ORTMAN, DEBORAH ELLEN. Training Letter Discrimination in Preschool Children by Manipulation of the Confusability of Alternative Letter Choices in a Matching-to-Sample Task. (1976)
Directed by: Dr. Rosemery O. Nelson. Pp. 60

Based on Gibson's theory of teaching children to discriminate letters by means of distinctive features, three groups of preschool children (N = 22) were trained to discriminate letters of the alphabet using three different types of matching-to-sample alternatives: (1) three units of high-confusion alternatives, (2) three units of low-confusion alternatives, or (3) a sequence of low-confusion alternatives to be mastered followed by a series of middle- and then high-confusion alternatives. Results of posttest 1, given after a criterion of two consecutive errorless training days on the third unit, indicated no significant improvements over pretest scores among the three training groups or the delayed-treatment control group. Likewise, on posttest 2, given after each child had received a standard number of 14 training sessions, no significant improvements over pretest scores were found among the three training groups or the delayed-treatment control group. Neither the number of errors made during training nor the number of days to reach criterion differed significantly for any of the three training groups. Although the results failed to achieve statistical significance, the direction of most mean differences was as predicted and was consistent with previous literature. The high-confusion and sequence groups made greater gains at posttest 1 than the low-confusion group, but required more training sessions to reach the criterion to be given posttest 1. These differential gains were not apparent at posttest 2 when all groups had received a standard number of training sessions. Based on these results, suggestions for future research were made.

TRAINING LETTER DISCRIMINATION IN PRESCHOOL CHILDREN BY MANIPULATION OF THE CONFUSABILITY OF ALTERNATIVE LETTER CHOICES IN A MATCHING-TO-SAMPLE TASK

by

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A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
1976

Approved by

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ACKNOWLEDGEMENTS

The author is grateful for the technical assistance of her thesis committee persons: Dr. Rosemery O. Nelson (chairperson), Dr. Jacquelyn Gaebelein, Dr. Mary Geis, and Dr. Anthony De Casper; the research assistance of Karen Brown, Barry Misenheimer, Gordon Owen, Toni Sanginite, and Debbie Stanley; and the children and staff of Baynes' Happy Day Nursery, Tots Haven Nursery, and the following Guilford County Head Start Centers: Bessemer, Congregational, Laughlin, St. James, St. Matthews, St. Pauls, and Trinity.

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CHAPTER I

INTRODUCTION

Several different theories and models have been conceptualized over the years to explain the process of learning to read (Williams, 1973). Among these various models, reading has been considered theoretically within the framework of operant psychology by Bloom (1973) and Goldiamond and Dyrud (1966) as an academic behavior. The written symbol is considered the stimulus to be discriminated, and the reading response is the behavior under this stimulus control. Though Gibson's theory of reading is generally placed within the framework of a cognitive orientation (Williams, 1973), her theory also can be adapted to experimentation employing an operant model in terms of stimulus-response-consequence. Utilizing Gibson's theory, the present study involved varying stimulus conditions in order to determine which condition would result in the most desirable reading response.

Gibson's analysis of the reading process (Gibson, 1969) consisted of the following four phases: learning receptive and expressive language skills; learning to differentiate graphic symbols (i.e., letters); learning to decode letters into sounds (i.e., learning both variable and constant letter-sound relationships); and using progressively higher-order units of structure, including pronounceability, and semantic and syntactic constraints. The emphasis of the present study was on Gibson's second phase, that of learning to discriminate letters.

This second phase is an important one because it is generally assumed in the psychological analysis of the reading process that the ability to discriminate letters is a prerequisite for reading (Bond & Dykstra, 1967; Gibson, Gibson, Pick, & Osser, 1962). Thus, when most children begin to read, it is assumed that they can generally distinguish one letter from another with a fair amount of accuracy. Guralnick (1972) stated that, for most children, learning the letters of the alphabet is their first real encounter with academic materials. If not accomplished with a reasonable amount of ease, this may lead the child down a path of academic failure and frustration.

The purpose of the present study was to compare the differential effectiveness of several training methods of letter discrimination on children's performance on a letter discrimination test. The following is a review of the literature of relevent research studies which examined children's acquisition of letter discrimination.

Gibson, Gibson, Pick, and Osser (1962) conducted a series of two experiments to study the development of the ability to visually discriminate a set of letter-like forms in children from ages four through eight years old in a matching-to-sample task. They also examined the visual discrimination of a set of real letters by kindergarten age children. Specific transformations for each of a group of standard letter-like forms were constructed. The choices for transformations of each standard were intuitively based with regard to the distinctive features of letters as a set. Three types of transformations used were thought to be critical for discriminating printed letters (topological transformations, rotations and reversals, and line to curve), and one was not (perspective transformation). Results revealed that errors for topological transformations (i.e., break and closure) were few even for four year olds. Errors for rotations and reversals and for changes of line to curve were many for four year olds but declined almost to zero by eight years of age. Perspective transformations (i.e., 45° slants to left and backward tilt) resulted in many errors from ages four through eight. Gibson and her colleagues discussed these results in terms of learning to detect critical, invariant features or dimensions of difference which are necessary for differentiating letters. Children improve in their ability to discriminate these critical features with age. As a result of this study, the dimensions thought to be critical for differentiating letters were break versus closure, line versus curve, and rotations and reversals. Because there was very little decrease in the number of errors made by children from ages four through eight, perspective transformations were not considered critical dimensions for letter discrimination. Rather, these perspective changes were thought to be considered the same forms regardless of the angle to the line of sight.

Gibson, Osser, Schiff, and Smith (1963) used these dimensions of difference to draw up a feature chart listing 12 distinctive features. This resulted in a unique pattern for each of the 26 Roman capital letters such that any one letter could be distinguished from all of the other letters by its unique combination of features. From this chart, it was predicted that letters which shared many features in common would more likely be confused while letters which shared few features in common would be less frequently confused. These predictions were confirmed in a series of two experiments (Gibson et al., 1963) in which Gibson and her colleagues had prereading children match a standard letter with one of six letter choices (one of which was the standard). In the first experiment, the letter choices were randomly selected, with the sets of choices arranged so that every letter appeared an equal number of times in these sets for every standard letter. Additionally, the sets of choices were prepared so that the correct standard appeared once, in each of the six choice positions, in order to balance out the possibility of choosing by position. In the second experiment, a high-confusion list was constructed by selecting for each letter alternative letter choices which had been most frequently confused in the first experiment (derived from a resulting matrix of number of confusions between all possible letter pairs from Experiment 1), and which shared many distinctive features in common (as determined from their feature chart). Similarly, a low-confusion list used those letter choices which had not been confused at all with the standard letter to be matched, and which shared few, if any, distinctive features. As some letters did not fit into either the high-confusion or low-confusion categories, they were omitted as possible alternative letter choices. To determine if the distinctive features were being utilized in discrimination, Gibson and her colleagues replicated their matching-to-sample task of stimulus letter and six alternative letter choices, and then compared the number of feature differences between pairs of letters with the number of confusions which the children actually made between them. From the results of these experiments, two confusion matrices (one containing all possible letter pairs, and one containing more limited letter pairs) were constructed which gave the number of confusion errors between pairs of letters. From these matrices, it could be seen that some letters were more likely to be confused (high confusability) while other letters were seldom likely to be confused (low confusability).

The present study utilized the data derived from the two above-mentioned research studies by Gibson and her colleagues. Since letters that share many distinctive features in common are the most likely to be confused, then one would predict that training children to discriminate letters that are highly confusable would be more effective than training children to discriminate letters which are distinctively different in terms of their features and, thus, seldom confused. By presenting the child with the correct letter to be matched and several other letter choices that are similar in appearance, one would expect the child to attend more closely in order to distinguish letters which may differ by only one or a few features from other similar-looking letters.

Attention to distinctive features of letters was examined in a later study by Gibson, Shapiro, and Yonas (1968). They selected nine Roman capital letters from the alphabet which were thought to best represent the different critical features of Gibson et al.'s (1963) feature analysis. College students and seven year old children responded with a "same" or "different" judgment to a pair of letters presented simultaneously. The authors were interested in the confusability of the different letter pairs and their reaction time for judgment. Latency and error data correlated well, and high- and low-confusion errors were as predicted. Highly confused letter pairs had the longest latencies while low-confusion letter pairs had the shortest latencies for both groups. These results lent further support to Gibson et al.'s (1963) feature analysis, and to the distinctive feature theory of letter discrimination.

While Gibson's experiments dealt with capital letters, Popp (1964) used selected lower case letters of the alphabet in a matching-to-sample task with kindergarten age children to determine which pairs of lower case letters were most frequently confused by prereaders and would most likely be a source of difficulty in initial reading instruction. Results of her study indicated that confusions were greatest among letter pairs which were reversals or rotations of one another (e.g., b-p, d-b). Some confusions occurred among letter pairs with a high degree of formal similarity in which the confused letters contained similar or identical lines (e.g., k-y, h-n). Fewer errors occurred among letter pairs differentiated by a break versus closure (e.g., o-c). Thus, the data from this study involving highly confused lower case letters also lent support to Gibson's theory of distinctive features.

While Gibson and her colleagues and Popp provided data as to which letters were found to be highly confusable or infrequently confused, other authors have examined the effects of various methods of discrimination training on the child's ability to make improved discriminations on subsequent transfer tasks. Some of the studies have utilized letter-like stimuli either identical or similar to those forms used by Gibson et al. (1962); other studies used either upper or lower case letters. The emphasis of some studies has been on the perceptual mechanisms used by prereading children to discriminate these forms and letters; other studies have focused on the role of critical features in training letter discrimination. Thus, using the data revealed in the Gibson and Popp studies, these later studies have provided additional information in terms of specific training methods which may be used to aid the child who is learning to discriminate letters. The following is a review of the relevant studies involving discrimination training methods.

Pick (1965) used Gibson letter-like forms (Gibson et al., 1962) to teach three groups of kindergarten children to distinguish transformations from copies of three standard forms. She was interested in determining if children would improve their ability to make discriminations by first constructing schemata or models of the objects to be discriminated, and then matching the sensory data to the models in order to identify them as "same" or "different" (prototype learning). The second hypothesis investigated was that improvement of discrimination might consist of learning the distinctive features which differentiated the objects to be discriminated (distinctive feature hypothesis). After the children received training in distinguishing the transformations from the copies of the standards, they were randomly assigned to one of three transfer conditions. These three transfer conditions were the following: the "prototype" group received the same standards as in training and three different transformations; the "distinctive feature" group received three new standards and the same three types of transformations as those used in training; the control group received three standards and three transformations all of which were different from the ones used in training. Performance on the transfer task for the distinctive feature group which received different standards and comparable transformations was superior to the performance on the transfer tasks for either the prototype group receiving the same standards and comparable transformations or the control group which received both different standards and transformations. From these results, Pick concluded that learning distinctive features may have been a significant component in the improvement of visual discrimination of the letter-like forms used.

Also employing Gibson's letter-like forms (Gibson et al., 1962), Williams (1969) used three training methods with kindergarten children in a delayed matching-to-sample task: discrimination training in which different transformations of the same form were given as alternative choices to match the standard; discrimination training in which different forms were given as alternative choices to match the standard; and reproduction training in which three forms were each traced twice and copied three or four times. Each child in each of the first two groups viewed three different standards followed by a series of twelve cards, each of which contained two forms from which to choose (the correct standard and another form or transformation). Though the children in the first group made the most errors during training, they performed significantly better than either of the other two groups on a transfer task which involved discrimination of letter-like forms. These results lent further support to the idea of learning distinctive features as an aid to discrimination of letter-like forms.

Odom, McIntyre, and Neale (1971) did a replication of Pick's (1965) study in comparing the perceptual learning styles of reflective and impulsive kindergarten children. The children were selected as either reflective or impulsive based upon a pretest matching task in which the latency of their responses was measured. All of the children received the same training procedure as that used by Pick (1965). Then an equal number of reflective and impulsive children were assigned to each of the three transfer groups which followed the same transfer procedure used by

Pick (1965). As expected, results indicated that the reflective children made fewer errors in both training and transfer than the impulsive children, and they took fewer training trials to reach criterion than did the impulsive children. For reflective children, fewer errors were made by those children in the distinctive feature transfer group than those children in either the prototype or control group. Though the overall analysis of the impulsive children's performances failed to reveal any significant differences, a comparison test of those children in the prototype group indicated that they made more errors than those in the distinctive feature group. Thus, the authors concluded that, at least for the reflective children, their performances indicated that they perceived and evaluated information based upon the feature differences in the stimulus arrays. The information processed by the impulsive children could not be clearly identified.

Thus, it appears that discrimination of letter-like forms is aided when children have prior training experience with letter-like stimuli which can be discriminated by means of the distinctive features thought critical for differentiating them. Tawney (1972) extended these findings on discrimination training of letter-like stimuli to a subsequent transfer task involving discrimination of letters. He trained two groups of four year old children to respond to specific features of letter-like stimuli in a matching-to-sample task. The letter-like stimuli used in training were the same as those in the Gibson et al. (1962) study. One group of children was trained to attend to features critical for letter discrimination as determined from the Gibson et al. (1963) confusion matrix for highly confused letter pairs. The other group was trained to attend to features thought to be non-critical for letter discrimination, such as size of the standard, width of a line, etc. The transfer task consisted of matching-to-sample one of five letter choices to the stimulus letter. The letter choices consisted of the correct matching letter, letters with which the stimulus letter was highly confused (defined as five or more errors in Gibson's confusion matrix, Gibson et al., 1963), and letters that showed somewhat lesser degrees of confusion in the Gibson confusion matrix. Tawney found that those children who were reinforced for responding to features of letter-like forms thought to be critical for discriminating letters performed significantly better on the later matching-to-sample task of discrimination of real letters than did those children who were reinforced for responding to non-critical features. Tawney concluded that these results supported the hypothesis that reinforcement of discriminative responding to critical features of letter-like stimuli resulted in greater improvement in a later task of real letter discrimination than reinforcement of discriminative responding to the non-critical features of such stimuli. Thus, it appears that emphasis of critical features during discrimination training of letter-like stimuli will aid in later discrimination involving real letters.

Silver and Rollins (1973) further investigated the effects of emphasis of distinctive features by visual and/or verbal emphasis of the relevant stimulus features of Gibson letter-like forms (Gibson et al., 1963) to be discriminated by kindergarten age children. Relevant features of several letter-like forms were visually emphasized by highlighting these features in red, and verbal emphasis was given in the form of verbal descriptions of the relevant features. Following differential pretraining in which the children were exposed to visual emphasis of the relevant features, verbal emphasis of these features, visual and verbal emphasis of these relevant features, visual observation but no emphasis, or no pretraining at all, they were trained to identify variants of the two forms and then tested for transfer to two other variants of the same forms. Results indicated that those children who had been given the visual emphasis discrimination pretraining more easily learned to make discriminations among letter-like forms on the later transfer task. Though the performances of the children in the groups receiving the verbal emphasis either alone or in conjunction with visual emphasis were not as good as those in the visual emphasis group, they, nonetheless, showed improvement over the performance of the no-treatment control group. Therefore, it was concluded that the use of visual and verbal emphasis of the relevant features of letter-like stimuli facilitated discrimination of other forms on a later transfer task. Thus, more support was given to the hypothesis of emphasizing critical features of letter-like stimuli as a means of improving later discriminations among letter-like stimuli.

Other studies have utilized the above-mentioned results pertaining to the emphasis of distinctive features and have investigated the effects of feature emphasis of real letters during discrimination training in order to facilitate later tasks involving letter discrimination. In a study of the effect of distinctive feature training on the subsequent paired-associate learning to name letters, Samuels (1973) utilized the following three training groups of preschool age children: visual discrimination that forced attention to the distinctive features of the letters b, d, p, and q; visual discrimination of these same letters, but not on their distinctive features; and mere exposure to these letters with no visual discrimination. Results of a later task which involved learning the letter names by a paired-associate anticipation procedure indicated that the first group learned to name the letters in significantly fewer trials and with fewer errors. Samuels concluded that training on distinctive features facilitated later paired-associate learning of letter names.

More recently, Egeland and his colleague (Egeland, 1975; Egeland & Winer, 1974) have conducted further investigations into the effects of distinctive feature emphasis of letters in a training procedure as a means of improving later letter discrimination. Egeland and Winer (1974) taught preschool children to discriminate selected highly confused letters of the alphabet in a matching-to-sample task using either errorless discrimination pretraining in which the distinctive feature of the letter to be discriminated (e.g., the diagonal stem in the letter R) was highlighted in red and gradually faded out as training proceded, or through a reinforcement-extinction approach in which the children were merely told whether their responses were correct or incorrect. The children in each group were trained in 10 trials each to discriminate each of two highly confused letter pairs (either C-G and Y-V or R-P and K-X). Six letter choices were presented each trial (three of which were the correct letter and three of which were the incorrect letter). Results revealed that children taught to discriminate between these letter pairs using the errorless discrimination training made fewer errors during training and on a later transfer task of discrimination of these same letter pairs than those children whose training involved the reinforcement-extinction approach.

Egeland (1975) replicated the Egeland and Winer (1974) study and also compared the effectiveness of errorless discrimination training which highlighted the distinctive feature of the letter to be discriminated and errorless discrimination training in which the obvious cue did not highlight the distinctive feature. This latter manipulation consisted of strips of red highlighting under the letter to be discriminated. The procedure followed was the same as that in the Egeland and Winer (1974) study with the addition of a third letter pair to be used in training and transfer (either M-N or Q-O) and a second transfer task one week after completion of training. Results indicated that the distinctive feature errorless training group made fewer errors during training than the reinforcement extinction group (consistent with the Egeland & Winer 1974 findings). The distinctive feature errorless training group also made significantly fewer errors on both the immediate and delayed transfer task than did either the irrelevant cue errorless training group or the reinforcement extinction group. The results of this study and the Egeland and Winer (1974) study, thus, lent support for the effectiveness of feature emphasis as a means of teaching young children to discriminate letters of the alphabet. Furthermore, the results of the Egeland (1975) study indicate the superiority of feature emphasis when the distinctive feature of the letter to be discriminated rather than an irrelevant cue is highlighted during discrimination training. These results further supported Tawney's (1972) findings of the superiority of critical feature emphasis of letter-like stimuli and extended these findings to the superiority of critical feature emphasis of actual letters of the alphabet.

Varying the level of confusability between the letter to be discriminated and other alternative letter choices in a matching-to-sample task of Roman capital letters was investigated in a series of studies by Nelson and Wein (Nelson & Wein, 1974; in press) as another possible method of improving children's ability to discriminate letters of the alphabet. In their first experiment, Nelson and Wein (1974) utilized the following three groups of preschool children: a high-confusion group that received training trials on discrimination of the stimulus letter from two other alternative letter choices that were highly confused with the stimulus letter (based upon letter pairs that were confused four or more times in Gibson's confusion matrix, Gibson et al., 1963); a low-confusion group that received training trials on discrimination of the stimulus letter from two other alternative letter choices that were seldom confused with the stimulus letter (based upon letter pairs that were confused no times in Gibson's matrix, and which shared the least number of distinctive features as determined by Gibson's chart of distinctive features for letters, Gibson, 1969); and a no-treatment control group which merely received a pre- and posttest of letter discrimination. The pre- and posttests were the same and consisted of a matching-to-sample task of a stimulus letter with one of five alternative letter choices (the correct letter, two high-confusion letters and two low-confusion letters as determined from Gibson's confusion matrix--see above). It was revealed that performance on the posttest (transfer task) was superior for both the high-confusion ($p < .01$) and low-confusion ($\underline{p} < .05$) training groups in relation to the no-treatment control group. Though the high-confusion group required more training trials to reach criterion, its performance on the posttest was better than the low-confusion group ($\underline{p} < .06$).

As an extension of their 1974 study, Nelson and Wein (in press) conducted a study which, in addition to comparing matching-to-sample letter discrimination of high-confusion and low-confusion alternative letter choices (as examined in their previous study), also utilized a sequence training group which was presented a sequence of matching-to-sample alternative letter choices which progressed from low-confusion alternatives (no confusion errors in Gibson's confusion matrix, Gibson et al., 1963), to medium-confusion alternatives (four or five confusion errors in Gibson's matrix), and finally to high-confusion alternatives (5 to 18 confusion errors in Gibson's matrix). Additionally, a second posttest (transfer task) of letter discrimination was given after each child completed 20 training trial sessions to correct for a possible confound in the 1974 study between number of training trials and post-test performance (in the 1974 study, the children reached criterion with differing numbers of training trial sessions and were posttested immediately--thus, some children had more training trial experience than others before their posttests). Results of this second study indicated that on the posttest 1 (given after a criterion of two consecutive errorless training days), only the high-confusion and the sequence groups improved significantly over their pretest scores in comparison to the no-treatment control group. The gains made by the low-confusion group were no better than those made by the no-treatment control group. On the posttest 2 (given after a standard number of 20 training sessions), the performances of all three experimental groups, though superior to the control group ($p < .01$), resulted in no differences among themselves. Thus, the results of the two experiments by Nelson and Wein lent evidence to the hypothesis that training preschool children to make discriminations among highly confusing letters improved their performances on a later task of letter discrimination involving both highly confusing and infrequently confused letter choices.

Thus, from the examination of the research literature of letters and letter-like forms, several conclusions can be made. First of all, it appears that there are certain distinctive, invariant features or dimensions of difference which are critical for differentiating letters (e.g., break versus closure, line versus curve, and rotations and reversals). Based upon the feature chart constructed by Gibson et al. (1963), results from several studies have indicated that letters which are frequently confused with one another (high confusability) generally share many of these critical features in common, while those letters which are seldom confused (low confusability) share relatively few of these features in common. Additionally, several studies have shown that training on these distinctive or critical features facilitates the discrimination of letters and letter-like stimuli by preschool children. Such training may involve matching-to-sample tasks in which the choices are transformations of the standard, reinforcement for responding to the critical rather than non-critical features of the forms, forcing attention to the distinctive features of letters by emphasis of these features, highlighting a distinctive feature rather than an irrelevant cue about the letter to be discriminated, and matching-to-sample tasks which exclusively focus training on letters thought to be most confusing, or in which training progresses from low-confusability to high-confusability.

The results of the two studies by Nelson and Wein (Nelson & Wein, 1974; in press) do indicate the superiority of training preschool children to make discriminations among highly confused letters that share many distinctive features in common rather than discrimination among letters that are distinctively different in appearance and thus, seldom confused. In particular, the hypothesis that a sequence group that receives training on slides ranging from low-confusion to high-confusion letters deserves special attention. Hively (1962) developed a method of programming stimuli in a matching-to-sample task whereby he began with an easy discrimination and approached the eventual matching task through a series of "successive approximations" (shaping procedure) similar to teaching machine programming. He found that learning by the child was more efficient in terms of either trials or errors, when training on the difficult discrimination was preceded by training on similar but easier discriminations than when all of the training was received on the difficult discrimination alone.

Statement of Purpose

The present study proposed to utilize these results found by Hively (1962) in a partial replication of the Nelson and Wein (in press) study. Pre- and posttest letter discrimination performance of four groups were compared: low-confusion, high-confusion, and sequence training groups, and a delayed-treatment control group. The results found by Nelson and Wein (1974) and Samuels (1973) indicated that, though the training group which made discriminations among high-confusion alternative letter choices needed more training trials than the training group which made discriminations among low-confusion alternative letter choices, this high-confusion group made fewer errors on a later posttest in comparison to the low-confusion group. Likewise, Nelson and Wein (in press) found that their sequence and high-confusion training groups made fewer errors on posttest 1 than did the low-confusion training group. However, posttest 2, given after a standard number of 20 training days, resulted in comparable numbers of errors made by all three training groups. Thus, in a rather surprising finding, the superiority of the high-confusion group over the low-confusion group in terms of numbers of errors made was "washed out" once the number of training days was equated. Therefore, the present study attempted to replicate these findings by comparing the performances among the training groups after two posttests: the first given after the training criterion was reached by each child, and the second given after a standard number of training days had been reached for each child (based upon the number of training days to reach criterion by the slowest child).

The procedure followed by the sequence group was a revision of Nelson and Wein's procedure. The children in the Nelson and Wein (in press) study were presented with a sequence of low-confusion alternative letter choices, followed by middle-confusion alternative letter choices, and finally high-confusion alternative letter choices on a daily basis (rather than across sessions) in what was originally considered to be a shaping procedure. The results of this study indicated that, although the sequence group made gains from their pretest to posttest scores comparable to those gains made by the high-confusion and low-confusion groups, this group made as many errors during the 20 training sessions as the high-confusion group and required even more days than the high-confusion group to meet the criterion of two consecutive errorless training days. A possible reason given for these findings was that the children in the sequence group were exposed to both low-confusion and high-confusion alternative letter choices so that there were fewer high-confusion trials for this training group than for the high-confusion training group. Thus, it may have taken the sequence group longer to "learn how to learn" (Harlow, 1949) to discriminate the distinctive features of letters than the high-confusion group because there would have been less training in high-confusion discrimination of the distinctive features, thereby resulting in more errors.

Therefore, the present study proposed to use a shaping procedure across sessions as outlined by Hively (1962) for the children in this sequence group. First, a unit of low-confusion alternative letter choices was mastered to criterion followed by a unit of middle-confusion letter alternatives, which when learned to criterion, was followed by a final unit of high-confusion alternative letter choices. In order to match this sequence training procedure, the high-confusion and low-confusion training groups also each received training on three units of alternative letter choices appropriate to each group; the high-confusion group received training on three units of high-confusion alternatives, while the low-confusion group received training on three units of low-confusion alternatives. Each unit was mastered to criterion before training was received on the next unit. The analysis of the present study thus compared the performances among the high-confusion, the low-confusion, the sequence, and the delayed-treatment control group (which eventually received the sequence training after posttest 2).

The hypotheses investigated were the following. Though the high-confusion training group would make more errors during training and require more training days to reach criterion than the low-confusion group, it was expected that its performance on posttest 1 would result in fewer errors than either the low-confusion group or the delayed-treatment control group. This was predicted because discrimination training among high-confusion letters would focus greater attention to the distinctive features of the letters. Thus, one would expect more errors made by children who were required to discriminate among highly confusing letters with a resulting greater number of trials in order to make perfect discriminations. However, once these children were able to attend to the distinctive features distinguishing these frequently confused letters, one would predict that they would be able to make more accurate letter discriminations on later transfer tasks than children who were not required to make discriminations among highly confusing letters or children who received no discrimination training at all before the transfer tasks.

Also investigated was the hypothesis that children in the sequence training group would be able to perform as well as those in the high-confusion training group on the later transfer task of letter discrimination without making as many training trial errors or requiring as many training trial sessions to reach criterion. This prediction was based upon Hively's (1962) finding that discrimination learning for children would be much more efficient in terms of either trials or errors, when training on difficult discriminations was preceded by training on similar but easier discriminations than instances where all the discrimination training was received on the difficult discrimination alone.

Another hypothesis of interest was the question concerning the high-confusion and sequence training groups maintaining their posttest superiority if the number of training sessions was equalized across all training groups. As mentioned previously, Nelson and Wein (in press) found that, although the high-confusion and sequence groups made significantly greater improvements from their pretest scores to posttest 1 scores than did the low-confusion or no-treatment groups, there were no differences found among the three training groups on posttest 2. It was predicted that these results would be replicated in the present study.

Finally, it was predicted that the performance of the low-confusion training group would be better than that of the delayed-treatment control group on the two posttests. This was based upon the findings of Nelson and Wein (1974; in press) and Samuels (1973) which indicated that training in general on letter discrimination resulted in better posttest performances than lack of such training.

CHAPTER II

METHOD

Subjects

A total of 188 children, ages 3 to 5 years, who attended eleven local day care centers and who had written parental consent, completed a pretest of letter discrimination. A sample parental permission letter is found in Appendix A. Forty-six children who completed the pretest of 60 items made 11 or more total errors (including the same error made on two or more different slides). From these 46 children, 32 children who made 11 or more different errors were chosen and assigned to one of four matched groups. Any child who made more than 30 errors (one-half possible) was excluded from the study. It was determined through observations made during these pretesting sessions that the two children who made more than 30 errors did so for one or more of these reasons: (1) they randomly pointed to any alternative choice, (2) they perseverated on the same alternative choice position, or (3) they did not understand the concept of matching-to-sample. For those subjects included in the study, matching was carried out on the basis of number of correct pretest responses, age, sex, race, and the day care center which the child attended. The four matched groups were randomly assigned to the four experimental conditions: the high-confusion group, the low-confusion group, the sequence group, and the delayed-treatment control group. Six of the subjects (one from the high-confusion group, three from the low-confusion group, one from the sequence group, and one from the delayed-treatment control group) were replaced at the start of the training procedure either due to their irregular attendance at the centers or as a result of having moved from the area since the time of the pretesting sessions. The replacement subjects were children who had made at least 11 total pretest errors, but not 11 different pretest errors. Two other subjects were dropped midway during training; one subject's family unexpectedly moved out of the area (this subject was in the high-confusion group), and the other child (this child was in the low-confusion group) went on an extended vacation with her family. Neither of these latter two subjects was replaced. The final composition of the experimental groups was as follows. For the high-confusion group ($\underline{n}$ = 7; 3 females, 4 males; 3 whites, 4 blacks), the mean age was 51.43 months, and the mean number of correct pretest responses was 40.71. For the low-confusion group ($\underline{n}$ = 7; 2 females, 5 males; 3 whites, 4 blacks), the mean age was 48.00 months, and the mean number of correct pretest responses was 40.43. For the sequence group ($\underline{n}$ = 8; 4 females, 4 males; 3 whites, 5 blacks), the mean age was 50.63 months, and the mean number of correct pretest responses was 41.5. For the delayed-treatment control group ($\underline{n}$ = 8; 5 females, 3 males; 1 white, 7 blacks), the mean age was 49.25, and the mean number of correct pretest responses was 40.00. The groups did not differ significantly in age, $\underline{F}(3,29) = 0.28335$, $\underline{p} > .10$, or in pretest scores, $\underline{F}(3.29) = 0.8382$, $\underline{p} > .10$.

Materials

Testing slides. The same set of slides was used during both pre- and posttesting. First, there was a set of 15 "familiarization" slides in which a child was able to either demonstrate his ability to match-to-sample or learn how to match-to-sample. These 15 "familiarization" slides consisted of circles or squares of colors to be matched. In order to acquaint the subject with the procedure of looking at each of five possible alternative choices, a shaping procedure was used with these 15 slides whereby the number of alternative choices gradually increased. The first three slides had only two alternative choices, the next four slides had three alternative choices, the next four slides had four alternative choices, and the final four slides had five alternative choices. To more reliably assess the child's skill in matching-to-sample using letter stimuli, the pre- and posttest consisted of 60 slides containing two duplicate sets of 30 slides. The slides were photographs of Roman capital letters. Matching-to-sample of each pre- and posttest slide consisted of one stimulus letter to be matched with one of five alternative choices appearing in a horizontal row beneath it. The five alternative choices, appearing in random order from slide to slide, were: the correct match, two low-confusion alternatives, and two high-confusion alternatives. A letter was judged to be highly confusable with another letter if they were confused at least four or more times in Gibson's Confusion Matrix I (Gibson et al., 1963). On the basis of this criterion, six letters (A, F, J, P, S, and Z) did not appear as stimuli to be matched because they were not confused at least four times with two alternatives. On the other hand, if a letter was confused at least four times with three other letters, it became the stimulus in two different slides. The letter G was confused at least four times with four other letters, and therefore, it became the stimulus in three different slides. A letter was judged to be of low-confusion with another letter if they were confused no times in Gibson's Confusion Matrix I. Since there were many alternative low-confusion choices for any stimulus letter, a second criterion was employed. Those low-confusion choices having the least number of distinctive features in common with the stimulus letter, as determined by Gibson's chart of distinctive features for letters (Gibson, 1969, p. 88), was used. A table of all the pre- and posttest slides is found in Appendix B(1).

Training slides. Six color matching slides (from the familiarization set) were used as "warm-up" slides prior to each training session for the three training groups. Three slides each had two alternative choices and three slides each had three alternative choices. For each of the three training groups, there was a set of 30 training slides divided into three sets of ten slides each using matching-to-sample with Roman capital letters. Each training slide consisted of the stimulus letter to be matched and three alternative choices in a horizontal row beneath it. For the high-confusion training group, the three alternative choices (appearing in random order from slide to slide) were the correct response and two high-confusion alternatives. The three sets of ten slides were randomly selected from the 30 high-confusion training slides. For the low-confusion training group, the three alternative choices (appearing in random order from slide to slide) were the correct response and two low-confusion alternatives. The three sets of ten slides were randomly selected from the 30 low-confusion training slides. For the sequence training group, a sequence of three types of slides were presented: the first unit of ten slides presented the correct matching response and two low-confusion alternative letter choices (no confusion errors in Gibson's Confusion Matrix I, Gibson et al., 1963); the second unit of ten slides presented the correct matching response and two medium-confusion alternative letter choices (four or five confusion errors in Gibson's Confusion Matrix I); and the final unit of ten slides presented the correct matching response and two high-confusion alternative letter choices (from five to eighteen confusion errors in Gibson's Confusion Matrix I). A table of all the training slides in each of the three training groups is found in Appendix B(2).

Apparatus. All slides were projected by a Kodak carousel projector onto a rear projection screen. A few raisins were given to each child at the end of each session, regardless of his or her performance during the session.

Procedure

Pretesting. The examiners were four undergraduate students who tested on a rotating schedule. Each was supervised on a random basis by the experimenter. Each subject was invited by an examiner to participate in a "letter game". If a child refused to go with the examiner or refused to perform, he or she did not participate further in the study. Each child pretested was taken to a private area of the day care center (either a separate room or a quiet corner of the classroom depending upon the facilities at each center) where the apparatus was set up. He or she sat in a small chair facing the screen onto which the slides were projected. The child indicated his or her response by pointing to the alternative choice on the screen with the wooden pointer provided for his or her use. A correction procedure was used during the color familiarization slides. If the child made an error in choosing the correct matching color choice, the correct response would be identified by the examiner and the child would be given additional trials on the same slide until he or she made the correct choice. The 60 pretest slides containing a stimulus letter and five alternative choices were presented one time each, without correction. Half of the slides (one set of 30 slides) were shown in each of the two pretesting sessions, which occurred one or more days apart (depending upon the child's and examiner's attendance at the center). Non-differential social reinforcement was used (regardless of the correctness of the response) in order to maintain responding. A few raisins were given to each child at the end of each of the two pretest sessions. Appendix C(1) contains the set of procedural instructions followed by the examiners during the pretesting sessions.

Training. The delayed-treatment control group merely continued to attend the day care centers and were pre- and posttested without receiving additional training during this period. For the high-confusion, low-confusion, and sequence training groups, each training session was conducted on an individual basis in the same area and using the same apparatus as during the pretesting sessions. The children in the three experimental groups received training every other day. The experimenters were two undergraduate students who trained the children on alternate days due to scheduling convenience. Four of the day care centers which some of these children attended were located within one section of the community, while the other four day care centers which the remainder of these children attended were located within the same area at the other end of the community. Approximately one-half of the children attended the centers in one area while the other half attended the centers in the other area. Each of the experimenters worked every other day. The first experimenter worked with the children from one of the areas for one week while the other experimenter worked with the children in the other area. Then in the following week, the first experimenter worked with children from the second area of centers while the second experimenter worked with the children from the first area. The two experimenters continued to switch areas on a weekly basis for the remainder of the study.

Each training session began with the six "warm-up" slides involving the matching-to-sample of colors. A correction procedure was used during both the warm-up slides and the letter slides. An incorrect response was followed by identification of the correct matching choice and additional trials were given until the child made the correct matching color response. Each training session consisted of completing a particular unit of ten slides appropriate to that training group. For each correct matching response, the child was given social reinforcement by the experimenter and the next slide appeared. For each incorrect matching letter response, the experimenter said, "No", the slide projector was turned off for five seconds (time-out), and then the same slide re-appeared. The child was given the opportunity to choose again on the same slide, repeating this procedure until the correct matching response was made. All incorrect responses were recorded by the experimenter on pre-coded data sheets. Appendix D contains a sample data sheet. Each training session ended when the child correctly matched the letters on each of the ten slides in the particular unit regardless of the number of slide exposures required to make a correct matching response.

Therefore, the number of correct matching responses was equated, though the number of slide exposures was not. At the end of each training session, the child was given a few raisins to be eaten before he or she was returned to the area containing the other children. Appendix C(2) contains the set of procedural instructions followed by the examiner during the training sessions.

The sequence of training slides in a given unit for each training group was randomized daily. When the child met the criterion of two consecutive errorless training sessions on the first unit of ten slides (the child in the sequence group began training on the unit of ten slides containing the low-confusion alternative choices), he or she was then trained in the same manner using the second unit of ten slides (the child in the sequence group was then trained on the unit of ten slides containing the middle-confusion alternative choices). When the child met the criterion of two consecutive errorless training sessions, he or she then repeated the same procedure using the last unit of ten slides (the child in the sequence group was then trained on the last unit of slides containing the high-confusion alternative choices). Once the criterion of two consecutive errorless training sessions was met on the final unit of ten slides, the child received the two sessions of post-test 1. Then the child repeated the same training procedure, starting again with the first unit of ten slides.

Two of the children took 14 training sessions in order to meet the criterion of two consecutive errorless training sessions using the last (third) unit of ten training slides. Since these two children took the longest to reach criterion, every child in each of the experimental groups received 14 training sessions in order to equate the number of training sessions for each child. The two sessions of posttest 2 were then administered individually to each of the children as he or she completed the 14 training sessions (actual time of completion varied as some children were absent on certain days when the experimenters were training at the centers). Posttest 2 was carried out within 2 weeks of completion of the 14 training sessions.

Posttest 1 and 2. Each child received two identical posttests: posttest 1 was given at different times as each child met a criterion of two consecutive errorless training sessions using the last (third) unit of training slides; posttest 2 was given individually to each of the children as he or she completed 14 training sessions. The timings of posttest 1 and 2 for the delayed-treatment control group was yoked to the performances of the children in the experimental groups. For every three experimental children who reached the criterion for posttest 1, one control child (randomly chosen) was also posttested. The same procedure was used for posttest 2, with the order of control group children posttested the same as that of posttest 1. The same slides used in the pretesting sessions were also used for both posttests. The slides consisted of the 15 familiarization slides and the 60 slides containing a stimulus letter and five alternative choices from which to select the correct matching responses. As during the pretest, to minimize the children's fatigue, both posttests were given in two sessions each. A few raisins were given to each child at the end of each posttest session regardless of his or her performance. A female examiner who was "blind" as to which group each child was assigned conducted all posttests. The procedural instructions followed by the examiners during the pretesting sessions were the same for the posttesting sessions and can be found in Appendix C(1).

CHAPTER III

RESULTS

Dependent Measures

Four dependent measures were utilized in the study. The first was the number of training session days required by each child in the experimental training groups to reach the criterion of two consecutive errorless training days on the third set of training slides for his or her particular training group. The second measure was the difference score between a child's pretest score and his or her posttest 1 score; posttest 1 was conducted after the above-mentioned criterion was met. The third dependent measure was the difference score between a child's pretest score and his or her posttest 2 score; posttest 2 was administered after a total of 14 training sessions was completed (the fact that 14 was the number of training sessions required of all experimental subjects was determined by the performances of the two slowest children who took 14 training sessions to reach two consecutive errorless training days on the third unit of training slides). The final measure was the total number of errors made by a child during the 14 training sessions.

Results of Multivariate Analyses of Variance (MANOVA)

The control group did not undergo training at the time the three experimental groups received training trials. Therefore, there were scores for the first and fourth dependent measures (training days to criterion and total number of errors made during the training sessions) for only the three training groups: high-confusion, low-confusion, and sequence. The results of the MANOVA indicated that these two dependent measures were not measuring different aspects of letter discrimination training (correlation between these two measures = 0.926619) and that the three groups did not differ significantly with these dependent measures considered jointly, $\underline{F}(4,38) = 1.23327$, $\underline{p} > .3127$.

In addition to the high-confusion, low-confusion, and sequence training groups, the control group also received posttests 1 and 2. The results of the MANOVA on the two difference scores (the pretest score was subtracted from each of the two posttest scores) for all four groups revealed that these two dependent measures were not measuring different aspects of letter discrimination training (correlation between these two measures = 0.836165). None of the four groups differed significantly on the set of difference scores, $\underline{F}(6,52) = .94683$, $\underline{p} > .528$.

<u>Training Days to Criterion</u>

Results of an analysis of variance (ANOVA) indicated that the three training groups did not differ significantly in the number of training days required to meet the criterion of two consecutive errorless training session days on the third unit of training slides, $\underline{F}(2,19) = 1.6401$, $\underline{p} > .2192$. An examination of the mean number of days to criterion, as given in Table 1, indicated that the high-confusion and sequence groups required the same number of training days to reach criterion, while the low-confusion group required fewer training days to meet this criterion. A subsequent test for homogeneity of variances ($\underline{F}$ max) revealed that the variance of the high-confusion group for days to criterion differed significantly from the variance of the low-confusion group for days to criterion, $\underline{F}(6,6) = 17.153652$, $\underline{p} < .001$. Likewise, the variance of the

Table 1

Mean Number of Correct Pretest Responses, Difference Scores on Posttests 1 and 2, Training Days to Criterion, and Errors during Training

Group	High-Confusion (n = 7)	Low-Confusion (n = 7)	Sequence (n = 8)	Control (n = 8)
Pretest				
Means				
Score (max.=60)	40.71	40.43	41.50	39.75
HC Errors	17.3	17.3	16.1	16.3
LC Errors	2.0	2.3	2.4	4.0
Training Days to Criterion				
Means	8.43	6.43	8.63	no training
Variance	9.1	0.53	6.98	
Posttest 1				
Means				
Difference	+12.29	+8.86	+13.25	+8.25
HC Errors	6.6	10.7	5.1	10.3
LC Errors	0.4	0.0	0.1	1.8
Variance	53.06	56.41	30.69	43.94
Posttest 2				
Means				
Difference	+13.71	+14.00	+14.25	+11.88
HC Errors	5.6	5.6	4.0	7.8
LC Errors	0.0	0.0	0.0	0.6
Variance	71.35	62.29	27.19	33.36
Errors during 14 Training Days				
Means	3.29	0.29	3.13	no training
Variance	9.63	0.20	11.86	

HC = High-confusion LC = Low-confusion

sequence group differed significantly from the variance for the low-confusion group, $\underline{F}(7,6) = 13.162764$, $\underline{p} < .001$. The variances for the high-confusion and the sequence groups did not differ significantly, $\underline{F}(6,7) = .3031952$, $\underline{p} > .05$.

Difference Scores Between Pretest and Posttest 1

Each child in the three training groups received posttest 1 after reaching the criterion of two consecutive errorless training days on the third unit of slides in his or her training group. For every three children in the training groups who met this criterion, a child in the control group also received posttest 1. Pretest scores were subtracted from posttest 1 scores to obtain the difference scores. An ANOVA on these difference scores indicated that these four groups did not differ significantly, $\underline{F}(3,26) = .89879$, $\underline{p} > .5427$. As indicated in Table 1, both the high-confusion and sequence groups did make slight gains over the low-confusion group in terms of mean difference scores; the low-confusion group obtained the same mean difference score as that obtained by the control group which received no training between pretest and posttest 1. A test for homogeneity of variance ($\underline{F}$ max) indicated that the variance of the control group did not differ significantly from the variance of the high-confusion group, $\underline{F}(6,7) = 1.2076527$, $\underline{p} > .05$; nor did this control group variance differ from the variance of either the low-confusion group, $\underline{F}(6,7) = 1.2838275$, $\underline{p} > .05$, or the variance of the sequence group, $\underline{F}(7,7) = 1.4317718$, $\underline{p} > .05$. Likewise, no significant differences were found between the variance of the low-confusion group and either the high-confusion group, $\underline{F}(6,6) = 1.0630767$, $\underline{p} > .05$, or the sequence group, $\underline{F}(6,7) = 1.831481$, $\underline{p} > .05$; nor were significant differences found between the variances of the high-confusion and sequence groups, $F(6,7) = 1.7290832$, $p > .05$.

Difference Scores Between Pretest and Posttest 2

After completing 14 training session days, each child in the three training groups was administered posttest 2. For every three children in the training groups who completed the 14 training session days, a control child also received posttest 2. Results of an ANOVA on difference scores (posttest 2 score minus pretest score) indicated that the four groups did not differ significantly, $F(3,26) = .16825$, $p > .916$. As revealed in Table 1, all three training groups obtained approximately the same mean difference scores. These mean difference scores were only slightly higher than that obtained by the control group. Tests for homogeneity of variance (F max) revealed that the variances of the control group and high-confusion group were not significantly different, $F(6,7) = 2.1387387$, $p > .05$; nor did the control group variance differ significantly from either the variance of the low-confusion group, $F(6,7) = 1.8671135$, $p > .05$, or the variance of the sequence group, $F(7,7) = 1.2270109$, $p > .05$. It was also found that the variance of the low-confusion group did not significantly differ from the variance of either the high-confusion group, $F(6,6) = 1.1454768$, $p > .05$, or the sequence group, $F(6,7) = 2.2909687$, $p > .05$. Finally the variances between the high-confusion and sequence groups did not differ significantly, $F(6,7) = 2.6242558$, $p > .05$.

Mean Errors During the 14 Training Days

The total number of errors made by each child in the three training groups during the 14 training sessions was determined. An ANOVA revealed no significant differences in the number of errors for each of the three training groups, $F(2,19) = 2.3575$, $p > .1203$. An examination of the mean number of errors during the training sessions, as given in Table 1, indicate that both the high-confusion and sequence groups made approximately the same number of errors, which was slightly greater than the mean number of training errors made by the low-confusion group. Results of the F max test for homogeneity of variance indicated that the variance of the low-confusion group differed very significantly from the variance of both the high-confusion group, $F(6,6) = 47.205554$, $p < .001$, and the variance of the sequence group, $F(7,6) = 58.117801$, $p < .001$. The difference between the variances of the high-confusion and sequence groups was not significant, $F(7,6) = 1.2311644$, $p > .05$.

Error Analysis

As illustrated in Table 1, it was revealed that, for all four groups, the most frequent type of pretest error occurred between high-confusion letters. During the 14 training session days, the high-confusion group was exposed only to high-confusion letter alternatives; the low-confusion group viewed only low-confusion letter alternatives; and the sequence group was eventually exposed to low-, medium-, and high-confusion letter alternatives. Despite the differential letter exposure during the training sessions, an examination of the means reported in Table 1 reveal that the majority of all the posttest errors for all the four groups (control group included) were confusions between high-confusion letters.

<u>Confusion Matrix</u>

As a corroboration of Gibson's Confusion Matrix 1 (Gibson et al., 1963), the pretest errors of all of the 188 children who completed the pretesting sessions were analyzed. In the present study, each letter did not have an equal opportunity to be confused with every other letter (as was the case in Gibson's study). Therefore, it was necessary to compute a percentage measure for each letter pair. This was accomplished by dividing the actual number of confusions for each letter pair by the number of opportunities for such confusions. Table 2 contains the resulting confusion matrix. The resulting pairs of data in 77 corresponding cells produced a Pearson correlation coefficient of .817 between the pretest letter confusion data in the present study and Gibson's confusion matrix.

Table 2

Confusion Matrix (Based upon Percentage Measure of Number of Confusions Made Divided by Number of Confusion Opportunities)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A																						7				
B							2			0				1				3								
C					0		3			1			1	0	7					0	3					
D								1							6				0					1		0
E						5		1													1	1				
F															0						0	1	1	1		
G								0			1		0				4	1				0	1	0	1	
H										0			4				1		1							
I												5					1			1						1
J											0		1					0		2				0		
K														7										7		
L													2		0		1			4			2			
M														11			0						29			
N															1						1		3			
O																	8		0							
P																		9				1	0			
Q																										
R																					2		1			1
S																				2					0	
T																										
U																						2				
V																								2	13	
W																										
X																									2	2
Y																										
Z																										

CHAPTER IV

DISCUSSION

The findings of this study may be summarized as follows: (1) none of the three training groups differed significantly in terms of number of training days required to meet the criterion of two consecutive errorless training days on the third unit of training slides; (2) on posttest 1, given after meeting the criterion of two consecutive errorless training days on the third unit of training slides, none of the four groups (control group included) differed significantly in their gains over the pretest scores; (3) on posttest 2, given after a standard number of 14 training sessions (14 training sessions were required by the two slowest children to reach the criterion of two consecutive errorless training days on the third unit of training slides), once again none of the four groups, including the control group, differed significantly in their gains over the pretest scores; and (4) during the 14 training days, none of the three training groups produced significantly more errors than the other training groups.

Though none of the results reached a level of significance, the direction of most mean differences was as predicted. The high-confusion and sequence groups both required slightly more training sessions to reach the criterion of two consecutive errorless training days on the third unit of training slides than did the low-confusion group. This trend was predicted and would agree with the findings of Samuels (1973) and Nelson and Wein (1974; in press), in that more difficult discriminations would require a longer period of time in order to be made successfully. However, it was also predicted that the sequence training group would require fewer training sessions to reach criterion than would the high-confusion training group; this did not result as both groups required approximately the same mean number of training sessions to reach the designated criterion.

As predicted, the high-confusion and sequence groups did obtain slightly higher mean difference scores from pretest to posttest 1 over those mean difference scores obtained by either the low-confusion group or the control group. This trend in the posttest 1 data would follow the findings of Nelson and Wein (1974; in press), Pick (1965), Samuels (1973), Tawney (1972), and Williams (1969), from which it was suggested that training procedures which require discrimination emphasizing the critical features of letters (or letter-like forms) would facilitate the learning of letter discrimination as measured by later transfer tasks. As opposed to previous findings, however, the control group made approximately the same mean gain in scores as did the low-confusion group.

An examination of the posttest errors revealed that all four groups, regardless of the training procedure (or lack thereof) made more errors among high-confusion letter alternatives than among low-confusion alternatives. This finding suggests that training letter discrimination by way of distinctive features of letters is the crucial training feature rather than mere familiarity with different sub-classes of letter stimuli, i. e., the high-confusion training group which had not been exposed to low-confusion letter alternatives in training did not, as a consequence, make low-confusion posttest errors (Nelson & Wein, in press).

The data on the mean difference scores between pretest scores and posttest 2 scores indicate that the three training groups obtained approximately the same mean difference scores. This result was predicted and is consistent with that found at posttest 2 by Nelson and Wein (in press). It appeared that the low-confusion group had "caught up" to the high-confusion and sequence training groups given the opportunity for additional training after posttest 1. These authors explained this finding by the fact that the high-confusion and sequence training groups were near the ceiling of posttest 1 and therefore had little room for further improvement; this also appeared to be the case in the present study. However, contrary to their findings and the present predictions, the results of the current study indicated that the performances of the three training groups at posttest 2 were not significantly better than that of the control group. This surprising finding might possibly indicate that improved letter discrimination performance may be a function of learning experiences unrelated to this experiment which occurred during the time between pretesting and posttesting.

Finally, the mean number of errors made during the 14 training sessions was approximately the same for both the high-confusion and sequence training groups, and these means were slightly more than the mean number of errors made by the low-confusion group. This result was not as predicted; it was expected that the sequence group, which mastered a series of low-confusion alternatives before progressing to the more difficult series of high-confusion alternatives would make fewer errors than the high-confusion training group. Nonetheless, this trend in the data agrees with the results of Nelson and Wein (in press).

They also found that children in their low-confusion training group made significantly fewer errors during training than those children in either their high-confusion or sequence training groups. Though their low-confusion group did require more training days to obtain good posttest performance (i.e., at posttest 2), Nelson and Wein suggested that, if duration of training was not a crucial point, then one might prefer to use discrimination training procedures which utilized low-confusion letter alternatives. This would agree with the suggestion of Terrace (1966) that discrimination training which included errors could produce negative emotional responses.

Though only the hypothesis of no differences among the three training groups at posttest 2 was supported by the findings of the present study, several possible explanations may be offered for the clearly non-significant findings which failed to fulfill the experimental predictions. First of all, there was a time lapse of between one and three months from the time the child received the two pretest sessions to the beginning of the training procedure. This delayed commencement of training was unavoidable for several reasons. The pretesting of children as potential subjects for inclusion in the study began in the second month of the school year. However, because so few children made a sufficient number of pretest errors to be considered as potential subjects, it was necessary to pretest many more children than planned. Thus, the pretesting phase of the study alone took three months to complete. As this phase of the study was completed just before the Christmas holidays, it was necessary to wait to begin the training phase until after the new year. Therefore, the children were first receiving training during the second half of the school year. It may have been the case that these preschool children were exposed to alphabet letter exercises in their day care center classes during this time lapse. This could possibly account for their nearly perfect letter discriminations during training and for the gains made in letter discriminations by the subjects in the control group.

Williams (1969) also found this to be true in that the number of training trials and the starting level of her subjects influenced the differential results of several discrimination training procedures utilizing letter-like forms. In Experiment 1, in which the children were in their first month of kindergarten and in which a standard number of five training trials was used, Williams found that discrimination training in which the comparison stimuli were transformations was superior to discrimination training where the comparison stimuli were completely different forms. In comparison, in Experiment 2, in which the children were in the last quarter of kindergarten and in which a standard number of only three training trials was used, the various training procedures produced no differential results. The superior performance of all children in Experiment 2 as compared to the differential performance of children in Experiment 1 suggested that perhaps the children who received discrimination training at the end of the school year had already reached the ceiling level of their discrimination skills. This suggested hypothesis could also be utilized to explain the non-significant findings of the present study; perhaps these children were at the ceiling of their letter discrimination skills, in which case training in distinctive features of letters might not produce superior performance when compared to other forms of letter discrimination training.

It may also be the case that the individual variance of the performances of a few children within each of the four groups could account for the lack of statistically significant differences among the means. As revealed in the results section, the $\underline{F}$ max test for homogeneity of variance did reveal significant differences between the variance of the low-confusion group and the variances of both the high-confusion and sequence groups for training days to criterion. The $\underline{F}$ max test also revealed highly significant differences between the variance of the low-confusion group and the variances of both the high-confusion and sequence groups for mean number of errors during training. This inflated variance could have resulted in the overall non-significant differences.

Several different undergraduate experimenters were involved in the experiment, and the individual differences among them must also be considered. Four undergraduate students (3 females, 1 male) besides the author pretested all the children. Two experimenters (one was a female who had also done some pretesting) conducted the training phase of the study. Each experimenter trained half of the children one week, and the other half the following week, switching centers weekly until the completion of training; thus each child in each of the three training groups was exposed to training with both experimenters. All posttesting was conducted by a female undergraduate student (she also was involved in the pretesting phase) who was unaware of the training groups to which each child had been assigned. Therefore, there were several experimenters involved in the various phases of the study. Though the pre- and posttest instructions were the same, and both training experimenters followed the same instructional procedure, it was impossible to control for individual differences in the experimenters' styles (e.g., interacting with the child during the session) as well as possible interactions between the sex and race of the experimenter and those of the child. Additionally, recording the data may also have been carried out in slightly different manners. It had been noted in the previous Nelson and Wein studies (personal communication) that some children had the tendency to choose impulsively and then correct their choices after a few seconds' examination of the other choice alternatives. The experimenters had been made aware of this point; yet, it was impossible to determine if they allowed for correction of impulsive choices in the same manner (e.g., a few seconds' allowance to change matching choice, or immediately assuming choice to be incorrect and recording it as such). Although the experimental design did not systematically confound experimental condition and individual differences among experimenters, experimenter differences may have affected the performances of the children in the four groups, thus obscuring differential findings.

The difference in the number of alternative letter choices in the pretesting slides and training slides should also be considered as possibly affecting the findings. It could have been the case that many children in the pretest phase chose impulsively from among the five alternative letter choices. When repeatedly confronted with fewer letter alternatives during the training phase, those children in each of the training groups may have learned to check all the letter alternatives before choosing the correctly matching letter; this learned procedure could then have been carried over to the posttest sessions, thus resulting in improved discriminations regardless of the specific training procedure utilized.

Despite the non-significant findings of this study, several suggestions for future research on letter discrimination training methods may be made. First of all, the use of a sequence training group appears to be a viable means for training children to learn to discriminate letters in a more efficient manner. As noted by Hively (1962), training on difficult discriminations can be achieved more readily with fewer trials and errors involved when preceded by training on similar but easier discriminations than when all training is received on the difficult discrimination alone. The present study utilized such a procedure in the sequence group, which required mastery of the discrimination task at a low level of letter confusability before proceeding to a higher level of letter confusability. Although the present results indicated that there were no differences in the four dependent measures between this sequence group and the high-confusion group, further research is needed before this finding (which is contrary to theoretical predictions) is accepted with assurance.

In terms of future research on the effectiveness of various training methods of letter discrimination, it might be best to choose younger children as subjects (e.g., $2\frac{1}{2}$ to $3\frac{1}{2}$ years old) who have not had much exposure to the alphabet letters and who are not near their upper limits in terms of learned discrimination skills. Excessive time lapses between pretesting and training, such as occurred in the present study, should be avoided. If one were interested in determining if improved letter discrimination performance could be achieved merely as a function of time, one could posttest the no-treatment control group of children at regular intervals (i.e., 2 month intervals) to determine if children who have not received any formal discrimination training could make letter discriminations as well as those children who have received some form of training.

As a final result of the present study, an analysis of the pretest letter confusions was carried out to corroborate Gibson's Confusion Matrix 1 (Gibson et al., 1963). The correlation between the letter confusions reported by Gibson and her colleagues and those which resulted in the current study was .817. Nelson and Wein (1974) computed a similar correlation coefficient of .783; results from their more recent study (Nelson & Wein, in press) revealed a correlation coefficient of .863. Briggs and Hocevar (1975) have recently provided an index of similarity used to predict letter pair confusability from various confusion matrices that have been derived (among them, that of Gibson et al., 1963). They found that the confusability of letter pairs was directly related to the percentage of features that the two letters had in common. Gibson's Confusion Matrix 1 correlated very highly with their index. Thus, this finding and the above-mentioned correlations lend support to the use in future research of Gibson's data on the high- versus low-confusability of specific letter pairs.

CHAPTER V

SUMMARY

An experiment was conducted to determine which of the following methods was most effective in teaching pre-school children to discriminate letters of the alphabet: (1) matching-to-sample training on three units of high-confusion letter alternatives; (2) matching-to-sample training on three units of low-confusion letter alternatives; or (3) matching-to-sample training on a sequence of low-confusion letter alternatives to be mastered followed by a series of middle- and then high-confusion letter alternatives. A delayed-treatment control group of children was also included. No significant improvements over pretest scores were found among the three experimental training groups or the control group on posttest 1, which was administered after the criterion of two consecutive errorless training sessions on the third unit was met. Similarly, no significant improvements over pretest scores were found among the three training groups or the control group on posttest 2, which was administered after each child had received a standard number of 14 training sessions. Neither the number of errors made during training nor the number of training days to reach criterion differed significantly for any of the three training groups. Despite the failure to achieve statistical significance, the direction of most mean differences was as predicted and consistent with previous literature. Results indicated that both the high-confusion and sequence groups made greater gains at posttest 1 than did the low-confusion group. However, both of these groups required more training sessions than did the low-confusion group to reach the criterion to be given posttest 1. At posttest 2, after all groups had received a standard number of training sessions, these differential gains were no longer apparent.

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APPENDIX A

SAMPLE PARENT PERMISSION LETTER

Date

Dear Parent:

We are at the present time planning a project which will be concerned with helping children to read letters. We, therefore, ask your permission for your child to participate in this project. Your child will remain at the day care center during the activity which will be conducted for approximately 15 minutes a day, for no more than 30 days.

Please fill out the permission slip at the bottom of this paper, include your child's name and your signature, detach the form and return it to your child's teacher. If you have any questions about the project, please call Dr. Nelson at 379-5013.

Sincerely,

Rosemery O. Nelson, Ph.D.
Associate Professor of Psychology
Department of Psychology
University of North Carolina at Greensboro

Deborah Ortman
Graduate Student, Dept. of Psychology
University of North Carolina at Greensboro

- - - - - - - - - - Detach and return form - - - - - - - - - - - - - - -

_____ My child can participate in the letter reading project.

_____ My child cannot participate in the letter reading project.

______________________________ ______________________________

Parent's Signature Child's Name

APPENDIX B(1)

PRETEST AND POSTTEST SLIDES

15 color slides (familiarization)

1. red: red and green squares
2. green: green and black circles
3. black: red and black squares
4. red: green, red and black squares
5. orange: orange, blue and green squares
6. black: black, blue and red circles
7. red: green, red and orange circles
8. black: black, red, blue and orange circles
9. blue: orange, blue, red and black squares
10. red: black, blue, red and green circles
11. orange: blue, green, black and orange squares
12. blue: green, orange, red, blue and black squares
13. green: red, green, orange, black and blue circles
14. orange: blue, green, black, red and orange squares
15. red: black, green, red, orange and blue circles

Two sets of 30 letter slides, 5 alternatives

1. B: B J G N R
2. C: E G C J N
3. C: C T O U M
4. D: S H O Z D
5. E: F H V E U
6. G: B C G M K
7. G: R Q Y G W
8. G: Q X B V G
9. H: J D H S M
10. H: G Q M H E
11. I: T I Q L Z
12. K: G N K J X
13. L: Q L W I T
14. M: G W J H M
15. M: N M L W Q
16. N: W U O M N
17. N: U N M C K
18. O: O L F Q C
19. O: N S O Q D
20. Q: Q O L G I
21. R: J G R P Z
22. R: B R P W U
23. T: I L J T S
24. U: U R C F V
25. V: G Y F A V
26. V: U E V X P
27. W: F N M P W
28. X: F G K X Y
29. X: D J V Z X
30. Y: X S V Y G

APPENDIX B(2)

TRAINING SLIDES

6 color slides (warm-up)

1. red: red and green squares
2. green: green and black circles
3. black: red and black squares
4. orange; orange, blue and green squares
5. black: blue, red and black circles
6. red: green, red and orange circles

High-confusion Group

Unit 1

1. G: G Q R
2. G: G C B
3. H: E H M
4. M: H W M
5. N: N M K
6. O: Q C O
7. T: T L I
8. U: U V C
9. V: U X V
10. X: Y K X

Unit 2

1. B: B R G
2. C: C G J
3. D: O D H
4. E: E H F
5. H: M H D
6. K: K N X
7. L: L T I
8. O: Q D O
9. R: R P G
10. Y: Y V X

Unit 3

1. C: O U C
2. G: B G Q
3. I: T L I
4. M: M N W
5. N: W M N
6. Q: Q G O
7. R: B P R
8. V: V A Y
9. W: N W M
10. X: Z X V

Sequence Group

Unit 1

1. C: E N C
2. C: T M C
3. E: U V E
4. G: M K G
5. Q: L Q I
6. R: U R W
7. R: Z R J
8. V: F G V
9. V: P E V
10. X: X D J

Unit 2

1. B: B R G
2. D: O D H
3. G: G Q R
4. G: B G Q
5. H: M H D
6. H: E M H
7. I: T L I
8. L: L T I
9. T: L I T
10. U: U V C

Unit 3

1. K: K N X
2. M: H W M
3. M: M N W
4. N: N M K
5. N: W M N
6. O: Q C O
7. O: Q D O
8. W: N W M
9. X: Y K X
10. Y: X V Y

Low-confusion Group

Unit 1

1. B: J N B
2. E: U V E
3. G: Y G W
4. H: S J H
5. I: I Q Z
6. K: G J K
7. L: W Q L
8. O: L O F
9. R: U R W
10. X: X D J

Unit 2

1. C: E N C
2. G: V G X
3. H: G Q H
4. M: L Q M
5. N: U N C
6. O: O S M
7. Q: L Q I
8. R: Z R J
9. V: P E V
10. X: F X G

Unit 3

1. C: M T C
2. D: S Z D
3. G: M K G
4. M: J M G
5. N: U N O
6. T: J S T
7. U: R F U
8. V: F G V
9. W: P F W
10. Y: S Y G

APPENDIX C(1)

PRE- AND POSTTEST INSTRUCTIONS

1. Obtaining subjects: (be sure the apparatus and data sheets are ready <u>first</u>)

   a. Notify director of center each time you arrive and are ready to leave.
   b. Test all children who have parental permission and who you've been instructed to test.
   c. Be sure that we know the complete name, birthdate, sex and race of each child, and the center which the child attends.
   d. Wear a nametag when taking children from classrooms.
   e. Tell the child that you are going to play a "letter game", and that you will bring him/her back to the class in a little while.
   f. If a child is crying, gently encourage him/her to come. If he/she continues to cry, note this on a data sheet, and try to persuade him/her to come on another day.
   g. <u>Always</u> return the child directly to the teacher.

2. Training on matching-to-sample (use the first 15 slides, involving matching of colors)

   a. Talk to the child a few minutes to help him/her feel at ease; suggested topics are his/her brothers and sisters, pets, toys, etc.
   b. Introduce yourself as "Ms. ________" or "Mr. ______".
   c. Put the first color slide on. Say, "See this color" (point to color stimulus on screen with your finger). "We are going to try to find another color just like this one". (E models and points to correct match). "See, this color (match) is just like this one (the stimulus)". Using the same slide, ask the child to find the color that looks just like this one (the stimulus). The terms "same as" or "just the same" can be substituted if the child has difficulty making the discrimination.
   d. Put Slide 2 on. Repeat identical instructions, including modeling, and the child's attempt.
   e. Record each incorrect choice on each color slide (i.e., red sq. - blue).
   f. Make sure the child is correct on each slide, regardless of how many trials or prompts are required for each slide. The minimum number of trials per slide is one; there is no maximum. Record the total number of training trials required per slide.
   g. If the child seems to have learned the matching-to-sample concept (correct on first try on at least 12 of the 15 slides in

sequence), continue on to the letter slides. If he/she is having trouble learning the concept, go through the color slides again. If he/she is unable to learn after repeated attempts, do not go on to the letter slides, and note this on the data sheet.

3. Pretest of letters (2 duplicate sets of 30 matching-to-sample letter slides) - also used for posttests

   a. After completing the "warm-up" with the color slides, administer only the first set of 30 slides during this first session. Give the next set of 30 slides on the next session.
   b. Say to the child, "Now we are going to do the same thing, but this time we're going to look for letters which are just alike". "Remember how we look at this top one" (point to letter stimulus), and "then we look for the one that looks like it on the bottom" (point to all matching letter choices). Do not show the correct match! -- ask the child to point to the correct match. In cases where it is difficult to determine which letter the child is pointing to, ask him/her also to tell you which is his/her choice (i.e., "this is it").
   c. Give only one trial per slide with the pretest (posttest) slides. As some children may impulsively point to the wrong letter choice, allow a few seconds (3-5) and if the child immediately corrects himself/herself, consider it as a correct choice (if indeed the second choice is correct).
   d. Record all incorrect responses on the data sheet by writing the stimulus letter and the incorrect choice given in the appropriate columns (we will analyze the type of errors made by the children).
   e. Reinforce the child for responding at all, not only for correct responses. Use social reinforcement of words and smiles and pats.
   f. At the end of each session, give the child a few raisins (to be eaten there before returning to other children in classroom).
   g. Use the same procedure on the second day for the other set of 30 slides (steps c - g).
   h. Hand in data sheets daily.

APPENDIX C(2)

TRAINING INSTRUCTIONS

1. There are a total of 30 slides (3 units each of 10 slides) in each group. It is very important that the right set of slides be used for each child:
   HC (High-confusion)
   LC (Low-confusion)
   Seq (Sequence of Low- to High-confusion)

2. Be sure that projector, screen and data sheets are ready before bringing child to the experimental room (Note: On each data sheet, indicate only child's name, your name, date, unit number (e.g., 1, 2, or 3), session number, and group).

3. Training Instructions
   a. There are 6 warm-up color slides to re-introduce the concept of matching-to-sample. After the first session, use only a few (e.g., 3) of the color matching slides as warm-up. If all or most are correct, then go on to the appropriate unit of 10 training slides for that day.
      1. If S is correct in his/her choice, go on to the next slide.
      2. If S is incorrect in his/her choice, say "No" at the same time you are giving a 5-second time-out (switch machine to FAN and no eye contact or verbalizations). Then repeat trial.
      3. Each slide is repeated until the child makes the correct choice.
      4. Session ends when child has correctly matched the stimulus letter on each of the 10 training slides used that day.
      5. On the data sheet, record each incorrect response which the child makes; if repeated trials are given because of incorrect choices, indicate on the data sheet each incorrect choice and the stimulus letter (may make same error several times—record each time).
      6. After each session, give a few raisins to each child (if he/she wants them). The raisins are to be eaten before the child is returned to his/her room.
   b. Slides in each unit of 10 must be randomized daily. (Do not interchange slides between units—e.g., from 2nd to 3rd unit of low-confusion).

4. Scoring
   a. On master sheet, mark session number next to the names of each child you tested that day.

b. Indicate on the paper attached to the side panels of the projector case, the number of errors made by each of the Ss you trained that day. Be sure to mark in the appropriate spaces.
c. Hand in all data sheets daily.

5. Determining what unit of slides to use in each session.
   a. Start with 1st unit of 10 slides appropriate for the group the child is assigned to.
   b. When 2 consecutive errorless training days on that unit occur, start with the 2nd unit of 10 slides appropriate to the child's group.
   c. When 2 consecutive errorless training days occur with this 2nd unit, start with the 3rd unit for that group.
   d. When 2 consecutive errorless training days occur with the 3rd unit, the child will be posttested (by another experimenter), then the same procedure will start again with unit 1, and so on.

   Note: You will need to refer to the master list and the list on the side panels of the projector case each time you attempt to give a training trial to an S so as to know the appropriate unit to give.

APPENDIX D

SAMPLE DATA SHEET

Name: ______________________ Experimenter: ____________________

Birthdate: __________________ Date: __________________________

Sex: ________ Race: ______ Session No.: ______ Unit No.: __

Day Care Center: ____________ Condition: Pre 1a 1b Post 1a 1b 2a 2b
HC LC SEQ CONT

Summary: Types of Errors: HC __________ LC __________
Total Errors: ____________

Stimulus	Response	Stimulus	Response	Stimulus	Response