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THE EFFECT OF FADING TO TRAIN b-d AND p-q DISCRIMINATION IN CHILDREN WITH SPECIFIC LEARNING DISABILITIES

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ABSTRACT

The present study was designed to assess the effectiveness of a stimulus programming technique, fading, in teaching visual discrimination and name association to the letters b-d and p-q. The Ss were first and second grade children with diagnosed learning disabilities, who displayed a high frequency of reversal errors, particularly to the letters b-d and p-q. The study also provided a means of assessing the benefit of the fading technique in Ss ability to read words and phrases, and discriminate b-d and p-q when they appear in the context of a nonsense syllable. The results indicated that the fading technique was responsible for the Ss' improvement in visual discrimination and name association of b-d and p-q, when seen individually, and also in the context of nonsense syllables. However, the Ss made only minimal improvement in reading words and phrases containing b, d, p, and q, after fading training. It was hypothesized that the Ss' lack of progress in the reading task was due to their repeated practice in making the incorrect as well as the correct response to these words. When confusion errors are frequent, more practice on the incorrect response occurs, habits form, and this pattern of responding may become more resistant to change.

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INTRODUCTION

In children who have normal intelligence and visual acuity, the tendency to confuse and reverse symbols in reading is thought to be a major cause of failure to learn to read (Bond & Dykstra, 1967). Related to this, the ability to associate names with the letters of the alphabet is considered one of the most significant predictors of early reading skills (Bond & Dykstra, 1967; Teegarden (1932). Studies by Davidson (1935) and Teegarden (1932) showed that reversal errors (i.e., errors in discriminating mirror-image letters, such as _b-d_, _p-q_, _n-u_, etc.), are almost universal in kindergarten children, but that they tend to decrease in the normally developing child with increasing mental age and experience. Further, children who make numerous reversal errors tend to make less than normal progress in the first grade.

The frequency of occurrence of these reversal errors was one of the most frequently observed behavior in children who have learning disabilities (Orton, 1928). Learning disabilities have been defined recently by Congressional legislation.

> The term 'children with specific learning disabilities' means those children

> who have a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which disorder may manifest itself in imperfect ability to listen, think, speak, read, write, spell, or do mathematical calculations. Such disorders include such conditions as perceptual handicaps, brain injury, minimal brain dysfunction, dyslexia, and developmental aphasia. Such term does not include children who have learning problems which are primarily the result of visual, hearing, or motor handicaps, of mental retardation, of emotional disturbance, or of environmental disadvantage.[1]

Children with specific learning disabilities continue reversing letters well beyond the time when their peers no longer do so. Reversal errors then, have been a consistently appearing symptom and present a major obstacle in developing reading, writing, and spelling skills in children who are described as having specific learning disability.

Causes of Reversals

Experts in the field of specific learning disabilities have proposed numerous factors as possible causes of reversals. Orton (1937) suggested that reversal errors are caused by some variation, in time and degree, during the development of preference for either hemisphere of the brain, thus affecting the essential language areas of the brain. This process does not involve destruction of any part of the cortex, but rather is a developmental, physiological process. Orton coined the term "strephosymbolia" or "twisted-symbols"

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[1]The *Children with Specific Learning Disabilities Act of 1969*, Public Law 91-230, Title VI, "Education of the Handicapped", Section 602, Paragraph 15.

to describe the phenomena of reversal errors in certain children.

Money (1962) disagreed with Orton's cerebral dominance theory as a cause of mirror-image reversals in children with learning disabilities. Money sees the problem of children who have diagnosed learning disabilities as being "...confusion about the direction of the optical image of a symbol in relation to the muscular feel of making it (p.19)."

> Evidently the dyslexic[2] has confusion and difficulty in the matter of body image for the parts of the body he can both see and feel and those he can only feel. It is this confusion between visual and body images that seems to underlie the difficulties of directional orientation that have been noted as a characteristic of dyslexics. It is a three-dimensional, space-movement perception problem, involving the relationship of the visual image to the body image in ahead and behind, toward and away-from, left and right and facing upward or downward (p.20).

In contrast, Bender (1963) holds the view that specific learning disabilities are caused by a maturational lag. She draws similarities between childhood schizophrenia, which she believes is caused by a developmental lag at the embryonic level, and developmental lags in language, such as found in dyslexia (see Footnote 2). The developmental lag theory assumes that in each individual, certain abilities are maturing at different pre-determined rates. Therefore, the

[2]The Children with Specific Learning Disabilities Act of 1969 lists dyslexia as a generic term included under the more comprehensive label of specific learning disabilities.

children whose skills in certain areas are lagging behind those of their peers are merely showing a temporary developmental lag in maturation of those skills, rather than brain injury or cerebral dominance confusion.

In addition to these medically-oriented theories of the etiology of learning disabilities and reversal errors, educators have also observed the phenomena in terms of the various teaching strategies that may be applied to the problem. Their concern is more with the actual learning situation rather than the etiology of the problem (Lerner, 1971).

Krise (1949) and Cole (1951) hold the view that reversals are caused by confusion in spatial orientation, or confusion of the relation between symbols and their backgrounds.

As of yet, there is no conclusive evidence for the validity of any theory of etiology or reversals. The variety of disciplines contributing to the research in this area have presented diverse theories, many of which have already proven inadequate. But they have provided impetus for future research and theory development (Lerner, 1971).

A method of successfully remediating reversal errors would be of great benefit to learning disabled children. As confusions are greatest among letters which are mirror-image reversals of each other, such as b-d and p-q (Dunn-Rankin, 1968 ; Popp, 1964), the present study is concerned with teaching learning disabled children the visual discrimination and name association to the letters b-d and p-q.

Research on Discrimination and Distinctive Features

In the area of reversal training, research falls into two separate categories: that involving the differentiation of the graphic forms of the letters, and that involving the proper verbal, or name, association with each respective letter (Zeaman & House, 1963).

In studies of discrimination learning, an attempt has been made to isolate those groups of stimuli which are most readily confusable. Dunn-Rankin (1968) studies the relative similarity between lower-case letters of the English alphabet by means of a discrimination task. Each second- or third-grade S was presented, consecutively, a series of 21 target letters. He was then instructed to indicate which of the two additional letters presented to him was most similar to the target letter. It was thought that the letter combinations judged most similar would tend to be confused more often. Clearly definable clusters of confusable letters were revealed by the analysis of the scales. These include b-d, d-p, b-p, c-e, and n-u.

In another study, Dunn-Rankin, Leton, and Shelton (1968) focused on the structural similarity of the lower case letters of the alphabet. A factor analysis based on an index of common area to independent area of each letter revealed five clusters of letters: (a) p, b, q, d; (b) i, f, l, j, t; (c) y, v, x, w, z, k, s; (d) n, u, m, h; and (e) e, c, o, s, and a.

Gibson, Gibson, Pick, and Osser (1962) studied the development of the ability of children from four to eight years old to discriminate visually a set of letter-like forms. They were interested mainly in the type of errors made in the discrimination process. Instead of using actual letters, the experimenters constructed standard letter-like forms, on the basis of similarity to actual letters, using number of strokes, straight vs. curved lines, angles, open vs. closed forms, and symmetry. They then developed transformations of each of these standard forms as follows: three degrees of transformations of line to curve or curve to line; five degrees of rotation and reversal; two perspective transformations, 45^{o} slant left and a 45^{o} backward tilt; and six topological transformations, i.e., break to close. Results indicated that there was a decrease in errors for all transformations as age increased, but that rate of improvement varied in relation to the type of transformation. Errors of rotations and reversals started high, but declined to almost zero by the time the subject had reached eight years of age. There was a sharp drop in the number of rotation and reversal transformations at the age of five, little change up to age six, and then gradual decline from age seven to age eight.

In the preceding study, Ss used a matching-to-sample task, in which they were required to make a judgement that the stimuli they were presented were the same or different from a sample stimulus. On the basis of that study, Gibson hypothesized that most children improve with age in a matching-to-sample task, because they become more aware of the distinctive features that serve to differentiate graphic symbols. Children are able to detect these distinctive features because of experience they have had with solid objects in their environment. There is, therefore, a transfer of distinctive features learned from a child's experience with solid objects.

Gibson looked at these distinctive features more completely in her 1969 study using upper case forms of the English alphabet. Prereading 4 year-olds performed a matching task and an error matrix was derived from their results. The percentage of common features shared by these letters was determined, and then was correlated with the confusion errors made by the children. It was expected that those letters sharing many features in common would be more difficult to discriminate than those sharing only a few features. Gibson's results indicated that this was the case, as there were 12 statistically significant correlations which could expedite future alphabet training.

Along these same lines, Gibson, in 1970, further described the distinctive features of individual letters by means of a cluster analysis of the 26 Roman capital letters. Using adults and 7-year-olds to make a same-different judgement of these letters, Gibson compared their errors using features of verticality, horizontality, diagonality, curvature, openness or closure, and intersection.

Her results indicated that these are the types of features used by individuals in making discriminations of letters. To carry her hypothesis even further, she explained the frequency with which errors of rotation or reversal occur among kindergarten children by the lack of relevance of these dimensions for object identification.

Although the preceding studies have been conducted with normal school children (i.e., children who do not have diagnosed learning disabilities), rather than learning disabled children, they do indicate that attention to the critical distinctive characteristics of the stimuli is of utmost importance in learning to discriminate them. According to Guralnick (1972), a training program, teaching children to attend to these specific features, would be of great benefit in increasing discrimination skills. Much research has been concerned with training Ss in directional and spatial orientation and most of it involved some pretraining task using the orientation dimension to teach discrimination of forms.

Pretraining Techniques

Because of the considerable frequency with which errors of rotation and reversal occur, they have been given attention in studies using pretraining techniques.

Jeffery (1958) found that motor pretraining aided 3- and 4-year-old children in making verbal responses to stick figures oriented in different directions. The motor response consisted of pushing a button corresponding to the left-right direction of the respective stick figure. Results indicated that the motor response, corresponding to the direction of the stick figures, was helpful in drawing Ss' attention to the directionality features needed for discrimination.

Hendrickson and Muehl (1962) compared three groups of kindergarten children in learning names for the letters b and d. Their study stressed the effects of attention on pretraining groups to attend to the directional difference between b and d, as compared to the control group. One group of Ss was trained to attend to the direction of letters and make motor responses consistent to each letter. A second group was given attention training also, but their motor responses were to be made inconsistent with the letter. A control group received attention and motor training to color stimuli. The two groups attending to the direction of letters were superior to the control group on the letter naming task, but the motor factor had no significant effect.

Williams (1969) disagreed with Gibson that distinctive features of letters would account for attention to their details. Instead, he hypothesized that reproduction of the letters would effectively draw attention to their details. He gave groups of kindergarten children pretraining under one of three conditions: discrimination training where the comparison stimuli were different from the standards; discrimination training where the comparison stimuli were transformations of the standards (right-left, up-down, 90°

and 180° transformations): and reproduction training. For training, a delayed matching-to-sample task was used. The results indicated that discrimination training in which the comparisons were transformations of the standards was superior to discrimination training in which the comparison stimuli were totally different forms. Therefore, comparisons in which the stimuli were only slightly different from the standards forced Ss to attend more closely to the attributes of the standard. Reproduction training was not as effective as discrimination training with transformations, but was as effective as simple discrimination training. Thus, Williams concluded that the effectiveness of reproduction training in drawing attention to detail of forms depended on the degree of similarity of forms, used in the discrimination task, as compared to the standard.

Caldwell and Hall (1969) suggest that the concepts of same and different, rather than attention factors, are crucial to discrimination learning. They gave three groups of kindergarten children warm-up tasks designed to teach the concept of same and different. The warm-up involved use of overlays of nonsense forms to match a standard to stimuli varying in orientation. All groups of Ss were given feedback as to the correct answer, but one group was given information in which the orientation of the overlay to the stimuli was relevant, and a second group was given information in which the orientation was irrelevant. A control group was given no orientation information. Caldwell and Hall hypothesized that children given orientation-relevant information, designed to produce the concept of same and different, would make fewer errors than a control group on a transfer task of letter perception, involving b, d, p, and q. Conversely, the orientation-irrelevant group should have more confusions than a control group on the letter perception task. The hypotheses were borne out, since the orientation-relevant group had significantly fewer confusions than the control group, and the orientation-irrelevant group had significantly more confusion than the control group. Results indicated that kindergarten children could discriminate b, d, p, and q on the basis of the concept of same and different.

These studies, using normal school children indicated that they, at least, can learn to discriminate forms with pretraining instruction on the orientation dimension. However, as Guralnick (1972) points out, this may not be true with children who have specific learning disabilities or poor attending behaviors. One important aspect of the pretraining, as far as learning disabled children are concerned, is the difference between the pretraining task and the subsequent discrimination task. If the difference is large, then children with specific learning disabilities have a great deal of difficulty in making a transfer, if, indeed, they can at all. One possible solution to this problem would be through use of carefully programmed training.

Stimulus programming techniques provide for gradual change of a stimulus dimension, as well as opportunity for immediate reinforcement and feedback. In this programming process, correct performance is maintained by starting with an easy discrimination and gradually progressing to a more difficult one. Sidman & Stoddard (1967), Hively (1962), and Moore & Goldiamond (1964) have demonstrated the effectiveness of carefully programmed training by use of fading techniques, specifically.

Training Procedures

Sidman & Stoddard illustrate the use of a fading technique in their 1967 study. They attempted to teach severely retarded boys a circle-ellipse discrimination, using a nine-key matrix in which the outer keys were illuminated and the inner key was darkened. In the first part of their study, the Ss were required to make only a brightness discrimination between the model, a circle, and the background. In the second part of their study, ellipses were gradually faded into the other six squares of the matrix, so that the final discrimination was between the one circle and the six ellipses. With this program, seven out of ten children learned the discrimination. In a control group not provided with the first stage of this experiment, only one of the nine children learned the discrimination. It should be noted that Ss were initially provided with an easy discrimination and were required gradually throughout the study to make more difficult discriminations.

In a similar study, Hively (1962) used a programmed teaching machine to train preschool and first grade children in a series of progressively difficult discrimination tasks. In the first series of the program, there were no incorrect choices available to the _S_s because the matching stimulus was always located directly below the sample stimulus. Thus, _S_s were discriminating on the basis of position of the matching stimulus. As the program progressed, the position cue was gradually faded out until _S_s had to make the final discrimination on the basis of cues provided by the stimuli themselves. This training was found to be more efficient in eventual discrimination of the stimulus, than training in the final discrimination by position cues alone.

Moore & Goldiamond (1964) did a matching-to-sample discrimination study in which triangles were used as stimuli. One triangle matched the sample in degree of rotation, but the other two differed slightly. For preschool children, correct discrimination was very difficult on the basis of distinctive features alone. A fading technique was introduced and only the correct triangle was illuminated at its brightest intensity of light, while the other triangles remained at their lowest intensity. _S_s were then able to make the correct response readily. The difference in brightness diminished as the light intensity of the incorrect triangle choices gradually increased to the level of the correct triangle choice. Thus, the _S_s were less able to make the discrimination on the basis of brightness, but were forced to discriminate on the basis of degree of rotation. Ss accomplished this in an almost errorless sequence.

The training procedures cited here have an important element in common. They all present two stimuli which differ along at least two different dimensions (such as size, color, shade, position, etc.). During the course of the training, one dimension changes gradually until there is no difference between the two stimuli along that dimension. It is called the fading dimension. By this process, the Ss initially master an easy discrimination, but via the fading dimension, they are able to acquire a difficult discrimination with few or no errors. Thus, errorless discrimination results from such a fading technique.

Other studies have shown that errors are the result of responding to extraneous properties of the experimental situation, and if allowed to occur repeatedly, become extremely resistant to change (Hively, 1962; Moore & Goldiamond, 1964; Sidman & Stoddard, 1967; and Touchette, 1968). A fading technique provides for a return to a simpler discrimination when Ss do make errors, so that the Ss may undergo further training. It is important that Ss meet a strict criterion of correct performing at each level of the discrimination training (Guralnick, 1972).

The research on fading techniques has been concerned mainly with teaching children to discriminate forms on the basis of directional and spatial orientation. Few researchers have been concerned with distinctive features as related to alphabet discrimination. However, Guralnick (1972) indicates that after having learned to discriminate the critical features which represent differences among letters, children may be transferred gradually to letter discriminations.

Fading techniques are applicable to treating children with specific learning disabilities because of the emphasis placed on perceptual training (Guralnick, 1972). Thus, children who have long been reversing such letters as b and d, or p and q, should, by fading training learn to distinguish the critical distinctive features of these letters.

Presently, one of the most commonly used techniques for remediating reversal errors in learning disabled children is the multi-sensory technique first suggested by Orton (1928). In this form of remediation, the child traces the form of a letter or word, at the same time saying the name of it so as to involve training in the kinesthetic, auditory, and visual channels simultaneously. The purpose of this is to fix, with multi-sensory cues, the association of the sound with the properly oriented form.

This technique is often successful, but may be a very time-consuming process with children who have severe specific learning disabilities in which their misperceptions are more numerous and occur more frequently (Orton, 1928). The implications of the time element are obvious when one considers the obstacles created for reading, writing, and spelling progress in school when a child persistently makes reversal errors.

Fading techniques would allow for a shorter term training period and still act to draw attention to the distinctive features of the letters to be discriminated.

The present study was designed to implement fading procedures in teaching learning disabled children the visual discrimination and name association of the letters b-d and p-q. A fading technique would enable Ss, at first, to make a visual discrimination and name association to the stimulus letters on the basis of a concept, such as brightness, which they already had in their perceptual repertory. It was hypothesized that through the gradually changing fading dimension, i.e., the brightness dimension, visual discrimination and name association would finally be made on the basis of the distinctive features of the letters alone.

Following this line of reasoning, once the child learned the visual discrimination and name association of the letters, when seen individually, he should be able to transfer this training to a situation in which the letter was seen in the context of words.

Therefore, it was hypothesized that Ss would not only learn the visual discrimination and name association of b-d and p-q when seen individually, but would transfer this learning when these letters were found in words or nonsense syllables. This would be directly applicable to the school reading, writing, or spelling class in which there were learning disabled children whose reversal errors present a handicap to their performance and achievement.

If the results of this study support the hypotheses, they would be of value to classroom teachers as well as reading specialists in their teaching of children with specific learning disabilities.

Chapter 2

METHOD

Subjects

Four male children, ranging in age from seven years seven months, to eight years four months, served as Ss. Three Ss were first grade students and one a second grade student at a private boy's school in Richmond, Virginia. Ss were selected on the basis of their diagnoses of specific learning disability, and on the basis of their high frequency of b-d and p-q reversal errors. Each S, prior to the beginning of the present study, had been referred for psycho-educational evaluation by his pediatrician, teacher, and/or principal. Referral was based on the Ss' erratic academic performance, i.e., poor in some academic areas and adequate in others; their distractibility; their seeming discrepancy between ability and performance; and their high frequency of reversal errors. Diagnosis, by a clinical psychologist, was made on the basis of a battery of intelligence, achievement, and perceptual tests, including the Wechsler Intelligence Scale for Children (WISC), Bender-Gestalt Test, Wide Range Achievement Test (WRAT), Gray Oral Reading Test, Wepman Auditory Sound Discrimination Test, Iota Word Recognition Test. These score are reported in Appendix A. The Ss' performance on these tests indicated the presence of symptoms of specific learning disabilities as described by Clements (1966): scatter of scores on subtests of the WISC within both the performance and verbal scales; "spotty" or "patchy" performance on tests of academic achievement such as the WRAT, Gray Oral Reading, and the Iota Word Recognition; below mental age level on tests of visual-motor performance such as the Bender-Gestalt; and impairment of perception on tests such as the Wepman. On the basis of these test results, each S had been referred for individual remedial tutoring, and had participated in prescriptive tutoring sessions for periods ranging from seven to nine months prior to the initiation of the present study. The Ss continued their tutoring sessions throughout the duration of the study. The author was serving as the reading tutor for each S at the time the study was being conducted.

Experimenters

Two undergraduate students, majoring in psychology at the University of Richmond, Virginia, served as the Es. One E had had prior experience in observing and training children with specific learning disabilities, and also had a sound background in principles of behavioral psychology. The second E had had no experience in working with children or in the study of learning disabilities. However, he had had coursework in behavior modification techniques and had participated in previous studies and projects involving use of these techniques. Training and practice sessions with the apparatus and the pretests, including pronunciation of the nonsense syllables, were given to each E by the author prior to the initiation of the present study.

Apparatus

The discrimination apparatus (Psychological Instruments, Inc., Richmond, Virginia) was a table top unit, equipped with two 4-in. by 5-in. viewing screens of translucent plexiglas, on which the letters to be discriminated were projected from behind the screen. A hood, projecting over the viewing screens, was used to screen out extraneous light. The apparatus was positioned so that the viewing screens faced the S, and the E sat to the rear of the apparatus, facing the setting mechanisms. Below each viewing screen was a selector button on which the S indicated his responses. Two lights on the rear of the apparatus, corresponding to each selector button, blinked on when its respective selector button was pressed, thus indicating to the E the S's response. Dimmer switches on the rear of the apparatus allowed the brightness of the letter to be altered in nine arbitrary divisions, from above threshold, up to 1½ footcandles. A shutter system, within the apparatus, closed off all light from the viewing screens while the E made changes in the position or brightness of the stimuli.

Position of the stimuli could be changed by moving a 4-in. by 15-in. slide, inserted in the side of the apparatus, to the left or right. One slide, with the letters b, d, b, printed on it, was constructed by spraying, with black paint, all of the slide except the letter forms. This allowed the background to always remain dark, and the brightness of the letter stimuli to vary according to the light intensity shining from within the apparatus through the unpainted letter form. When the slide was in place, only two letters, one _b_ and one _d_, were visible to the _S_. A second slide was constructed in the same manner, except that it contained the letters _q_, _p_, _q_. When it was in place in the apparatus, only the letters _p_ and _q_ were visible to the _S_.

The apparatus was equipped with an 18-in by 20-in. masonite screen fitted over the top and on the sides to shield the _E_ from view of the _S_.

A buzzer was used to signal to the _Ss_ the end of the day's trials.

The experimental room was an 11-ft. 8-in. by 8-ft. 8-in. room at the _Ss'_ school. The major light source in the room was from a 8-ft. 7-in. by 4-ft. 8-in. window, located to the rear of the experimental apparatus. In order to control, as much as possible, for variation in external light intensity, the overhead lights in the experimental room were turned off during the discrimination training, and the drapes at the window were partially closed. As the experimental room faced toward the west, there was no direct sunlight entering the room during the morning training sessions.

Procedure

The experimental procedure was divided into two stages, each stage consisting of a pretest session, nine training sessions, and a posttest session. There was a different E for each stage, and there was a one-week interval between the stages. The design was counterbalanced in that two of the four Ss were trained in b-d discrimination in Stage 1, and the remaining two Ss were trained in p-q discrimination. During Stage 2, the two Ss who previously had had b-d training were given p-q training, and the two Ss given p-q training initially were given b-d training.

Pretests

Before discrimination training began, the Ss were given a series of pretests to determine their percentage of correct responses out of the total single letter, nonsense syllable, or word presentations of the letters b and d, or p and q. The pretests were in six categories, and were given to each S consecutively in two sittings during one day.

Pretest I. The first pretest was designed to test the Ss' ability to discriminate the visual form of the letters b, d, p, and q. without name association, using a delayed matching-to-sample task. The sample was shown to the S for three seconds, then removed, and the choice was made by pointing to one of four letters as the proper match. This pretest provided information as to the Ss' ability to note the orientation of the respective letters (see Appendix B).

Pretest II. The purpose of the second pretest was to determine the Ss' ability to make a visual discrimination and name association to the letters b and d, and to the letters p and q. In this pretest, one letter was printed on each $2\frac{1}{4}$-in. by $3\frac{1}{2}$-in. stimulus card, and two stimulus cards were simultaneously presented to the S. Only those letters which are horizontal-axis rotations of each other were presented simultaneously. That is, p and q might be presented together, but p and b could not, because they are vertical-axis rotations of each other. This stipulation was important in controlling for the similarity of this pretest and the subsequent discrimination training task, which involved discrimination of horizontal-axis rotated letters only. The left-right position of the letters presented simultaneously, as well as the order of presentation for each pair, was randomized. The E provided the S with the name of the letter to be discriminated, and the S indicated the stimulus card which corresponded to the name (see Appendix C).

Pretest III. The purpose of the third pretest was to determine, again, the Ss' ability to discriminate the visual form of the letters b and d, and to make name associations to them. This time, however, the letters were associated with other letters, in the context of nonsense syllables, Consonant-vowel-consonant nonsense syllables were chosen for this test because they closely approximated words in the Ss' reading vocabulary, and they lacked the semantic cues and familiarity that real words might have for the Ss. These nonsense syllables were chosen from a list by Underwood and Schulz (1970) on the basis of their pronounciability and the position of the b and d within the syllable. An equal number of syllables was chosen with b or d in the initial position, and b or d in the final position. In this pretest, one nonsense syllable was printed on each $2\frac{1}{4}$-in. by $3\frac{1}{2}$-in. stimulus card, and two stimulus cards were presented simultaneously to the S. This pretest was divided into two sections based on the instructions given to the Ss. In Part A, the S was asked to indicate the nonsense syllable with the b in it, or with the d in it, as the case may be. This set of instructions was more similar to the discrimination training to follow than was Part B. In Part B, the S was asked to indicate, for instance, the word which read "bem". This set of instructions more closely approximated the reading response for the S (see Appendix D).

Pretest IV. This pretest was identical to Pretest III in form, except the p and q nonsense syllables were used (see Appendix E).

Pretest V. The purpose of the fifth pretest was to test the Ss' ability to discriminate the visual form of b and d and to associate their respective phonetic sounds in the context of actual words and phrases. This was the pretest of most interest to the Ss' classroom teachers because of the applicability to the Ss' reading performance. Words and phrases containing b and d in both initial positions and final positions were selected from Group 5 and Group 16 of The Teaching Box (Hathaway, 1970). Also selected from these groups were words which contain both b and d, words in which b is in both the initial and final position, words in which d is in both the initial and final position, and three-word phrases with one or more words containing a b or d. Each word or phrase was printed on a $2\frac{1}{4}$-in. by $3\frac{1}{2}$-in. stimulus card, and presented consecutively to the S. The order of presentation of the words was randomized. Ss simply were instructed to read the words and phrases (see Appendix F).

Pretest VI. This pretest was identical to Pretest V in form except that p or q words and phrases, selected from Group 15 and Group 30 of The Teaching Box (Hathaway, 1970), were used (see Appendix G).

Visual Discrimination and Name Association Training

The fading program, used to train visual discrimination and name association of the letter b-d and p-q, began on the day following administration of the pretests. The training period extended for nine consecutive schooldays, with each daily session consisting of a minimum of ten trials. A single trial was defined as one position setting of the apparatus, in which a b appeared on one viewing screen and a d on the other, or a p appeared on one screen and a q on the other.

On the first day of the discrimination training, the S was seated in front of the apparatus. The E demonstrated the use of the selector buttons and discussed the concepts of "bright" and "dark" as related to the letter stimuli appearing on the viewing screens (see Appendix H).

On that day, the b (or p, depending on the letters involved in the discrimination training for a particular S) was illuminated at its brightest intensity and the d (or q) was simultaneously illuminated at its lowest intensity on the viewing screens. The S was instructed to select the "bright b" (or "bright p") by depressing the corresponding selector button (see Appendix H). The position of the letter stimuli on the viewing screens was randomly assigned using a table of random numbers (Kendall & Smith, 1938). One stimulus occurred no more than three times, consecutively, in the same left or right position because of the limited number of trials presented to the Ss each day. With a minimum of ten trials per day, it would be easy for the S to fall into the habit of responding on the basis of position rather than form discrimination.

On the second day of the training, and every day thereafter, the d (or q) was illuminated at progressively brighter levels of intensity. That is, a new level of increased intensity for d (or q) appeared with the first trial of each day, and that intensity remained the same for all trials that day. The next brighter intensity began on the first trial of the following day, so that, by the ninth day, the b and d (or p and q) were of equal intensity of light. From the second day of training to the ninth, the S was instructed merely to select the "b" (or "p") rather than the "bright b" (or "bright p"), which was his instruction on the first day of training.

Only one letter of each pair of reversible letters, i.e., either b or p, was consistently reinforced in the present study. That is, the E always asked the S to select the "b" (or "p") and never the "d" (or "q"). Hicks (1968) suggested that in children with specific learning disabilities, who often confuse letters, it is far better to work on only one of a pair of reversible letters at a time so as to reduce the confusion as much as possible.

In addition to the instructions given to the S preceding each trial, the E indicated to the S whether his responses were correct or incorrect. This should have helped prevent the S from forming a habit of responding to incorrect stimuli in the training sessions.

Errors were not allowed to occur more than once during any given day's trials. If a second error occurred, the S was returned to the simpler discrimination task of the preceding day for more training. After he met the criterion of ten correct responses on the simpler task, he could proceed to the next more difficult discrimination. If a S made only one error in a given day's trials, he still had to make ten consecutive, correct responses after his error before he could successfully complete the training for that day. The criterion, then, for successful completion of trials for any given day, was ten consecutive, correct responses.

The Ss were expected to make few, if any, errors in the discrimination training because of the structure of the fading technique. Since the discrimination began with a simple task, and the difficulty increased gradually, the Ss should not have numerous errors (Hively, 1962; Sidman & Stoddard, 1967; Touchette, 1968).

Reinforcement

For children with specific learning disabilities, repeated failure in academic tasks is usually a common occurrence. Often, the entire classroom experience becomes aversive to them. In view of this it appeared that teacher attention and approval of academic performance would serve as a strong reinforcer to children with learning disabilities (Lovitt, 1968). This type of reinforcer provided the teacher an opportunity to approach the S positively in regard to an academic task, and provided the S an opportunity to have positive interaction in one part of his classroom experience.

On the first day of the training program, each S received from the E a blank progress chart on which his progress throughout the training could be determined by a linear progression from a starting point on Day 1 to a goal point on Day 9. The criterion for marking the progress chart was completion of ten consecutive, correct trials on a given day. The buzzer signaled to the S that he had met this criterion and could mark the chart. After doing so, the S returned to his classroom with the chart, and his classroom teacher immediately offered praise for his good work. The teacher kept the chart until the next experimental session, when she instructed the S to return the chart to the E. At the end of the nine-day training period, the S was allowed to keep his chart.

The author had an initial meeting with the teachers concerning the importance of the timing of their praise of each S's work. The author explained that it was important for each S to receive praise immediately following his training session so as to help him associate the praise with the fading task. Also, the teacher's consistency in giving praise to the Ss each day of the training was stressed. The author met briefly with teachers, on a biweekly basis, to give them feedback as to the progress of the respective Ss.

As the fading program was structured to allow for success, it was expected that each S would meet the criterion for marking his chart, and receive teacher praise, each day. If the S made errors during the training one day, the E returned him to easier discriminations until he finally made ten consecutive, correct trials.

The E also provided praise for the S as he marked his progress chart in the E's presence.

Posttests

On the day following completion of nine days of training, the Ss were given posttests identical to the pretests described previously. This was done for both Stage 1 and Stage 2 of the experiment.

Criteria for Improvement

The unit of measure was a percentage-gains score, obtained by computing the difference between the Ss' actual gain and the investigator-hoped-for gain. The treatment outcome goal, or the level of performance that the investigator hoped the Ss would attain, was arbitrarily set at 100% error-free discrimination. The pretests served as the baseline measure of the Ss' performance in each stage of the experiment, and the posttests were a measure of the Ss' actual gain.

The percentate-gains score was derived by computing the difference between a S's baseline, or pretest, score and his actual attained score, and dividing this by the difference between the S's baseline score and the treatment outcome goal. The result of this computation was then multiplied by 100, as follows:

$$\frac{\text{Pretest - Posttest}}{\text{Pretest - Treatment Outcome Goal}} \times 100$$

For instance, if the S had a pretest score of 75 and a posttest score of 95, then the formula for finding the percentage-gains score, with a Treatment Outcome Goal of 100% would be as follows:

$$\frac{75 - 95}{75 - 100} = \frac{20}{25} \times 100 = 80\%$$

The S would have gained 80% out of the total possible gain he could have achieved.

Therefore, the percentage-gains score, in the present study, was a measure of the percentage of the treatment outcome goal that each S attained through discrimination training (E. H. Tiller, personal communication, July, 1973; Wilson & Tosti, 1972).

Chapter 3

RESULTS

The Ss' percentage of correct responses (i.e., the Ss' total number of correct responses divided by the total number of possible responses on a test) on visual discrimination and name association, based on their scores from Pre- and Posttest II, can be found in Figure 1, p. 33. Both the design of Pre- and Posttest II and its instructions to the Ss were more similar to the subsequent fading training than any of the other pre- or posttests. It will be recalled that the Ss were instructed to indicate the "b" or "d" from a b-d stimulus pair or the "p" or "q" from a p-q stimulus pair during Pre- and Posttest II. Since this task holds such similarity to the fading task itself, scores from Pre- and Posttest II are considered a direct measure of the effectiveness of the fading technique.

Percentage-gains scores (i.e., the Ss' percentage of actual gain out of the total possible gain) for visual discrimination and name association of b-d and p-q, also derived from Pre- and Posttest II, indicated that the Ss made actual gains scores ranging from 40% to 100% of the total possible gain (see Table 1, p. 34). Subject C was performing at a maximum during both the pre- and posttest Stages 1 and 2.

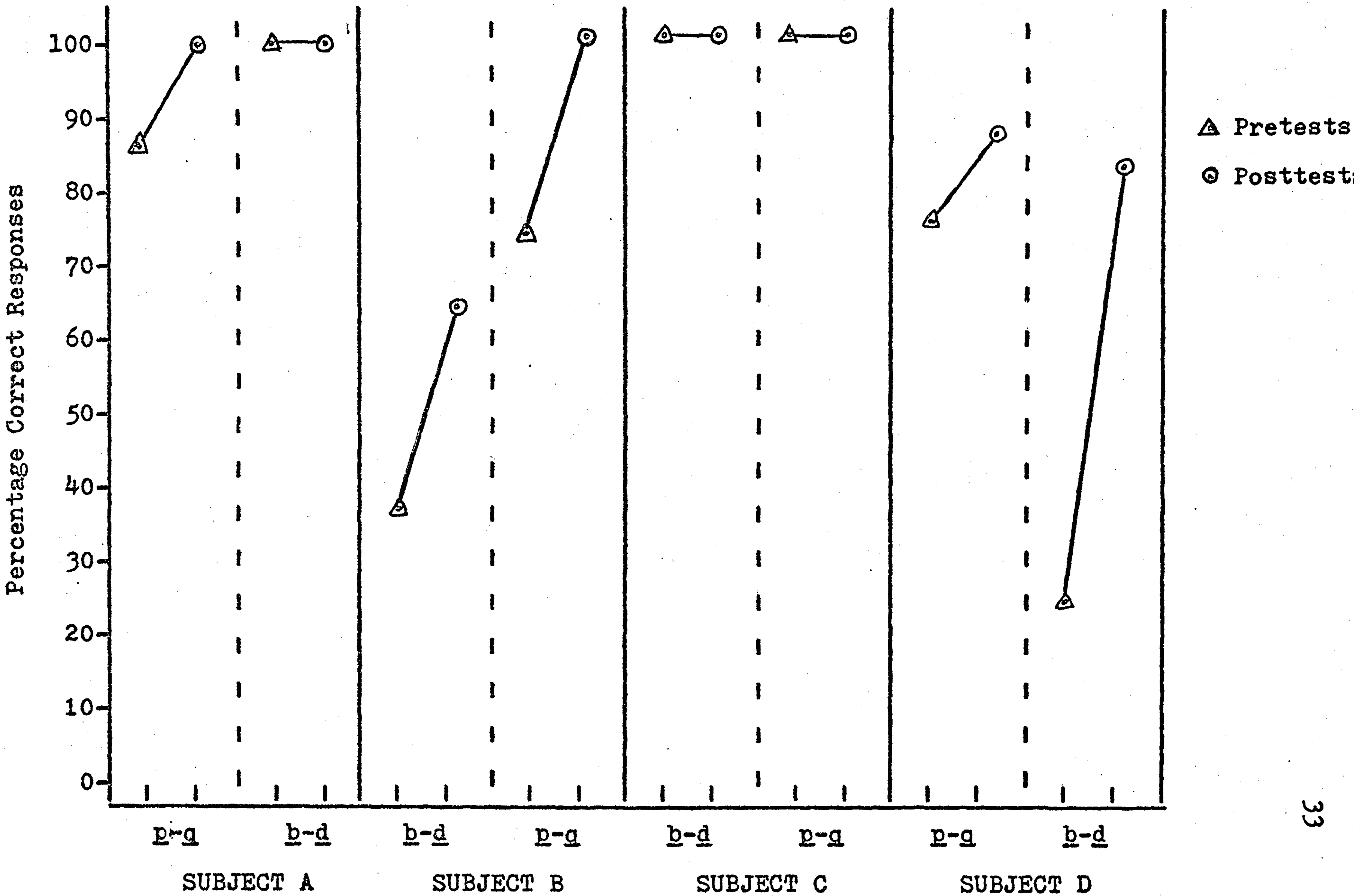

Fig. 1. Percentage correct responses for visual discrimination and name association of b-d and p-q, based on Pre- and Posttest II performance.

TABLE 1

Percentage-Gains Scores for S performance on all Pre- and Posttests

Ss	Experimental Training Stages	Pre- and Posttests							
		I	II	III-A b-d	III-B b-d	IV-A p-q	IV-B p-q	V b-d	VI p-q
A	Stage 1 p-q training	*	100%			*	*		100%
	Stage 2 b-d training	loss	*	100%	49%			16%	
B	Stage 1 b-d training	*	40%	75%	60%			100%	
	Stage 2 p-q training	loss	100%			100%	100%		no gain
C	Stage 1 b-d training	100%	*	100%	*			no gain	
	Stage 2 p-q training	*	*			*	*		*
D	Stage 1 p-q training	100%	52%			100%	100%		*
	Stage 2 b-d training	no gain	77%	100%	49%			no gain	

* Indicates that the S was performing at a maximum during both the pre- and posttest scoring.

The percentage of correct responses by the Ss on the tests of visual form discrimination, without name association, was derived from Pre- and Posttest I (see Fig. 2, p. 36). Test results indicated improvements in the scores of two Ss. The other two Ss made more errors after training than before.

Percentage-gains scores of visual form discrimination indicated two instances of actual gain after fading training (see Table 1, p. 34). This discrimination task was the only one in the present study in which the Ss showed a loss in performance after training (i.e., in which the Ss performance on the posttest was lower than his performance on the pretest). The instance in which there was "no gain" occurred when a S was not performing at a maximum during the pretest, and he failed to improve or decline in accuracy on the posttest.

The Ss' percentage of correct responses for visual discrimination and name association of b-d and p-q, in the context of nonsense syllables, was based on the Ss' scores on Pre- and Posttest III-A and IV-A respectively (see Fig. 3, p. 37). Results indicated that each S improved his performance on at least one of the two test scores after discrimination training. It should be noted that on Pretest IV-A, Subject D was inadvertently interrupted during his testing.

Percentage-gains scores for visual discrimination and name association of b-d and p-q in the context of nonsense syllables indicated that the Ss, if not already performing at a maximum

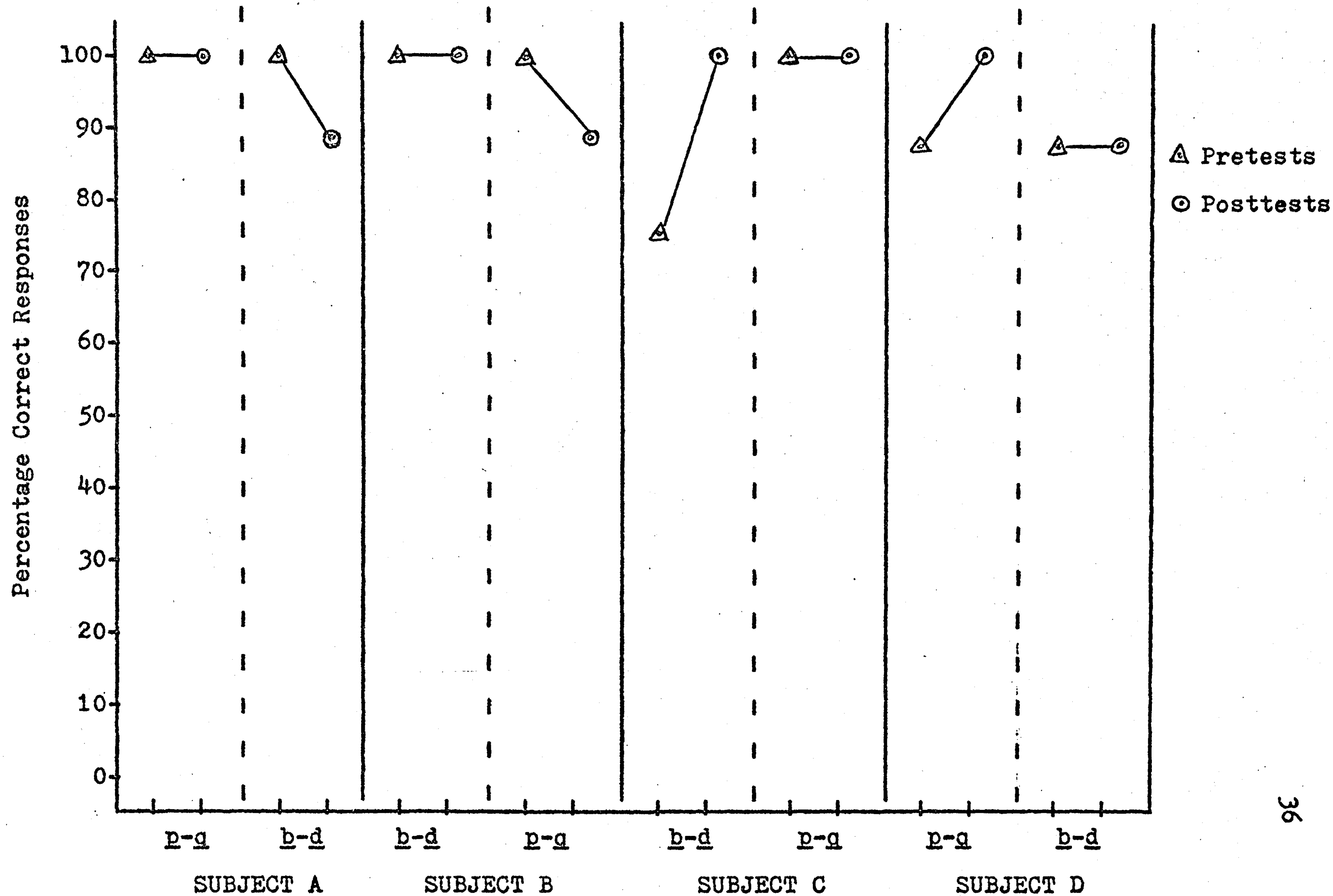

Fig. 2. Percentage correct responses for visual form discrimination of b-d and p-q, based on Pre- and Posttest I performance.

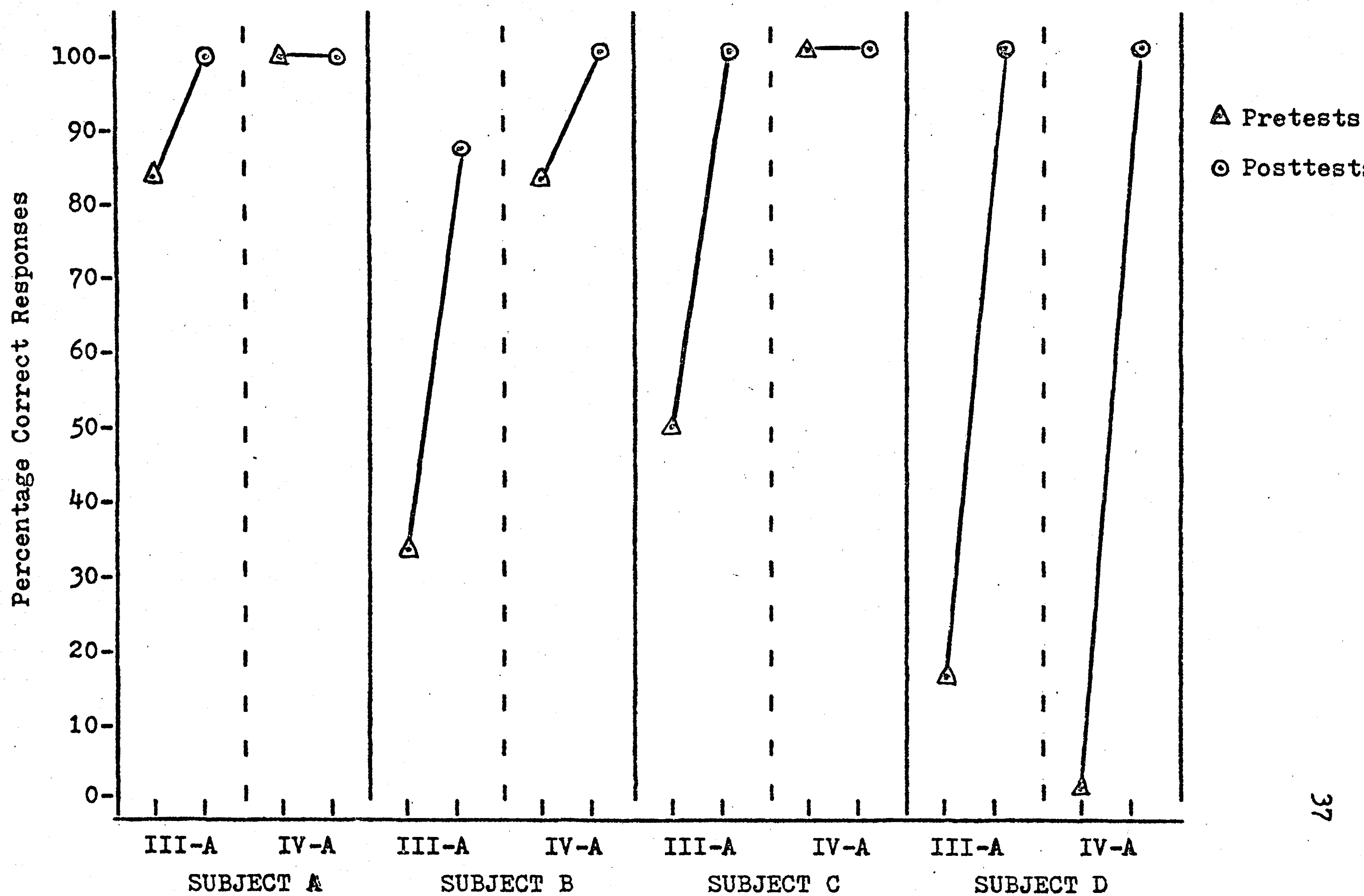

Fig. 3. Percentage correct responses for visual discrimination and name association of b-d and p-q in context of nonsense syllables, based on Pre- and Posttests III-A and IV-A.

during the pretest, made actual gains of at least 75% of the total possible gain (see Table 1, p.34).

Figure 4, (p. 39), represents the Ss' percentage of correct responses of the phonetic sound of b-d and p-q in the context of nonsense syllables. Scores for this task were derived from Pre- and Posttest III-B and IV-B. Three out of the four Ss improved their performance in at least one of the two tests after training. Subject C was performing at a maximum level on both pre- and posttests.

Percentage-gains scores for the phonetic sound of b-d and p-q in the context of nonsense syllables indicated that the Ss made gains ranging from 49% to 100% (see Table 1, p.34). These scores were also derived from Pre- and Posttests III-B and IV-B.

The Ss' percentage correct responses in reading words and phrases containing b, d, p and q, were derived from Pre- and Posttests V and VI (see Fig. 5, p. 40). Results indicated that the Ss improved their performance in three out of eight tests. Most Ss did not improve as a result of the training procedure.

The percentage-gains scores for reading words and phrases containing b, d, p, and q, showed that two of the four Ss made gains after the training procedure (see Table 1, p. 34).

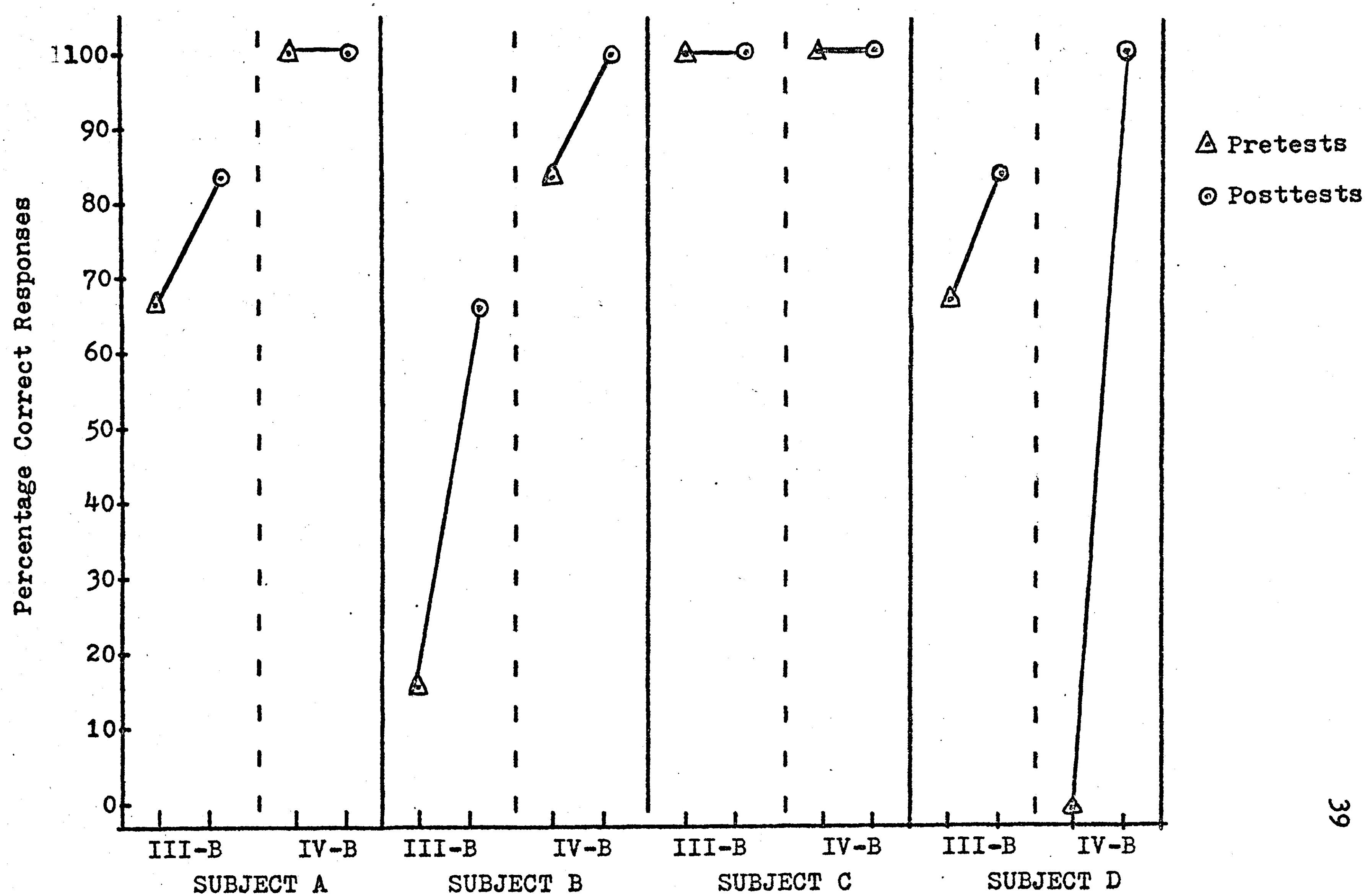

Fig. 4. Percentage correct responses for phonetic sound of b-d and p-q in the context of nonsense syllables, based on Pre- and Posttests III-B and IV-B.

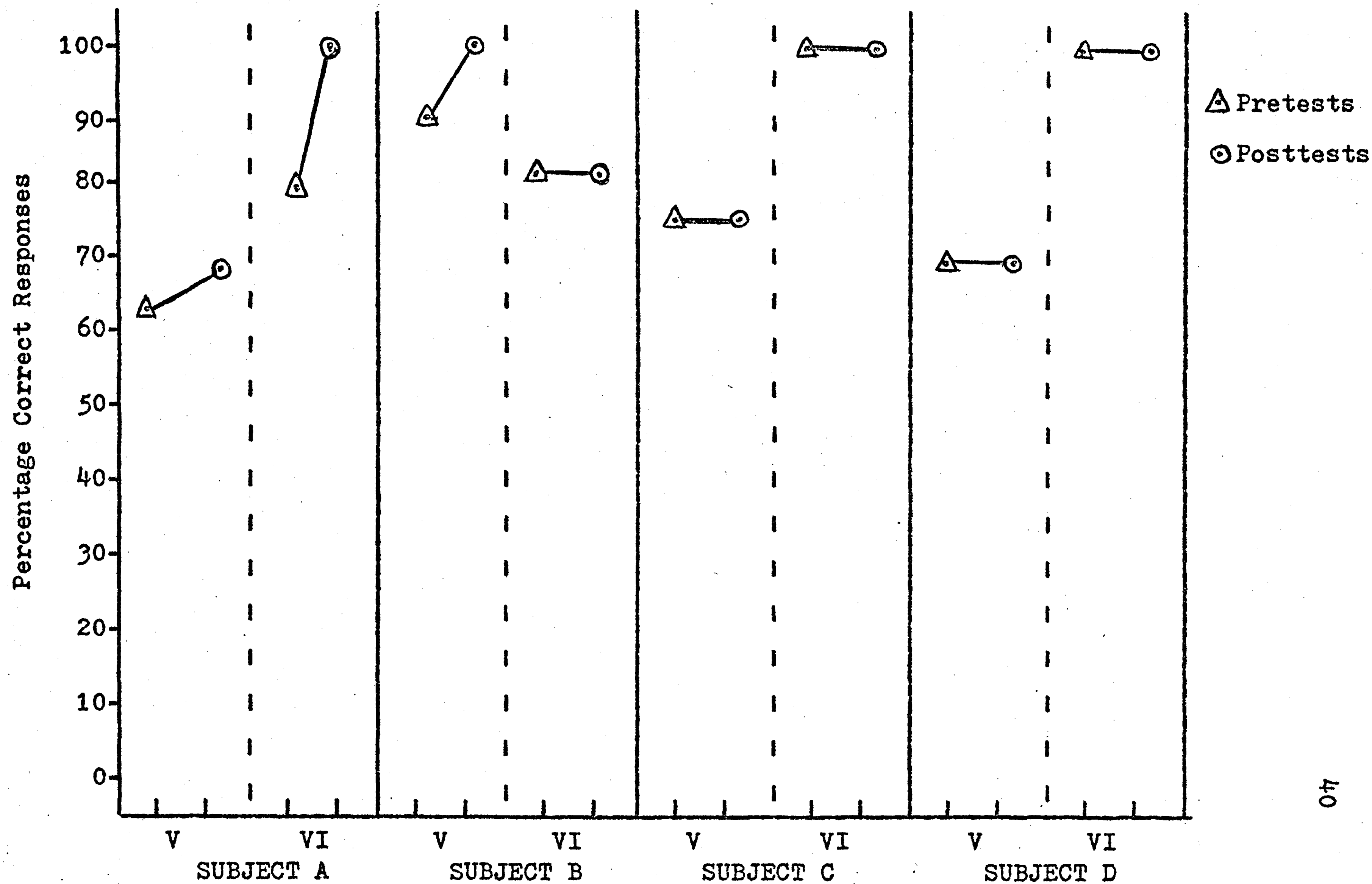

Fig. 5. Percentage correct responses for reading b-d and p-q in single words and phrases, based on scores from Pre- and Posttests V and VI.

Chapter 4

DISCUSSION

The purpose of the present study was to demonstrate that a fading technique, which emphasized gradual change of one stimulus dimension (i.e., brightness), while keeping a second dimension (i.e., visual form of the letters) constant, would be successful in teaching learning disabled _Ss_ the visual discrimination and name association of the letters _b-d_ and _p-q_.

The results demonstrated that the fading technique was, indeed, helpful in teaching the _Ss_ visual discrimination and name association of _b-d_ and _p-q_. The _Ss_' performance on tests designed to measure _b-d_ and _p-q_ visual form discrimination, without name association, indicated that the fading training was only slightly effective in this task, as there were only two out of eight instances in which improvement took place. However, the _Ss_' performance on tests of visual discrimination of _b-d_ and _p-q_ in the context of nonsense syllables indicated that the fading technique was helpful in learning these tasks. The _Ss_ made improvement both in the percentage of correct responses per test and in the percentage-gains score. The tests of reading words and phrases containing _b_, _d_, _p_, or _q_ indicated that the _Ss_ made only slight improvement as a result of the fading procedure.

The counterbalanced design of the present study, described in the Procedure (p. 22), assured that there was no practice effect attributing to the Ss' improved scores.

The data from Appendix I, which lists the Ss' percentage correct responses on all pre- and posttests in both Stage 1 and 2, demonstrate the effect of transfer of training from one pair of reversible letters to another.

For Subject A, there was no improvement in his b-d scores on Pre- and Posttests III-A, III-B and V (i.e., tests which are concerned solely with b-d), after Stage 1 (p-q) training. In fact, his b-d performance declined in all three instances, so that perhaps there was negative transfer of training.

Subject B's p-q scores on tests IV-A, IV-B, and VI (i.e., tests which are concerned solely with p-q) indicated that he improved on one test and had no change in scores on the other tests after Stage 1 (b-d) training. Therefore, positive transfer may have occured on one test, but there was no transfer on the other two.

Subject C had b-d training in Stage 1. However, his p-q scores were at a maximum throughout both Stage 1 and Stage 2, so that there was no possible transfer. Subject C performed better, as a whole, than the other Ss throughout the study. Most of his reversal errors occured in b-d discrimination, and he made few errors in p-q discrimination.

Subject D showed improvement on two of his b-d scores after Stage 1 (p-q) training, and declined on one score.

Therefore, he showed positive transfer from the initial p-q training to performance on two b-d tests.

As these data concerning the effect of transfer of training do not follow any particular trend, it would be difficult to make assumptions from then.

Although this study was designed mainly to demonstrate the effect of fading on the visual discrimination and name association of b-d and p-q, the results which are of most importance to the Ss' classroom performance and to his teachers are those in which the S discriminated b-d and p-q when in the context of nonsense syllables or words.

Pre- and Posttests III and IV were tests using nonsense syllables, with training on b-d and p-q respectively. Results indicated that, for tests III-A, IV-A, III-B, and IV-B, all Ss improved their performance with the exception of those who were already performing at a maximum during the baseline (see Fig. 3, P. 37 and Fig. 4, p. 39). Thus, the Ss were able to discriminate the visual form and associate the name of the letter b-d and p-q in the context of nonsense syllables, and were also able to discriminate the phonetic sound of these letters in nonsense syllables when the E pronounced the syllables.

The scores on the reading tests (V and VI), however, were not as impressive (see Fig. 5, p. 40). Although the Ss made gains in three instances, their scores, for the most part, reflect the lack of change between the pre- and posttests.

The data indicated that fading training had little effect on the Ss' reading performance using words with b, d, p, and q.

It would seem logical that the Ss would have more trouble with nonsense syllables than words and phrases, since the words on the pre- and posttests were familiar to the Ss and the nonsense syllables were seen for the first time. However, the very familiarity of the words may have been responsible for the Ss' difficulty with them. The Ss had been exposed to these words many times previously in their reading, and had had many opportunities to make incorrect as well as correct reading responses to them. However, the incorrect responses meant that the S was possibly responding to the stimulus (or letter) characteristics that were irrelevant to the discrimination process. After repeated practice, habits were formed, and these errors became highly resistant to change (Hively, 1962; Sidman & Stoddard, 1967; Touchette, 1968). Therefore, it is possible that the Ss' familiarity and practice with the words used in Pretest V and VI made their confusion errors more resistant to change, and therefore the fading technique was not effective in changing it. Since the nonsense syllables had not been seen frequently by the Ss before this study, the Ss had not had a chance to practice incorrect responses with them. The nonsense syllables were not as resistant to change, then, as the words.

The visual discrimination, without name association, of the letters b-d and p-q in Pre- and Posttest I indicated that the Ss were experiencing confusion with the form discrimination of the letters both prior to and after the fading training (see Fig. 2, p. 36). This confusion and the inconsistency of correct responses are very characteristic of learning disabled children and are in accordance with observations of the Ss in the present study, both by their classroom teachers and their reading tutor prior to the initiation of the study. It is apparent that the fading technique, as used in this study, was not effective in teaching the Ss the form discrimination, even though there were two instances of improvement on the posttests. One reason for this could be that the verbal instructions to S during the present study focused on the name-association to the letter b-d and p-q, rather than to the visual form discrimination alone. If the fading technique had been designed to focus on the visual form of the letters, drawing attention to their distinctive features without name association involved, then the Ss may have been more likely to make improvement (Guralnick, 1972). Also, as discussed previously, the Ss, because of their age and grade level, had formed a habit of incorrect discriminations in relation to the letters b-d and p-q. So, these letters may have been resistant to change as were the familiar words in Pre- and Posttests V and VI (see Fig. 5, p. 40).

The fading concept includes the process of errorless discrimination. The occurrence of errors during the nine-day training sessions of each stage of the present experiment would be important in interpretation of the results. If repeated errors had occurred, then it would be possible that the fading procedure was not allowing enough time on each step in the program, or was forcing the Ss to take too big a step in progressing to the next more difficult level in the training.

The results of this study indicated that the Ss made training errors in less than 2% of the trials during Stage 1, and less than 1% of the trials during Stage 2. The errors were distributed among the Ss so that no one S ever made more than three errors within one stage of the experiment. Most Ss made two or fewer errors.

The majority of the errors which did occur happened on the seventh or eighth day of the nine-day training session. It was on both these days, during Stage 1, that each S made verbal comments as to the difficulty in discriminating between the brightness of the two letters on the apparatus viewing screens. These comments possibly indicate their difficulty in switching from the concept of brightness, which was fading out, to the concept of letter forms in making their discriminations. Their errors might have been further eliminated in one of two ways: providing for less difference between the consecutive discriminations (the size of the steps) in the training program, or lengthening the training on each step of the program (Hively, 1962).

Analysis of the pre- and posttest scores indicated that the Ss in the present study had more difficulty in discriminating the letters b-d than p-q. Results from Stage 1 of this study showed that, from the pre- and posttests using b-d stimuli (i.e., III-A, III-B, and V), the Ss completed only 8 out of a possible 24 pre- or posttests without making any errors within the pre- or posttest. In contrast, using Pre- and Posttests IV-A, IV-B and VI to examine p-q scores, 16 out of 24 possible pre- and posttests were completed with no errors. In Stage 2, the Ss again had 8 out of 24 possible b-d pre- or posttests completely correct, but only 14 out of 24 p-q pre- or posttests correct (see Appendix I). These results clearly show that the Ss had more confusion errors in the b-d discrimination than in the p-q discrimination. One possible reason for the lack of confusion in p-q discriminations, using Pre- and Posttest VI, was the "qu" combination that must occur in all English words containing a "q". The Ss had learned the "qu" combinations in words prior to the initiation of the present study, so this was probably an added cue in pronunciation of words. No comparable cue was available in the b-d discrimination.

Analysis of the types of nonsense syllables or words missed more often by the Ss in this study, revealed no trend in the nonsense syllable pre- or posttests, but revealed three words from Pre- and Posttest V that were confused often (see Appendix F). The words "bib" and "did" were consistently confused more often than any other words in the test. During Stage 1, the Ss made 10 errors out of 16 possible errors mispronouncing the word "bib". They either reversed the initial or final b, or both. During Stage 2, "bib" was confused 13 out of 16 times. It was most commonly called "did". The word "did" was mispronounced 7 out of 16 times during Stage 1 and 5 out of 16 times during Stage 2. The word "bib" was always presented to the Ss before the word "did" in the randomized presentation-order of the stimuli. The third word missed frequently was "dam". The _d_ was pronounced as a _b_ 2 out of 8 times in Stage 1 and 6 out of 8 times in Stage 2. There was no seeming explanation for the difficulty of this word, except that it was a word that commonly appeared in the _Ss_' reading material, and the _Ss_ may have habituated numerous confusions with that word.

The lack of an effective reinforcement procedure was a problem during the present study. The classroom teachers occasionally misplaced the progress charts, were absent at the time of the training, or were otherwise unable to deliver praise to _S_. The fact that the study was carried out during the final weeks of the school year could have been a factor in the teachers' lack of follow-through. The school planned more extracurricular activities during these last weeks, and the teachers' schedules were often disorganized at this time. Thus, even with the meetings between the author and teachers, and the frequent feedback concerning the _Ss_' progress given to the teachers, they were still unable to maintain the suggested schedule of reinforcement.

The _Ss_ also were disinterested in the progress charts after the first stage of the experiment. During Stage 2, the _Ss_ often misplaced their chart themselves. On these occasions, the _E_ returned with the _S_ to his classroom, and gave the teacher a verbal report of the _S_'s progress. The teacher could then administer her praise. Every attempt was made to see that the _Ss_ received the teacher reinforcement, even in the absence of the charts.

In summary, the present study provided support for the following:

(1) A fading technique, as a specific example of a stimulus programming technique, aided the Ss in learning the visual discrimination and name association of the letters b-d and p-q.

(2) The fading technique was especially useful for children with a specific learning disability because it provided a training task that was very similar in structure to one of the measurement criterion (Pre- and Posttest II, Fig. 1, p. 33). As Lovitt (1967) points out, the commonly-used evaluation methods are at times grossly inadequate in assessing children with learning disabilities because the method of assessment is so different from the program of remediation that are eventually set up for the child. Lovitt says that assessment is more valid if it matches its observations with those behaviors that will subsequently be modified.

(3) The fading technique not only provided for the Ss' visual discrimination and name association of letters seen individually, but also enabled the Ss to transfer this learning to b-d and p-q discriminations in the context of nonsense syllables.

(4) The fading technique provided only slight aid to the Ss in the reading task. The author hypothesized that the lack of improvement by most Ss, in reading behavior, was due to repeated practice on incorrect responses to the stimulus words. Since the Ss in the present study had reached seven or eight years of age, were completing either the first or second

grade, and had had numerous experiences with confusing b-d and p-q in words, they may have formed strong habits highly resistant to change (Hively, 1962).

Implications of this study for future research suggest use of a baseline measure which would be taken over several days rather than on a single day as in the present study. As Lovitt (1967) suggests, this long-term methodological assessment would be more valuable than merely one evaluation of the behavior, because measurement over time allows for more accurate observations of the deficits and strengths. For a learning disabled child, whose reversal errors are often inconsistent from day to day, the long-term evaluation would allow for more accurate measurement of the reversal occurrence.

Further, an improved screening procedure for subject selection might include use of cut-off scores on the pretests, or increasing the range of difficulty of the six pre- and posttests to allow greater S variability on the test scores and to raise the ceiling so that no S would make a perfect score.

It would be interesting to use kindergarten-age children in a program designed to train them in the distinctive features of forms (geometric figures, standard transformations of nonsense forms, etc.), and gradually incorporate those distinctive features which Gibson et al. (1962), Dunn-Rankin (1968), etc. have attributed to alphabet letters (Guralnick, (1972). After the children have learned the distinctive features of the forms, then the letter-name association could be incorporated into the design. In the present study, it was hypothesized that the Ss had already directed their attention to irrelevant features of reversible letters for so long, it was difficult to change them. Kindergarten children, whose concepts are in the process of formation, would have had little practice in incorrect responses.

This study demonstrated that a programmed stimulus technique, fading, does lend itself to improvement in reversal errors of learning disabled children. The concept of learning in small increments with gradual change, as exemplified by the fading technique, is not a characteristic of the most commonly used educational methodologies. Fading appears to be one of the best available techniques for children who may have gaps in their perceptual abilities.

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APPENDIX A

Tests	Subject A	Subject B	Subject C	Subject D
WISC (scaled scores)				
Information	12	12	9	17
Comprehension	14	11	6	12
Arithmetic	9	10	9	11
Similarities	14	13	6	8
Vocabulary	16	11	13	14
Digit Span	12	13	8	10
Picture Completion	13	8	17	7
Picture Arrangement	13	13	11	11
Object Assembly	10	12	7	16
Block Design	10	9	17	14
Coding	13	9	7	6
Verbal IQ	119	110	91	113
Performance IQ	113	101	113	106
Full Scale IQ	117	107	101	110
Chronological Age (at time of testing)	6-7	7-3	7-6	7-7
Bender-Gestalt (developmental age)	6-0 to 6-6	* ◁5-0	5-6 to 6-0	* ▷7-7
Grade level (at time of testing	1.7	2.1	(Repeat) 1.0	(Repeat) 1.2
WRAT				
Reading Grade Level	1.5	1.9	1.4	1.5
Spelling " "	1.6	2.3	1.8	1.8
Arithmetic " "	2.1	1.9	2.1	2.1
Gray Oral Reading (grade level)	1.1	1.2	1.1	* ◁1.1
Iota Word Recognition (grade level)	1.8	1.2	* ◁1.0	2.0
Wepman Auditory Sound Discrimination Test	** 2 Y errors	*** 27 Y errors	8 Y errors	2 Y errors

* ◁ means "less than" and ▷ means "greater than".

** This test was an unstandardized auditory discrimination test using word pairs of 20, instead of the Wepman.

*** These scores probably invalid.

APPENDIX B

Pre- and Posttest I

Instructions to the S.

The S was instructed to look at the model stimulus card, and when it was removed, to choose a letter that matched the model from one of our presented simultaneously.

	Sample	Choice Stimuli
1.	b	b q p d
2.	p	d b q p
3.	b	d p b q
4.	d	q d p b
5.	q	p q d b
6.	d	q d b p
7.	p	b p q d
8.	q	p b d q

APPENDIX C

Pre- and Posttest II

Position of Stimuli	Instructions to the S
1. b - d	"Show me the d."
2. d - b	"Show me the d."
3. p - q	"Show me the p."
4. q - p	"Show me the q."
5. b - d	"Show me the b."
6. d - b	"Show me the b."
7. q - p	"Show me the p."
8. p - q	"Show me the q."

APPENDIX D

Pre- and Posttest III

Part A

Position of Stimuli	Instructions to the S
1. dem - bem	"Show me the one with b."
2. bic - dic	"Show me the one with d."
3. wod - wob	"Show me the one with b."
4. bal - dal	"Show me the one with b."
5. lud - lub	"Show me the one with d."
6. zab - zad	"Show me the one with d."

Part B

Position of Stimuli	Instructions to the S
1. dem - bem	"Show me the one that says bem."
2. bic - dic	"Show me the one that says dic."
3. wod - wob	"Show me the one that says wob."
4. bal - dal	"Show me the one that says bal."
5. lud - lub	"Show me the one that says lud."
6. zab - zad	"Show me the one that says zad."

APPENDIX E

Pre- and Posttest IV

Part A

Position of Stimuli	Instructions to the S
1. qax - pax	"Show me the one with p."
2. pim - qim	"Show me the one with q."
3. tuq - tup	"Show me the one with p."
4. pes - qes	"Show me the one with p."
5. vaq - vap	"Show me the one with q."
6. fip - fiq	"Show me the one with q."

Part B

Position of Stimuli	Instructions to the S
1. qax - pax	"Show me the one that says pax."
2. pim - qim	"Show me the one that says qim."
3. tuq - tup	"Show me the one that says tup."
4. pes - qes	"Show me the one that says pes."
5. vaq - vap	"Show me the one that says vaq."
6. fip - fiq	"Show me the one that says fiq."

APPENDIX F

Pre- and Posttest V

Instructions to the S.

"I would like you to do some reading for me."

Order of Stimuli Presentation.

1. bad
2. back
3. bus
4. dam
5. dim
6. rid
7. bib
8. sob
9. did
10. a sad man
11. on a dam
12. on the bus
13. in the cab

APPENDIX G

Pre- and Posttest VI

<u>Instructions</u> <u>to</u> <u>the</u> <u>S</u>.

"I would like you to do some reading for me."

<u>Order</u> <u>of</u> <u>Stimuli</u> <u>Presentation</u>.

1. quip
2. puck
3. pick
4. quit
5. quiz
6. pup
7. gap
8. quill
9. sop
10. grab it quick
11. on the map
12. in the pack
13. quit it

APPENDIX H

Instructions to the S for Discrimination Training

Instructions: Day 1

"I want to show you how to operate this machine. When I turn it on, you can see two letters. I'll make one letter bright now, and the other one dark. You see, the bright letter shows up clearly, but the dark one is hard to see."

"See the red buttons underneath each screen. When I ask you to show me the bright letter, push the red button underneath the bright letter. Do it now. Fine." (E changes position of the bright letter, which is always the b during the b-d discrimination, and the p during the p-q discrimination). "Now show me the bright letter again. Good."

"Now I am going to ask you to show me the bright letter a few more times, and when we're through, you'll hear a buzzer sound. Any questions? Ready? Show me the bright b (or p)."

Instructions: Day 2 - 9 (during each stage of the experiment)

"Show me the b (or p)."

APPENDIX I

Percentage of correct responding on Pre- and Posttests

SUBJECTS			Pre- and Posttests							
			I	II	III-A b-d	III-B b-d	IV-A p-q	IV-B p-q	V b-d	VI p-q
A	Stage 1 p-q	Pre.	100%	88%	100%	100%	100%	100%	75%	79%
		Post.	100%	100%	83%	83%	100%	100%	69%	100%
	Stage 2 b-d	Pre.	100%	100%	83%	67%	100%	100%	63%	81%
		Post.	88%	100%	100%	83%	100%	100%	69%	69%
B	Stage 1 b-d	Pre.	100%	38%	33%	17%	83%	83%	88%	88%
		Post.	100%	63%	88%	67%	100%	83%	100%	88%
	Stage 2 p-q	Pre.	100%	75%	100%	83%	83%	83%	56%	81%
		Post.	88%	100%	100%	83%	100%	100%	81%	81%
C	Stage 1 b-d	Pre.	75%	100%	50%	100%	100%	100%	75%	100%
		Post.	100%	100%	100%	100%	100%	100%	75%	100%
	Stage 2 p-q	Pre.	100%	100%	83%	100%	100%	100%	100%	100%
		Post.	100%	100%	100%	100%	100%	100%	75%	100%
D	Stage 1 p-q	Pre.	88%	75%	67%	100%	0%	0%	63%	100%
		Post.	100%	88%	100%	75%	100%	100%	75%	100%
	Stage 2 b-d	Pre.	88%	25%	17%	67%	0%	0%	69%	100%
		Post.	88%	83%	100%	83%	83%	0%	69%	100%

Fig. 1. Front view of the apparatus showing the viewing screens, with the b illuminated to a brighter intensity than the d; the selector buttons; and the hood projecting over the viewing screens.

Fig. 2. Rear and side view of the apparatus, showing the dimmer switches, shutter control, and lights on the rear, with the slide projecting from the side of the apparatus.

VITA

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