothesis-testing experiments, but by a series of program modifications and revisions found necessary as individual subjects proceed through such a program.

Statement of Problem

The purpose of this study was to design a training program in which the terminal objective was the correct discrimination of \( b, d, p, \) and \( q \). Left-right directionality is the characteristic feature which differentiates these letters so the program consisted of phases which progressed from gross directional differences to more subtle ones. The first series of stimuli featured arrows pointing left or right; the arrow became an oval and then a circle in subsequent series. The criterion tests were to differentiate \( b \) and \( d \); \( p \) and \( q \); \( b \) and \( q \), and \( d \) and \( p \). The discrimination was made as an oddity response; the odd stimulus was to be chosen from an array of non-odd stimuli.

The main steps of the program were:

1. A paper-and-pencil pretest of the child's ability to identify each of the letters, \( b, d, p, \) and \( q \) in an array of one odd and four non-odd letters.

2. A teaching machine program which was graduated in difficulty from gross directional differences to more subtle ones, with criterion
tests of differentiating be, pq, bq, and dp. Passage through the program phases was contingent upon successful performance in preceding steps.

3. A paper-and-pencil posttest to assess ability to identify each of the letter stimuli. This criterion test was identical to the initial test.

Additionally, the machine used in the program was designed to be used in educational settings with low budgets and nonprofessional help. If the program was effective, in this economical version, the machine and programs such as this one, could be welcome contributions to individualized instruction in preschool education.
METHOD

The aim of this study was to devise a program which would guide young children in making discriminations of oddity based on left-right directionality. Through a series of increasingly more subtle differences, they would be led to differentiate b, d, p, and q which differ from each other in their directionality.

There were eight program phases:

1. An array of geometric forms from which the child was to select the odd stimulus. This phase had the two-fold purpose of familiarizing the child with the machine and procedure and of appraising the experimenter of the child's understanding of oddity itself.

2. An array of stimulus figures which were vertical lines from the middle of which pointed arrows, four in one direction, one in the other. This was Phase A.

3. An array of stimulus figures similar to those in Phase A except that the arrow was replaced with an oval. This was Phase B.

4. An array of stimulus figures in which the oval has been replaced with a circle the same size as the circles in the criterion letters b, d, p, and q. These circles, however, are still in the middle of the vertical line. This was Phase C.

5. An array of alphabet letters b and d, with either letter alternating as odd. This was Phase D.
6. An array of alphabet letters \(p\) and \(q\), with either letter alternating as odd. This was Phase E.

7. An array of alphabet letters \(b\) and \(c\), with either letter alternating as odd. This was Phase F.

8. An array of alphabet letters \(d\) and \(p\), with either letter alternating as odd. This was Phase G.

An additional phase was incorporated when some children experienced difficulty with Phase A. This series featured large black triangles, one of which had its apex pointing in a direction opposite to that of the other four. This was Phase X.

**Subjects**

Ten children, seven boys and three girls, served as subjects. They were enrolled in a day-care center in Tucson, Arizona. This center is funded for children of working mothers. Eligibility is determined by financial need. Two children were white; eight were black and their ages ranged from four years, eleven months to six years, six months.

They were selected from nineteen children, chosen at random, who were given the written pretest. Six of the nineteen children made one or no errors and were not candidates for training. The other three children were characterized by center personnel as irregular attenders.

**Apparatus**

A simple version of a teaching machine was chosen for the training program for the tighter control of the reinforcement
contingencies necessary for optimal learning. This same control which enables a child to learn enables an experimenter to study that learning.

The machine is made of 1/4 inch Douglas fir plywood, framed with 3/4 inch pine trim. It is 53 inches high and 30 1/2 inches wide. The height was to screen the operator. There are two rows of holes, 2 inches in diameter, 1 3/4 inches apart. The top row is 1 1/2 inches above the lower row. Beneath each hole in the bottom row is a handle, 5 x 3/4 inches, which when depressed pulls down the individual wooden screen which covered that hole. These handles are powered by rubber bands. The cost for materials was $5.00. A view of this apparatus can be seen in Appendix A.

This is placed on a child-sized table, or even on two child-sized chairs with the handles facing the child who is seated. On the other side the operator can hold large cards on a rack which exposes the cards through the rows of holes.

An additional advantage of a machine is possible juxtaposition of the stimulus, reward, and response. Stollnitz (1965) noted that increasing the separation of the cue and the response decreases what he called $p_o$, the probability of observing. Subjects look where they put their fingers, and the farther the cue from the response, the less likely the subject will look at it. Polidora and Fletcher (1964) declared that any experimentally imposed observing response which results only in exposure of the stimuli does not necessarily insure that the subjects attends to them. Their hypothesis of stimulus
sampling needs an assumption that the act of touching a site is preceded by an observing response of looking at it. If this assumption is valid, there are two possible situations concerning the instrumental response in a discrimination learning experiment. If the initial component is made spatially contiguous with the stimulus to be discriminated the subject can sample the experimentally defined relevant stimulus elements while he looks at the stimulus site. If the initial instrumental response is discontiguous the subject would look at a remote site and sample irrelevant stimuli there.

Response-reward contiguity was found to be important by Murphy and Miller (1959). Suppes and Ginsberg (1962), in a number concept task, found a separation of 6 inches was sufficient to interfere with efficient learning in young children.

With this machine, the stimulus elements appeared in the upper row of holes; the response was made by the child on handles 3 1/2 inches below, and the reward appeared in the lower row of holes which were 1 1/2 inches below the stimulus row and 1/2 inch above the response handles.

Stimulus Materials

1. A paper-and-pencil test with geometric forms. A square, circle, triangle, and rectangle appeared twice as the odd stimulus in twelve randomly ordered presentations.

2. A paper-and-pencil test with b, d, p, and q in rows in which an odd letter was to be discriminated. Each letter appeared as the odd stimulus four times. The odd stimulus never appeared in the same
spatial position twice in succession and each of the four positions received an equal number of odd assignments. The middle position was never odd in this test. These tests were reproduced on ditto sheets.

3. Four sets of cards were prepared for each program phase. These were made of white poster board, 22 x 7 inches, with the stimuli drawn with a black felt pen. Throughout the program each spatial discrimination of left or right was odd an equal number of times and each machine position held the odd stimulus an equal number of times, with the middle position never odd. No position was odd twice in succession.

Examples of stimulus materials can be seen in Appendix B.

Under the odd stimulus, a colored seal was affixed in such a position that it would show through the lower hole if the child pulled down that handle. A variety of pictures was purchased from a stationery store—flowers, storybook characters, sports figures, animals, and dolls. These were changed frequently.

The colored seals as types of reinforcement were chosen because they had been selected frequently by young children in an earlier study conducted by the experimenter. They were also chosen because the child would be responding under conditions of stimulus change and stimulus control. Both these effects may act as reinforcers. Berlyne (1960) cited support for the role of stimulus change in reinforcement and Hively (1962) suggested both of them as having possessed reinforcing value in the teaching machine study of form discrimination which he conducted. He hypothesized that whether one
or both of them are operating the effects would be the same. In a
given series of slides observing and responding to relevant stimuli
may be reinforced by the appearance of novel items. He was referring
to the test stimuli themselves; in this experiment it was hoped that
this effect would be strengthened by the addition of another stimulus
change potentially under the child's control.

**Procedure**

All training and testing sessions were conducted individually.
In the written test, the child was told: "Draw a line on the one that
is not the same as the others."

Each session in the training program was held in a small room
at the center. Three researchers were present, one behind the machine
to change the cards and two behind the child to record responses and
response latency times.

The child was seated facing the machine and told: "Push the
handle under the one that is not the same as the others." During the
pretraining phase, with the geometric forms, the child was told, after
a correct response: "You will see a picture in the window each time
you are right." No comment was made after an incorrect choice.
Subsequently, during pretraining and training, verbal reinforcement
accompanied each correct response.

If six consecutive correct choices were made, the subject was
advanced to the next phase. If he made an error, ten correct choices
were required before an advance. After four incorrect choices the
child repeated the previous series until the criterion was met.
Fifty trials were given each day unless criterion was met before fifty trials. More than fifty trials were given to two children who were nearing the end of the program at the end of a session. Each session lasted ten to fifteen minutes.

The time between the initial presentation of the stimuli and the child's manual response was recorded with a stop watch. Suppes and Ginsberg (1962) declared that little systematic work has been done with response latency as a variable which may serve as a central criterion of learning; yet he felt that much of the experimental work has shown that for many kinds of learning, latencies are a much more sensitive index than are response errors themselves.
RESULTS

The terminal objective of the machine training program was the correct discrimination of b, d, p, and q in arrays of one odd and four non-odd stimuli. These were Phases D, E, F, and G. Phases A, B, and C featured first arrows, then ovals, and then circles oriented to the left or right. Phase X had as stimuli triangles inverted to the left or right.

Eight of the ten children completed the program, meeting the criterion of six successive correct choices or ten correct with only one error. (See Table 1.) Two children completed the program in one session; the range was from one to eight sessions (Fig. 1). The total number of responses made is seen in Figure 2, with a range from 45 to 395.

The machine criterion tests, Phases D through G, were given to each child one week after the end of his work with the machine. Six children made one or no errors (Table 1). These had all been successful children and another successful subject, JW, made only two errors.

The paper-and-pencil criterion test was given immediately after criterion had been met on the machine training program. Only five children chose correctly 90% of the alphabet letters. Four of these five children had completed the program and included KV who had not done well on the machine retest. Of the other successful trainees, KF showed some improvement over his pretest score; T remained the same;
Table 1. Total Number of Graphemes Correctly Discriminated by Subjects on Criterion Tests

<table>
<thead>
<tr>
<th>Child</th>
<th>Age in years</th>
<th>Training status</th>
<th>Written pretest</th>
<th>Written posttest</th>
<th>Machine retest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>5.7</td>
<td>Completed</td>
<td>4</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>JW</td>
<td>6.5</td>
<td>Completed</td>
<td>4</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>KF</td>
<td>6.9</td>
<td>Completed</td>
<td>8</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Ra</td>
<td>4.9</td>
<td>Completed</td>
<td>8</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>JB</td>
<td>6.0</td>
<td>Completed</td>
<td>10</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>T</td>
<td>6.5</td>
<td>Completed</td>
<td>8</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Ri</td>
<td>5.7</td>
<td>Completed</td>
<td>4</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>KV</td>
<td>5.6</td>
<td>Completed</td>
<td>2</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>G</td>
<td>5.7</td>
<td>Not completed</td>
<td>12</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>P</td>
<td>5.6</td>
<td>Not completed</td>
<td>4</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>A</td>
<td>5.8</td>
<td>No training</td>
<td>6</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Lu</td>
<td>5.3</td>
<td>No training</td>
<td>5</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Li</td>
<td>5.2</td>
<td>No training</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
</tbody>
</table>
Figure 1. Total Number of Sessions (15±min.) Required to Complete Program
Figure 2. Total Number of Responses Required to Complete Program
Ri and Ra made more errors. Child G, who had been an unsuccessful trainee improved his number of correct discriminations from 12 to 16. The other unsuccessful child, P, also improved (Table 1).

No one of the three children who might have been training candidates on the basis of their pretest scores showed improvement.

Each child demonstrated a different pattern of number of errors, number of trials, and number of unsuccessful attempts at program phases. Performance records of individual children are shown in Appendix C. Records showing the daily percentage of correct and incorrect responses and the number of unsuccessful attempts to reach criterion can be seen in Appendix D.

The number of trials alone would not be a reliable index of phase difficulty due to the procedure of repeating a prior phase after errors. However, determination of an individual's most difficult level was made by combining his highest number of trials, errors, and unsuccessful attempts to meet the criterion of a program phase. This is shown in Table 2. Phases X, A, D, and E were found to be the most difficult for two children each; C was the most difficult for one subject.

Subjects who obviously found some parts of the program difficult were KV, G, and P. A study of the raw data during KV's training revealed a consistent error as he apparently had tried to learn the sequence of C during his repetitions of that phase. He would incorrectly choose the first position just prior to the time when it was correct in the sequence.
Table 2. Most Difficult Phases as Determined by Trials, Errors, and Unsuccessful Attempts to Meet Criterion

<table>
<thead>
<tr>
<th>Child</th>
<th>Highest number of trials</th>
<th>Highest number of errors</th>
<th>Highest number of unsuccessful attempts</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>T</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>KF</td>
<td>X</td>
<td>X</td>
<td>X,A</td>
</tr>
<tr>
<td>JB</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Ri</td>
<td>C,A</td>
<td>D,A</td>
<td>D</td>
</tr>
<tr>
<td>KV</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ra</td>
<td>E</td>
<td>C</td>
<td>E</td>
</tr>
</tbody>
</table>
The first position was selected by Child KV 67 times out of 138 incorrect responses. No such consistent competing response was seen on inspection of G's data.

No children experienced difficulty with the geometric form pre-test, written or machine.

Response latency, the time between stimulus presentation and the child's pulling of the machine handle was recorded for each child.

Of the six children who met criterion and were trained in more than one session, only one decreased his response time. Four subjects increased their time to respond; one remained the same. The time to respond correctly was faster than incorrect response time for three children throughout training and for three children at the end of training. There was an increase in response time on retest for five children, a decrease for three. (Refer to Table 3.)

To determine for future programs the effectiveness of allowing four errors before returning the child to a prior phase, the data were inspected to see if any child had a run of correct choices after errors. It was found that only twice was there a series of correct choices after three errors; there was never a correct series after four errors.

Summary of Results

1. Eight of ten children who participated in a training program for grapheme discrimination performed successfully on criterion tests given on the same training machine.
Table 3. Summary of Characteristics of Individual Response Latencies in Training and on Retest

<table>
<thead>
<tr>
<th>Child</th>
<th>Shorter latency time in training</th>
<th>Latency time at training end</th>
<th>Latency time on retest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Incorrect responses</td>
<td>---</td>
<td>Longer</td>
</tr>
<tr>
<td>JW</td>
<td>Correct responses</td>
<td>---</td>
<td>Shorter</td>
</tr>
<tr>
<td>Ra</td>
<td>Correct responses</td>
<td>Longer</td>
<td>Shorter</td>
</tr>
<tr>
<td>KF</td>
<td>Correct responses</td>
<td>Shorter</td>
<td>Shorter</td>
</tr>
<tr>
<td>T</td>
<td>Incorrect responses</td>
<td>Same</td>
<td>Shorter</td>
</tr>
<tr>
<td>JB</td>
<td>Incorrect, then correct responses</td>
<td>Longer</td>
<td>Longer</td>
</tr>
<tr>
<td>Ri</td>
<td>Incorrect, then correct responses</td>
<td>Longer</td>
<td>Shorter</td>
</tr>
<tr>
<td>KV</td>
<td>Incorrect, then correct responses</td>
<td>Longer</td>
<td>Longer</td>
</tr>
</tbody>
</table>
2. The range of sessions was one to eight; the range of responses was 45 to 395 for these eight subjects.

3. On a machine retest, given one week later, six of these children made one or no errors.

4. Four successful children selected correctly 90% of the time the odd alphabet letter in an array printed on the paper-and-pencil criterion test. This test was identical in content and form to the one given as a pretest, and identical in content to the machine criterion test. One successful child showed some improvement; two did more poorly than on the pretest. Both unsuccessful children improved, one making all correct choices.

5. Phases X, A, and D were found most difficult by two children each; C and E by one each.

6. No consistent pattern was seen in a study of the response latencies.

7. Inspection of individual data revealed two consistent competing responses for two of the children: a position set and a sequence effect.

8. Inspection of the data revealed that only twice was a series of correct choices made after three errors, never after four errors.
DISCUSSION OF RESULTS

Ten young children were participants in a training program which reinforced correct discrimination of left-right directionality. Eight of the children were able to differentiate the graphemes b, d, p, and q in a criterion test given on the machine.

Two children were unable to learn the discrimination to criterion. For them and for other subjects, at times in the program, there must have been competing responses. In experiments with monkey subjects, Harlow (1959) identified four factors which consistently led to inappropriate responses to the problems. As these consistent but inappropriate responses were reduced, the percentage of errors lessened and learning was said to be taking place. The error factors (EF) which he described are:

1. Stimulus-perseveration. This involves repetitive choice of the incorrect stimulus object. It is presumed that this results from the subject's stimulus preferences, absolute or relative, innate or learned. He found several variables which affect stimulus perseveration during learning set formation: the criterial trials chosen, the amount and nature of adaptation, discrimination learning experience, and the stimuli chosen for presentation. The age of the subject appeared to be important, with perseveration appearing more frequently in younger ones. Usually the response tendencies producing stimulus perseveration were among the first to be suppressed or inhibited.
2. Differential-cue. This apparently results from the ambiguity on any trial between the object rewarded and the position rewarded. The greater the number of trials before the shift to a new position of the rewarded object, the greater will be this error frequency.

3. Response shift. This was described as perhaps the most persistent EF and is reflected in a strong tendency of the subject to respond to both stimuli. This is demonstrated by the choice of an unrewarded stimulus following a rewarded stimulus and the tendency may persist through many trials. Harlow conceived of it as resulting from an exploratory tendency in the subject.

4. Position habit. This is characterized by a tendency to respond consistently to one position or another.

Learning, in this interpretation, involves the elimination of responses and response tendencies inappropriate to a particular learning situation.

Ellis, Girardeau, and Pryer (1962) studied some of the error factors in children's acquisition of LS formation. They found that children of normal intelligence eliminated stimulus perseveration errors slowly over many trials and that position error was a significant source of error in normal learning. In another study, Hill (1965a) reported that during early trials both four and six-year-old subjects responded to position cues; the performance of four-year-olds was more seriously affected, especially when there was an increase in difficulty level. She contended that continued use of a response to position prevents any response to either relevant oddity-cue or irrelevant
object-cue. The six-year-olds did not exhibit strong alternation responses indicating that a single reinforcement pattern can determine the type of response at this age level. She also related that the performance of older subjects was not characterized by the consistent use of any particular response, suggesting that these subjects use a variety of responses and make frequent changes in the type they use.

The training procedure outlined in this study was designed more toward the ability to make a stable discrimination response than it was toward improving oddity responding. Saravo and Gollin (1969) noted that oddity discrimination training produced a reduction of position responding which apparently permitted subjects to respond to the object dimension in terms of oddity. They did find that older children needed less discrimination training; they used fewer non-solution responses such as object and position.

Harlow attributed the increasing interproblem transfer to the reduction of interfering response tendencies, omitting any conception of reinforcement as directly strengthening any response. Restle (1958) proposed that the strengthening of a response was accomplished through reinforcement. He postulated that in learning set experiments there are three kinds of cues:

1. Type-a cues which are valid and common to all problems of the experiment. These are consistently reinforced and constant even when particular stimulus objects are changed.

2. Type-b cues which are valid during a given problem but not valid in the long run.
3. Type-c cues which are found in the situation, apparatus, procedure, and stimulus but are not consistently reinforced at any time.

During any one problem, Type-a and Type-b cues become conditioned to correct responses and Type-c cues become habituated. Slowly as more and more problems accumulate Type-c cues become habituated permanently so they no longer affect performance. Learning within problems proceeds faster. Type-b cues become gradually habituated until eventually the subject is responding in terms of abstract Type-a cues only. This interpretation stresses the importance of rewards as information-giving cues.

Levine (1959) set forth a model of hypothesis behavior which assumes that the subject is capable of responding in terms of hypotheses and hypotheses may be strengthened by reinforcement. One of the hypotheses, Win-Stay, Lose-Shift (with respect to the object) is the hypothesis which the experimenter chooses to reinforce. This hypothesis is analogous to Restle's Type-a cues. Learning set formation is the gradual strengthening by means of 100% reinforcement of this hypothesis and the gradual extinction because of partial reinforcement of the other hypotheses.

Hill (1965a) stated that both the availability of problem-solving responses and the control and direction of attention appear to underlie learning set performance. House (1964a) found that subjects in the random alternation method in which competing response tendencies are not consistently reinforced did not do as well as did
the subjects who received the successive reversal method. Her explana-
tion was expressed in terms of attention theory which states that
visual discrimination training requires a chain of responses: attend-
ing to or observing the relevant dimension and choosing the correct
cue of that dimension. Oddity dimension, however, is a relation among
the cues of other dimensions and requires two observing responses. To
perceive oddity, the subject must see the dimensions carrying the
oddity—the vehicle dimension—and must then see the oddity relation
among the cues of the vehicle dimension. Thus, oddity responding
requires a chain of two observing responses and one terminal instrumental
response. If the subject does not develop a high probability of
observing the vehicle dimension the chain is broken. This is the
explanation she offered for the success of subjects in the successive
reversal condition: subjects receive differential reinforcement for
appropriate specific cues of the vehicle dimension as well as for
appropriate odd cues of that dimension, thus establishing the first
link of the chain.

This study used the successive alternation method to present
the stimuli to maximize the probability of observing responses. It
was also noted in Method that the stimulus, response, and reward were
spatially contiguous to encourage the subject to observe the relevant
dimension as he makes the response and is or is not reinforced.
Zeaman and House (1963) said that learning set could result from
"extinction of observing responses to the class of dimensions which
are never relevant and the acquisition of strong tendencies to observe
those dimensions which are frequently relevant" (pp. 219-220).
Hively (1966) discussed the difference between a correct hypothesis and an incorrect hypothesis. The correct hypothesis in a discrimination experiment is defined by the experimenter and is arranged by reinforcing a given class of responses in the presence of a given class of stimuli. Therefore, the difference between a correct hypothesis and an incorrect hypothesis is a matter of the probability that the behavior will be reinforced. Correct hypotheses are consistently reinforced; incorrect hypotheses received only chance reinforcement. However, the chances that incorrect hypotheses can be strengthened by accidental reinforcement are good; the actual contingencies of reinforcement depend upon what the subject actually observes.

Attention, according to Skinner (1953), is more than looking at something. If the subject actually observes, there is a controlling relation between his response and the stimulus and that relation is attention. When the subject is paying attention he is under the special control of the stimulus.

Various attention theories have been offered; some were the subjects of a review article by Mackintosh (1965). In surveying the relevant animal discrimination learning studies, he declared that the available evidence supported more of the implications of a two-stage attention theory than it did any other theories. He particularly listed some requirements of an adequate theory:
1. The attention stage should serve the function of permitting the animal to discriminate a given stimulus dimension. Evidence from all the experiments demonstrated that animals do not learn about all cues equally.

2. This selective attention effect cannot be attributed solely to overt receptor orientation; attention selects between stimulus dimensions and not between stimulus objects.

3. There must be two stages, one involving the attention responses and one involving the choice responses since there is no evidence to support the assumption that these responses obey the same laws.

He recognized that the concept of attention is considered somewhat mentalistic and stressed that the production of more rigorous studies is needed.

In an application of attention theory to discrimination learning in children, House (1964a) described the two stages necessary for adequate discrimination learning: (1) attending to the relevant dimension, and (2) choosing the correct cue of that dimension. In this study, the relevant dimension was the spatial directionality of the stimuli and the cue of that dimension was the oddness of that feature in one stimulus in relationship to the other four stimuli.

Differentiation theory is another which plays a role in any discussion of a learning task such as visual discrimination. The detection of distinctive features may be the necessary and sufficient condition for improvement in discrimination. One hypothesis regarding learning during the improvement of discrimination emphasizes the
dimensions of difference which distinguish objects. Practice enables
the subject to specify differences among objects. Pick (1965) noted
that it is these dimensions of differences which distinguish and
provide contrasts among the objects. The function of the practice
then is to enable the subject to respond to an increasing number of
stimulus variables and to discover which of these variables are critical
in distinguishing one object from another.

Children respond differentially to different types of stimulus
cues; this differential responsivity lends support to such explana-
tions of learning deficit as those which point to the ability to direct
and maintain attention to critical features.

It was the aim of this study to develop a program which would
aid children in the acquisition of that ability to direct and maintain
attention to the critical features of left-right directionality which
differentiate the graphemes d, b, p, and q.

Implications for Improving the Program

Although this was an efficient program for eight children, it
was not an errorless one. A study of the data of most of the subjects
attest to the presence of error-producing factors. The role of the
elimination of such factors in learning has been discussed but another
approach to learning emphasizes the efficiency of learning in which
error responses are not allowed to occur. The argument offered by
those favoring this type of procedure is that when errors occur,
there is lack of control over the learning process so that opportunity
is provided for intermittent reinforcement of incorrect responses. The procedure followed in training programs which attempt to teach a discrimination by errorless acquisition is to use stimulus cues to elicit correct responses and then to fade out these supporting cues gradually. Touchette (1968), for example, used a technique of graduated stimulus change in a simple discrimination learning problem with severely retarded children. He maintained that the contingencies set by the experimenter cannot exclude inappropriate observation behavior during trial-and-error learning so that the conditions under which reinforcement is delivered may be sufficient to shape superstitious control. He used color cues in which the black response key and display panel became progressively lighter while the red background gradually fades until all panels are white. Etzel (1969) also used a stimulus shaping technique in which the object to be discriminated as different is represented first on a very simple level and throughout the series gradually becomes more complex and more similar to the other pictured objects.

Moore and Goldiamond (1964) trained a discrimination of degree of line rotation by gradually increasing the intensity of the incorrect match which had been presented at a very low intensity early in training. Karraker and Doke (1970) studied the discrimination of b and d. Their procedure included the gradual reduction of color intensity on successive presentations.

The adoption of this technique could be accomplished in this program by using color as a stimulus cue. The similar stimuli would
be black; the odd one would begin the series in a red of 100% satu-
ration. This would be decreased in each phase from 100% to 90% to 70% to 50% and finally to 30%.

This would increase the number of cards in each phase and, with a randomized sequence, the possibility of sequence errors could be decreased. This is a graphic illustration of the shift in responsibility in this kind of teaching/learning. In Phase C, KV's difficulty was due not to a learning disability but to a serious programming error.

The marked difference in performance on the paper and machine criterion tests attests to the need for including generalization procedures for some children. When Glaser and Reynolds (1964) found that successful children in a time-telling program could not read real clocks, they concluded that transfer and generalization must be explicit instructional objectives.

The letters of the two tests were the same size but they were separated by 1 inch on paper and by 3 inches on the machine card. There was the additional physical separation of the machine itself. The paper stimuli were the light purple of ditto sheets; the card stimuli were drawn with a black felt pen on a white background. All of these are factors to be considered in adding a generalization phase to the program.

The wisdom of the a priori decision to allow the child to make four mistakes before returning to an earlier step was not supported by the data. Only twice did any child go on to successful performance after three errors and never after four errors. However, this is an area which needs further investigation with more subjects.
The discriminations of \( p \) from \( d \) and \( b \) from \( q \) (Phases F and G) were not difficult for any child who completed the program. There was both the right-left distinction and the additional cue of up and downness. Benton (1959) reported that the average child masters the distinction between up and down during preschool years but does not begin to make the left-right discrimination until early elementary years. Harris (1969) stressed environmental factors which contribute to the difference in acquisition of these two spatial discriminations. He cited greater opportunities for practice of up and downness and cues in objects themselves.

Child P was a classic example of the child about whom teachers (and researchers) wail, "I know she can do better." It was extremely difficult to administer the paper-and-pencil tests to this child as she apparently preferred talking and other forms of social interaction. While she was more task-committed while at the machine, there was often a very rapid choice as if the result were not important.

The empirical selection of more powerful reinforcers, probably in a form of contingency management, would be a relevant part of a programming procedure for a child like this. There is a need for the study of both stimulus and motivation parameters in any learning situation.

**Suggestions for Application to Educational Settings**

There is a common practice in traditional education to include a regular amount of practice involving geometric form and letter discrimination. The results of this study would indicate that there is
little transfer from the ability to discriminate geometric forms to the ability to discriminate graphemes. All children were able to perform the form discrimination but they varied in their performance with letters. The variety of these performances with letter discrimination would strongly suggest that it is inefficient to give the same amount of practice to all children.

The program of this study involved 15 minute sessions and the children needed only one to eight sessions. This appears to be a modest amount of educational time to devote to a form of training which contributes to a process as important as reading.

A by-product of this research was the successful use of an inexpensive teaching machine. It did not have the valuable recording features of electronic devices but its low cost and uncomplicated operation make it practical for learning situations in classrooms.

The stimuli could be printed on both sides of the cards and the card-manager could see the selection made and determine the next step. This card-manager need not be a professional person; the steps of the program would be outlined ahead of time. It is even possible that children could perform this role in a peer-peer learning interaction.

Other programs for preschools are possible for inclusion in a development such as this. Discrimination of size, shape, fine color differences, and orientation are some possibilities. With the addition of verbal labelling by the teacher, a child could be asked to choose the object that starts with a p, for example, or the object which is a tool in an array of increasingly similar objects.
ILLUSTRATION OF TEACHING MACHINE APPARATUS
APPENDIX B

PROGRAM STIMULI

Geometric form stimuli; stimuli of phases X, A, B, C, D, and E; and criterion graphemes.
Geometric Form Pretest
Geometric Form Pretest—Continued
Phase X Stimuli
Phase A Stimuli
Phase B Stimuli
Phase C Stimuli
Criterion Graphemes
Criterion Graphemes—Continued
APPENDIX C

INDIVIDUAL PERFORMANCE IN PROGRAM PHASES

Number of errors, number of trials, and number of unsuccessful attempts to reach criterion.
Table C1. Child Y—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

<table>
<thead>
<tr>
<th>Phase</th>
<th>Number of unsuccessful attempts</th>
<th>Number of trials</th>
<th>Number of errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>A</td>
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<td>D</td>
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<td>E</td>
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<td>6</td>
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</tr>
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<td>F</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>0</td>
<td>6</td>
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<tr>
<td>Total</td>
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Table C2. Child JW—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

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<th>Number of trials</th>
<th>Number of errors</th>
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</tr>
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<td>F</td>
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</tr>
<tr>
<td>G</td>
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<td>Total</td>
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Table C3. Child Ra--Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

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<th>Number of errors</th>
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<td>Total</td>
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Table C4. Child KF—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

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Table C5. Child T—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

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<th>Number of errors</th>
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<td>C</td>
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<td>G</td>
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<td>Total</td>
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<td>35</td>
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Table C6. Child JB—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

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<th>Number of errors</th>
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<td>B</td>
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<td>C</td>
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Table C7. Child Ri—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

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<th>Number of errors</th>
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<tr>
<td>A</td>
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</tr>
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<td>G</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>342</td>
<td>90</td>
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</table>
Table C8. Child KV—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

<table>
<thead>
<tr>
<th>Phase</th>
<th>Number of unsuccessful attempts</th>
<th>Number of trials</th>
<th>Number of errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1</td>
<td>41</td>
<td>22</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>45</td>
<td>12</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>92</td>
<td>11</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>164</td>
<td>55</td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>G</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>375</td>
<td>113</td>
</tr>
<tr>
<td>Phase</td>
<td>Number of unsuccessful attempts</td>
<td>Number of trials</td>
<td>Number of errors</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>X</td>
<td>5</td>
<td>243</td>
<td>59</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>31</td>
<td>8</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>F</td>
<td>-</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>-</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>346</td>
<td>82</td>
</tr>
</tbody>
</table>
Table C10. Child P—Trials, Errors, and Unsuccessful Attempts at Meeting Criterion

<table>
<thead>
<tr>
<th>Phase</th>
<th>Number of unsuccessful attempts</th>
<th>Number of trials</th>
<th>Number of errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1</td>
<td>88</td>
<td>28</td>
</tr>
<tr>
<td>A</td>
<td>9</td>
<td>240</td>
<td>72</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>80</td>
<td>17</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>D</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>G</td>
<td>1</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>456</td>
<td>141</td>
</tr>
</tbody>
</table>
APPENDIX D

DAILY PERFORMANCE RECORDS

Percentage of correct and incorrect responses, and number of unsuccessful attempts to reach criterion.
Table D1. Percentage of Correct Responses, Daily

| Child | Sessions | | | | | | | | Total |
|-------|----------|---|---|---|---|---|---|---|      |
|       |          | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |      |
| JW    | 92       | - | - | - | - | - | - | - | - | 92 |
| Y     | 98       | - | - | - | - | - | - | - | - | 98 |
| Ra    | 88       | 94| - | - | - | - | - | - | - | 182|
| KF    | 64       | 96| - | - | - | - | - | - | - | 160|
| JB    | 70       | 74| 88| 96| - | - | - | - | - | 328|
| T     | 68       | 76| 88| 98| - | - | - | - | - | 330|
| Ri    | 54       | 68| 86| 76| 72| 74| 68| - | - | 518|
| KV    | 62       | 58| 58| 76| 62| 74| 86| 82| - | 578|
| G*    | 70       | 60| 72| 72| 66| 76| - | - | - | 416|
| P*    | 54       | 66| 60| 60| 78| 70| 76| 82| 78| 624|

*Did not complete training.
Table D2. Percentage of Incorrect Responses, Daily

<table>
<thead>
<tr>
<th>Child</th>
<th>Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Y</td>
<td>2</td>
</tr>
<tr>
<td>JW</td>
<td>8</td>
</tr>
<tr>
<td>Ra</td>
<td>12</td>
</tr>
<tr>
<td>KF</td>
<td>36</td>
</tr>
<tr>
<td>T</td>
<td>32</td>
</tr>
<tr>
<td>JB</td>
<td>30</td>
</tr>
<tr>
<td>Ri</td>
<td>46</td>
</tr>
<tr>
<td>KV</td>
<td>38</td>
</tr>
<tr>
<td>G*</td>
<td>30</td>
</tr>
<tr>
<td>P*</td>
<td>46</td>
</tr>
</tbody>
</table>

*Did not complete training.
Table D3. Number of Unsuccessful Attempts to Reach Criterion, Daily

| Child | Sessions | | | | | | | Total |
|-------|----------|---|---|---|---|---|---|---|---|
|       | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Y     | 0 | - | - | - | - | - | - | - | 0 |
| JW    | 0 | - | - | - | - | - | - | - | 0 |
| Ra    | 1 | 0 | - | - | - | - | - | - | 1 |
| KF    | 2 | 0 | - | - | - | - | - | - | 2 |
| T     | 1 | 2 | 1 | 0 | - | - | - | - | 4 |
| JB    | 1 | 4 | 1 | 0 | - | - | - | - | 6 |
| Ri    | 1 | 3 | 1 | 2 | 2 | 0 | - | - | 9 |
| KV    | 2 | 3 | 3 | 1 | 1 | 2 | 2 | 0 | 14 |
| G*    | 2 | 1 | 1 | 2 | 1 | 4 | - | - | 11 |
| P*    | 1 | 1 | 2 | 2 | 2 | 3 | 1 | 6 | 20 |

*did not complete training.
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