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ERRORLESS DISCRIMINATION LEARNING WITH NEUROLOGICALLY IMPAIRED CHILDREN

by

© ROY FERGUSON

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

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FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Errorless Discrimination Learning with Neurologically Impaired Children," submitted by Roy Ferguson in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

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ABSTRACT

The present study compared two methods for teaching neurologically impaired children to discriminate between two abstract figures which differed only in spatial orientation. Eighty-five subjects were randomly assigned to errorless and traditional training groups and performance differences were examined considering the factors of chronological age and symptomatology of the child.

A significantly greater number of subjects were able to learn the discrimination by errorless training than traditional training across three age levels. The errorless-trained subjects also learned the discrimination more quickly.

When the sample was grouped according to neurological category it was demonstrated that significantly more neurologically impaired children demonstrating either "hard" or "soft" symptomatology could learn the discrimination with errorless training than traditional training. Again, the errorless group also learned the discrimination faster.

The results indicate the effectiveness of errorless training with neurologically impaired children regardless of the chronological age of the child or symptomatology. The application of errorless training techniques to educational problems presented by neurologically impaired children is discussed with particular reference to reading reversal difficulties.

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I'd like to begin by thanking the many people at the Glenrose School Hospital whose cooperation and interest greatly facilitated this piece of research. In particular, I'd like to thank the children at the hospital who were the subjects in the study. I learned many things from them; things not found in textbooks. They taught me, through their own example, what Goethe meant in saying "To live is to adapt." Appreciation is also expressed to Andy Lamothe who designed and constructed the apparatus required for this study.

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Finally, I'd like to thank my wife Faye for her tremendous and continual support.

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How easy Psychology has made it
for us to dismiss the perplexing
mystery with a label which assigns
it a place in the list of common
aberrations.

--Hammarskjold

Chapter 1

Introduction

At one time experimental psychology and clinical psychology were considered distinct areas. Rarely did the experimental psychologist use children as subjects and rarely did the clinical psychologist employ experimental methods. In recent years, however, considerable attention has been given to the integration of these two areas. Staats (1968) suggests that the schism which existed between experimentalists and clinicians may be dissolved through adopting a common basis in methodology, theory and areas of study. The present study represents an attempt to do a theoretical piece of research which has direct clinical implications.

From the beginning of life the child is faced with a series of situations where a choice or discrimination is required. At first these discriminations are quite simple such as whether the face peering over the edge of the crib is that of mother, father or stranger. Later the child makes the choice of a favourite toy and then is required to make increasingly fine discriminations in order to reject other substitutes being offered to him. As the child grows older he is confronted with progressively more complex situations which must be responded to differentially. At all instances in this development the consequences of these discriminations are shaping subsequent behavior in the child.

In order to make a discrimination the child has to be able to respond to differences between stimuli, attending to some attributes and ignoring others. A central feature of the discrimination process, then, is the perception of stimulus differences.

Perceptual deficiency is a major factor in a child's poor performance on discrimination tasks (Fellows, 1968). Perceptual deficits, particularly in the visual modality, are commonly found in neurologically impaired children (Cruikshank, 1965) so that accurate visual discriminations are often difficult for these children.

House and Zeaman (1960.a) suggested that more attention be paid to the perceptual aspects of discrimination learning. It was proposed (Zeaman and House, 1963) that in acquiring a discrimination a subject has to learn two things. First, he has to learn to attend to the relevant stimulus dimensions; and second, he has to learn to attend to the positive cue on that dimension.

The attention deficiency theory of Zeaman and House (1963) was developed in working with retarded children. In the present research this theory will be examined in reference to discrimination learning with neurologically impaired children. An attention controlling technique, cue-fading or errorless training, will be employed to see if discrimination learning in neurologically impaired children is facilitated.

The results of this study will suggest the appropriateness of the House-Zeaman attention model to a population different from the one that the theory was developed on. The results will also indicate the utility of the technique being examined for approaching some of the specific educational problems presented by neurologically impaired children.

Chapter 2

Review of Literature

Discrimination Learning

Discrimination learning has traditionally been conceptualized as an interaction of acquisition and extinction through differential reinforcement. Thus, an organism learns to respond differentially to two stimuli, S+ and S-, when positively reinforced for responding to S+ and not reinforced for responding to S-. The discrimination is said to have been learned when the organism consistently responds to S+ and avoids responding to S-. However, during the acquisition of the discrimination responses to both S+ and S- occur, but S-responses (errors) eventually extinguish because they are not reinforced. Since responding to S- typically occurs, the generally accepted view has been that such responding is an integral part of discrimination learning (Terrace, 1963).

Keller and Schoenfield (1950) stressed the importance of errors and their immediate non-reinforcement in order to develop a response probability difference to the two stimuli that are to be discriminated. Their insistence upon the occurrence of errors was carried to the point of providing comparatively long and frequent periods of S- presentations thus ensuring the fullest utilization of the effects of non-reinforcement. This insistence upon the occurrence of errors was developed further in Harlow's proposal of _error factors_

(1959).

Kimble (1961) listed the four error factors which were considered by Harlow to be an integral part of all discrimination learning.

1. Stimulus perseveration. This class of errors reflects innate or previously learned tendencies to respond to the S- in a typical discrimination learning task.

2. Differential cue. There are extraneous cues which accompany the S- and which are present when the response to the S+ is reinforced. These cues also acquire evocative powers for the response in question. Thus, as trials progress, the organism must learn to suppress his response to these cues while maintaining his response to the S+. This appears to be the problem of learning what are the relevant cues in the discrimination task.

3. Response shift. This concept is offered as an explanation for the often observed fact that perfect performance is seldom ever achieved. That is, after a discrimination has been acquired to some criterion level an occasional error or series of errors may occur.

4. Position preferences. This source of errors would involve left/right position preference. Kimble's review of the evidence (1961, p. 390) leads him to classify this type of error as a relatively unimportant source in the discrimination learning of primates. Quite persistent position preferences, however, have been experienced by those who have worked with children in learning experiments (Jeffrey and Cohen, 1965;

White, 1964).

Harlow suggested that in discrimination learning the most important process is not acquisition, but, rather, the suppression of errors through extinction with the eventual emergence of appropriate stimulus control.

Errorless Discrimination Learning

Recent developments with errorless discrimination procedures question the emphasis placed on the function of S- responses in discrimination learning. Procedures related to errorless learning have been noted in the literature for some time. For example, some studies have shown that initial responding to S- can be minimal when the physical difference between S+ and S- is large (Frick, 1948; Raben, 1949; Spiker, 1956). Similar results are obtained when S- is introduced at some extreme value and gradually changed to the desired value.

William James (1890) found that he could obtain similar two-point limens if training began with a widely separated pair of points and the distance between them was gradually reduced. Pavlov (1927) obtained faster discrimination learning when he started conditioning with widely different stimuli and progressively reduced the difference between them as opposed to starting the conditioning with the final pair of similar stimuli and maintaining a constant difference. Schlosberg and Solomon (1943) and Lawrence (1952) found that rats could learn to discriminate two similar shades of grey without errors or with fewer errors if the task was begun with black and white stimuli with a progressive change to the final pair. Skinner (1938) obtained errorless performance by initiating the discrimination training immediately after the response had been conditioned in the presence of the S+. The critical variables in these earlier experiments seemed to be the time and manner of the introduction of S-.

Terrace (1963a) clarified the determinants of errorless performance in the discrimination learning of pigeons. The response used was key pecking and the stimuli to be discriminated were the colors red and green. Four procedures were tested:

1. Early-progressive S- discrimination training; the S- was introduced approximately 30 seconds after the key peck had been conditioned in the presence of the S+ and the S- was progressively changed from a barely illuminated green of 5 seconds duration to a fully illuminated green of 3 minutes duration.

2. Early-constant S- discrimination training; as above, discrimination training began approximately 30 seconds after the key peck had been conditioned in the presence of the S+ but the S- duration and brightness was at its final, maximum value of 3 minutes, full illumination.

3. Late-progressive S- discrimination training; The S- was introduced and progressively changed from a barely illuminated green of 5 seconds duration to a fully illuminated green of 3 minutes duration after 21 sessions of key peck conditioning in the presence of the S+.

4. <u>Late-constant S- discrimination training</u>: the S- was introduced at full duration and brightness after 21 sessions of key peck conditioning in the presence of the S+.

On the basis of his results, Terrace concluded that errors do not occur if (1) discrimination training is started immediately after the acquisition of the conditional response and (2) the S- initially differs in duration and brightness with color being the only final difference between them.

Terrace also observed post-criterion error bursts in these animals which had not been trained under the early-progressive procedure. Following discrimination learning without errors, disruptions of performance were never observed. The relatively poor performance of birds who learned with many errors may be partially attributed to early intermittent reinforcement resulting from responding to S-. This may have had the effect of retarding the subsequent extinction of responding to S-.

Other differences in performance were noted following discrimination learning with and without errors.

Differences in Performance Following Errorless and Traditional Training

It was observed that following discrimination learning with errors, S- evokes various emotional responses such as wing flapping and turning away from the key. The patterns of emotional responses that were observed in the presence of S- following discrimination learning with errors appear to be similar to those reported by Azrin and his colleagues

(Azrin, Hutchinson and McLaughlin, 1965) at the start of extinction. Of special interest was Azrin's observation that the removal of a positive reinforcer resulted in aggressive behavior that was strikingly similar to behavior that resulted from the presentation of an aversive stimulus.

The occurrence of emotional responses in the presence of S- by those birds which had experienced errors suggests that S- functions differently following discrimination learning with and without errors. This difference seems to be supported when one examines the rate or latency of responding to S+, the accuracy of long-term discrimination performance, the effect of drugs on responding to S-, and the location of the peak of a post-discrimination generalization gradient.

One of the consequences of training a discrimination is an increase in the rate (Reynolds, 1961) or a decrease in the latency (Jenkins, 1961) of responding to S+. Reynolds called these changes behavioral contrast because in each case the rate and latency of responding to S+ contrasted with the rate and latency of responding to S- during the formation of a discrimination. The discriminations that were studied by Reynolds and Jenkins were acquired with many errors. If a similar discrimination was trained without errors, no contrast is obtained (Terrace, 1963a, 1963b, 1966). Terrace (1968) suggested that this indicates that in traditional discrimination S- acquires aversive properties and behavioral contrast is a byproduct of frustration or similar emotional responses. Subsequent research (Rilling et. al, 1969) supported this view.

Hanson (1961) and Peirrel and Sherman (1962) demonstrated that the peak of a generalization gradient obtained after traditional discrimination training was displaced away from the S+ in a direction that was also away from the S-.

Terrace (1964a) demonstrated that a peak shift was obtained only if the discrimination was learned with errors. Since the peak of a post-discrimination gradient was displaced away from S- only if the discrimination was learned with errors the suggestion was that S- functions differently in a discrimination without errors. If no (or few) responses to S- occur during discrimination training S- may function as a neutral stimulus while if S- responses are extinguished during discrimination training, S- may function as an aversive stimulus.

Consequently, Terrace (1966) proposed that S- becomes an aversive stimulus as a result of discrimination training involving many non-reinforced responses to S-, and that the peak shift is a symptom of this aversive or inhibitory control. Weisman and Palmer (1969) supported the position of Terrace that behavioral contrast and peak shift are correlates of inhibitory control of S-.

The hypothesis that S- may acquire aversive properties when a discrimination is learned with errors was also investigated in two additional studies by Terrace (1963c, 1964). It has generally been observed that certain drugs will disrupt discrimination performance by inducing responding to

S- (Dews, 1955; Dews and Skinner, 1956). In the first study the effects of chlorpromazine and imipramine on discrimination performance after acquisition by errorless and trial-and-error (traditional) procedures was assessed. Both of these drugs are known for their anxiety reducing effects.

Terrace found that the injection of chlorpromazine or imipramine, at varying dosage levels, greatly impaired the discrimination performance (increased the number of responses to S-) of birds trained by the traditional method. Birds which had acquired the discrimination through errorless training were unaffected by both drugs and continued to perform errorlessly. Terrace took this to indicate that in the case of a discrimination learned with errors, chlorpromazine and imipramine presumably reduced the aversiveness of responding to S-.

Shifting Stimulus Control

While it is sometimes necessary to establish a new or basic discrimination, this is not always the case. Often behavior is already under stimulus control; the problem is how to bring the behavior under the control of other stimuli. One more of Terrace's experiments should be examined to see how he approached the problem of shifting stimulus control.

Terrace (1963b) studied three ways of shifting stimulus control from one S+ to a second S+. Pigeons had been trained by errorless discrimination techniques to respond when the red light (S+) appeared. The pigeons were then shifted to a discrimination situation in which a vertical line was the S+ and a horizontal line was the S-. Three procedures for implementing the discrimination shift were employed. The first technique involved an abrupt shift from the red-green discrimination to the vertical-horizontal discrimination. The second technique involved superimposing the vertical line on the red key and the horizontal line on the green key for five 60-trial sessions and then presenting the horizontal and vertical lines above. This procedure was superior to the abrupt shift procedure. The third procedure, superimposition and fading, involved superimposing the vertical line on the red key and the horizontal line on the green key for five sessions and then in the following sessions the red and green lights were progressively diminished until only the vertical and horizontal lines remained. This procedure resulted in a shift in discrimination without errors.

After criterion for learning was reached a re-test of discrimination performance for red-green was made. Though all the birds had originally learned this discrimination without errors the intervening experience with line orientations had a differential effect upon the re-test. The birds which had learned the vertical-horizontal discrimination without errors continued to perform errorlessly on the red-green task when re-tested. The birds which made errors in the acquisition of the vertical-horizontal discrimination now made errors when re-tested on the red-green task.

Terrace (1963b) concluded that once errors occur during the formation of a discrimination subsequent performance on that and also on related discriminations is permanently affected. He pointed out the relevance of this for teaching machines in that it provides evidence for the importance of learning a program with the fewest possible errors. Writers such as Holland (1960), Skinner (1961), Sidman and Stoddard (1967) supported this point of view arguing that a technology that generates errors is likely to be less effective for teaching than a shaping technology that reduces training errors. Holland (1965) refuted the position that errors are valuable and even necessary in the process of learning.

The Role of the S- in Discrimination Learning in Children

In the usual discrimination task for children the child must learn what stimulus to respond to and what stimulus to avoid or not to respond to. Whether each component of this dual process is of equal importance in determining the acquisition of a discrimination has been examined using retarded children as subjects.

House, Orlando, and Zeaman (1957) made an assessment of the role of the S- in a discrimination task with retarded children. Three training procedures were employed. The first used an S+ and S- which were unchanging over trials. The second used an unchanging S+ while the S- was any one of five different stimuli varied from trial to trial. The third procedure employed a varying S+ while S- was kept constant. The results showed that procedure three greatly hindered learning as compared to procedures one and two. This emphasized the importance of the role of the S+. There were no differences, however, between procedures one and two. This de-emphasized the importance of the role of the S-. The authors concluded that the avoidance of the negative cue was not a part of the discrimination process with retarded children.

In a later study (Zeaman and House, 1962), the role of the S- was questioned again. They demonstrated, with retardates, that during the initial acquisition of a discrimination the requirement of an avoidance response to the negative cue was responsible for a disruption of the learning rate. Supportive opinion was offered by O'Connor and Hermelin (1961) when they concluded that avoidance tendencies to negative cues may be altogether absent in some subnormal children.

If the role of the S- in discrimination learning can be questioned, as above studies suggest, then the use of errorless training procedures may be quite beneficial. Another reason for the use of errorless training is that it provides for the development of observing responses, or attention, early in the discrimination task. The rationale for this suggestion is found in the following studies.

House and Zeaman (1960a) related individual differences in the acquisition of visual discriminations, with retarded children to factors of attention rather than to differences in learning ability. House and Zeaman (1960b) again stressed the importance of an attention variable.

This latter study investigated two different training sequences of easy-to-hard discrimination trials and compared these for efficiency with a training sequence of hard discrimination trials only. The results showed that both of the easy-to-hard sequences were superior to the hard-only discrimination trials. The authors concluded that procedures which affect the probability of observing responses (RO) also affect the ease with which a visual discrimination is learned. Thus, the easy-to-hard sequence provided for a relatively high probability of RO. The occurrence of RO increased the probability of reinforcement, and reinforcement, in turn, increased the probability of RO. There is a circular relationship involved here. The opportunity for the development of RO and the circular relationship which accompanies it, may be provided in an errorless training procedure. That is, the initial use of supplemental cues in errorless training, like the initial use of an easy task in the House and Zeaman study, may provide for the initial reinforcement of RO.

O'Connor and Hermelin (1963) with a method somewhat analogous to Terrace's superimposition treatment only, demonstrated that the control over a verbal response could be shifted rather rapidly from a picture to a word when the subjects were ten moderately retarded children.

Sidman and Stoddard (1967) used fading techniques to transfer stimulus control in a multiple choice discrimination task so that severely retarded children learned to make rather fine discriminations between a circle and an ellipse. In another study (Stoddard and Sidman, 1967) they demonstrated that when a child proceeds from an easy discrimination through a series of intermediate steps to a difficult discrimination he has the opportunity to learn the behavior that is prerequisite for the finer discriminations.

Touchette (1968) found that position-based responses were the most probable type of error pattern with mentally retarded children. He used a complex stimulus which was gradually reduced until the remaining stimulus retained only the dimension of position as the response cue. Using this program of graduated stimulus changes he was able to teach this discrimination to severely retarded boys with few or no errors. Further, boys who had previously been unable to learn the task with a trial-and-error method were taught the discrimination with the graduated program. After a period of 35 days the subjects in the program group showed significantly better retention than the subjects in the trial-and-error group.

Touchette (1968) suggested that:

> Further, some retardates who give the appearance of being untrainable, may in fact be the victims of training techniques which generate perseverative error patterns. For them, a programmed graduated stimulus training procedure may provide the only means for discovering their true potential (p. 48).

The previous studies suggest the relevancy of errorless discrimination training with retarded children. Now let us look at some of the work being done in errorless training with normals.

Moore and Goldiamond (1964) studied the acquisition of a visual discrimination in preschool children. The stimuli were identical triangles differing in angle of vertical rotation. A successive match-to-sample techinque was employed. On any given trial the child was required to select one of three triangles as being identical in angular rotation to the sample triangle. Errorless training consisted of progressively making the incorrect triangles more similar in brightness to the sample. The correct triangle was always presented at the same level of illumination as the sample. With conventional training all four triangles were of identical brightness. A discrimination on the basis of angular rotation could be learned <u>only</u> when the errorless training was employed.

Gollin and Savoy (1968) administered a discrimination reversal task followed by a conditional discrimination problem to children from nursery and elementary schools. The task was to respond to one of two figures (triangle and circle) presented simultaneously on a common background. When criterion was reached on the original discrimination training, the same pair of cues was then presented on a different common background and the S+ and S- values of the cues were reversed. After criterion was reached on the second task, the test of conditioned discrimination was administered. Here the cue-background combinations were presented in a random order and the task was to respond to the cue-background combinations which were reinforced during original and reversal discrimination.

Original and reversal discrimination were given to some children using fading techniques and to other children as a traditional discrimination problem. The test of conditional discrimination for both training groups was identical.

The results indicated that subjects trained by the fading procedure were more likely to perform errorlessly during original and reversal discrimination, while subjects trained by the traditional procedure were more likely to succeed during the transfer task of conditioned discrimination.

The results of the conditional discrimination test are interesting in that the fading procedure was so effective in confining the subject's attentional responses to specific attributes of the S+ that he was at a disadvantage when other stimulus properties (e.g. background) were introduced.

However, Zeaman and House (1963) point out that we cannot assume that in a discrimination task the subject samples relevant stimuli in every trial. Allowing for the possibility that the relevant cues are not attended to on every trial the subject may have to learn to attend to the relevant stimulus dimension.

Thus far, then, the efficacy of errorless training procedures have been examined with respect to learning in normal and retarded children. It is now possible to relate the specific merits of errorless training to those particular problems that neurologically impaired children present.

Chapter 3

Rationale and Hypotheses

The Problem

It is generally accepted that perceptual deficits, often predominantly characterized by defects in the visual modality, are common in neurologically impaired children (Abercrombie, 1964; Crawford, 1966; Cruikshank, 1965; Finneran, 1964; Reswick, 1964). Since much instruction depends upon visual presentation of materials it would seem that methods of compensating for visual input deficiences would be particularly helpful.

Attentional deficits have also been traditionally cited as one of the underlying causes of educational difficulties in neurologically impaired children (Birch, 1964; Fisher, 1970; Laufer and Denholf, 1957; Paine, 1962). The tendency has been to stress the distracting effects of peripheral or extraneous stimuli. Much educational practice has been built around the work of Strauss and Lehtinen (1960), Strauss and Kephart (1955) and Cruikshank et. al. (1961). The central tenet was that brain-injured children are distractible and, therefore, in their educational treatment considerable attention must be given to reducing the amount of stimulation which the child has to cope with in his environment.

Other studies, however, (Brown, 1964; Browning, 1967; Cruse, 1961; Rost, 1967) have suggested that reducing the amount of visual stimuli in the environment does not necessarily have a differential facilitating effect with brain injured persons as compared with non-brain injured persons. Similar results have been reported with respect to the assumed detrimental effects of extraneous auditory stimulation (Brown, 1966a, 1966b; Cromwell and Foshee, 1960; Spradlin, Cromwell and Foshee, 1959).

It might well be, then, that the distracting effects of irrelevant stimuli may not be so central to much of the neurologically impaired child's learning difficulty as is the inability to organize the relevant stimuli in a problem-solving situation.

This deficiency in forming observing responses has been observed by Zeaman and House (1963) in their work with moderately retarded children. They point out that the trouble with retardates' discrimination learning lies in their initial inattention to the stimulus dimensions of the problem. Retardates show low initial probability of observing certain relevant dimensions but when they learn what the relevant dimension is they show the same final rates of approach to criterion as normal children.

Similarly, perhaps many of the basic learning difficulties demonstrated by neurologically impaired children might be avoided by structuring their attention through emphasizing the relevant stimulus dimensions of the learning situation.

Figure-ground relationships are commonly cited as a rather specific type of perceptual disturbance noted in neurologically impaired children (Bortner, 1968; Cruikshank, 1965, 1966, Cruikshank, Bice & Wallen , 1957; Dolphin & Cruikshank, 1951; Werner & Strauss, 1941). Neurologically impaired children tend to respond to background detail instead of the main figure in a visual field. Again, rather than being distracted by background stimuli perhaps this performance indicates an inability of these children to organize relevant stimuli in a situation.

Other visual perceptual problems frequently demonstrated by neurologically impaired children are rotation of designs (Shapiro, 1953) and reversals (Anderson, 1963; Burks, 1960; Laufer and Denhoff, 1957; Laufer, Denhoff & Solomons, 1957). Lyle (1969) and Tarnopol (1970) point out the difficulty that poor readers, and particularly those with neurological difficulties, have in making discriminations such as between b and d, p and q, saw and was, 69 and 96, etc. Most children up to the age of about six demonstrate reversal difficulties of this sort but they usually diminish with increasing age (Davidson, 1935; Lyle, 1969). Vernon (1957) reports b-d and p-q reversals in 12 percent of normal children aged 7-8 years. One would expect the neurologically impaired child's reversal difficulties to be more numerous and to persist longer.

Purpose of the Present Study

Although there is a considerable range in the estimates of incidence of learning disabilities the most frequently quoted figure suggests that ten percent of the school age population demonstrates educational difficulties related to neurological impairment (Roberts & Lazure, 1970). There has been a recent concentration of effort on these children to try to discover how they learn and why they do not learn. This educational emphasis has placed the educator in the position of needing to learn more about learning (Bruner, 1966).

It has been shown that neurologically impaired children characteristically demonstrate attentional and visual perceptual difficulties which in turn relate to more general educational problems. Preceding sections have also shown the efficacy of errorless training procedures in facilitating learning in lower organisms, retarded children and normal children. The purpose of the present research is to compare errorless and traditional training methods on a discrimination task with neurologically impaired children. The discrimination task chosen is of particular relevance to neurologically impaired children in that the discriminative stimuli are two figures which differ only in spatial orientation. This means that the two, two-dimensional figures are identical in form but can be made different from one another either by rotating one of them about an axis at right angles to the frontal plane or by reversing it through the third dimension

(Fellows, 1968). The discrimination of differently orientated forms is a very difficult one. It is a discrimination skill which seems to lag behind the development of visual shape perception in general. Discrimination of orientation is a skill of particular importance in that it is absolutely necessary for adequate performance on tasks such as reading and writing. Vernon (1957), in making this point, wrote:

> On one characteristic of the child's perception there seems to be general agreement: that he does not observe, or only observes and remembers with difficulty, the orientation of shapes . . . . (p. 16).

With the visual perceptual difficulties commonly demonstrated by neurologically impaired children and with the errors being typically of a reversal type the orientation discrimination used in the present study will be particularly difficult, especially for the younger subjects.

For the purpose of this study neurological impairment is meant to include a continuum of brain damage ranging from instances of anatomical fact ("hard signs") to a behavioral concept ("soft signs"). Cerebral palsy would present the "hard signs" of neurological impairment in terms of identifiable central nervous system damage. Minimal brain dysfunction, on the other hand, would represent a "soft" of behavioral concept of neurological impairment. The term minimal brain dysfunction has been used interchangeably with in excess of 38 other expressions (Clements, 1966) (e.g. brain damage, hyperkinetic syndrome, cerebral dysfunction, brain injured, etc.) and consequently has come to be regarded as a "catch-all" sort of phrase of questionable utility

(Birch & Bortner, 1968; Friedman, 1969; Heck, 1969). <u>The National Project on Minimal Brain Dysfunction (Learning Disabilities) in Children</u> was a collaborative program set up to clarify this issue. Their definition read as follows:

> The term 'minimal brain dysfunction' refers to children of near-average, average, or above-average general intelligence with certain learning and/or behavioral disabilities ranging from mild to severe, which are associated with deviations of function of the central nervous system. These deviations may manifest themselves by various combinations of impairment in perception, conceptualization, language, memory, and control of attention, impulse or motor function (Clements, 1966).

The present study wishes to look at performance differences between the "hard" and "soft" definitions of neurological impairment in children. In comparing errorless and traditional methods on a discrimination task with neurologically impaired children categorized according to "hard" and "soft" symptomatology a final factor was included. The subjects were divided into three age groups, (group 1) 72 - 107 months, (group 2) 108-143 months and (group 3) 144-179 months to see if there was any relationship between discrimination task performance and chronological age.

The present study was designed to provide information relative to four general questions regarding discrimination learning and neurologically impaired children.

1. Is discrimination learning performance related to age?
2. Is discrimination learning performance related to diagnostic category?
3. Is there a relationship between training procedure and age?

4. Is there a relationship between training procedure and diagnostic category?

Hypotheses

1. Discrimination learning proficiency increases as the age of the subjects increases.

2. Subjects in the "soft" category of neurological impairment will be more proficient at the discrimination learning task than subjects in the "hard" category.

3. A greater number of errorless-trained subjects than traditional-trained subjects across three levels will learn the discrimination.

4. Errorless-trained subjects will learn the discrimination more quickly (fewer trials-to-criterion) than traditional-trained subjects across three age levels.

5. A greater number of errorless-trained subjects than traditional-trained subjects in both "hard" and "soft" categories of neurological impairment will learn the discrimination.

6. Errorless-trained subjects will learn the discrimination more quickly (fewer trials to criterion) than traditional-trained subjects across both "hard" and "soft" categories.

Chapter 4

Method

Subjects

Eighty-five students attending the Glenrose School Hospital in Edmonton, Alberta, were selected as subjects. These were obtained by doing a computer search of the hospital patient information system on the parameters of primary diagnosis and age. The patients at the Glenrose School Hospital are classified according to the Hospital Adaptation of the International Classification of Diseases (H-ICDA) and the individual diagnoses are formulated after an extensive assessment involving Paediatrics, Neurology, Psychiatry, Psychology, Speech Pathology and Audiology, Social Service, Physiotherapy, Occupational Therapy and Education. Children with serious visual or auditory defects and children who had insufficient motor control or strength were excluded from the sample.

The search identified the 85 subjects, 51 male and 34 female, out of a total data bank of 1293 patients who had been assessed at the hospital. Chronological ages of the selected students ranged from 72 to 179 months (mean = 115.36 months). All of the subjects were enrolled in the hospital school program at the time of testing and the durations of institutionalization ranged from 5 to 142 months (mean = 35.84 months). I.Q. scores ranged from

46 to 127 (mean = 85.16) as measured on the Wechsler Intelligence Scale for Children.[1] The I.Q. scores are not particularly useful in describing the sample because of the difficulty in obtaining an accurate intelligence estimate of physically handicapped children, particuarly where there is a considerable degree of motor and verbal impairment (Reynell, 1970).

Raven Coloured Progressive Matrices (Sets A, A_B, B) raw scores ranged from 7/36 to 35/36 (mean = 19.53). Although this test was designed primarily as a measure of general ability (Anastasi, 1961) performance on it also relates to perceptual accuracy (Burke, 1958; Raven, 1963). Furthermore, within the set of six response choices for each stimulus plate there usually was a rotated or reversed variation of the correct figure. The Raven, then, gave a convenient perceptual measure without requiring the subject to reproduce a drawing. The effect of differential motor ability was cancelled while a tendency to choose rotated or reversed response figures could be noted.

Table 1 shows the number of subjects in each of the primary diagnostic categories used to formulate the sample.

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[1]Five of the subjects in the sample had IQ scores obtained from testing on the Stanford-Binet but these were transformed to equivalent WISC scores using a table devised by Horrocks (1964).

Table 1

Number of Subjects in Each Primary Diagnostic Category Used in Sample

Primary Diagnosis	Number of Subjects
Cerebral Palsy	37
Convulsive Disorder	10
Meningomyelocele	8
Hyperactive Behaviour Syndrome	8
Motor and Mental Retardation	7
Minimal Brain Damage	5
Central Nervous System Disorder	4
Brain Syndrome	4
Spinal Cord and Peripheral Nerve Disorder	2
	N=85

The subjects within each of these diagnostic categories were randomly assigned to the errorless and traditional training groups. Table 2 compares the means and standard deviations of the subjects in the errorless and traditional training groups on the four variables used earlier to describe the whole sample.

Table 2

Means and Standard Deviations of Training, Neurological and Age Groups Compared on Four Variables

	Neurological Category				Age Group						Training Procedure			
	Hard		Soft		27-107 mo.		108-143 mo.		144-179 mo.		Errorless		Traditional	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1. Length of Hospitalization in Months	53.74	38.24	17.04	13.20	32.62	20.94	46.28	40.90	56.11	46.28	38.57	32.25	46.10	39.43
2. Chronological Age in Months	112.38	29.28	125.21	24.69	85.84	9.10	121.61	11.24	156.72	9.97	113.52	26.42	117.20	29.41
3. Raw Score on Raven Progressive Matrices	18.02	7.38	23.21	7.93	13.48	4.33	20.86	6.83	27.06	6.73	18.27	7.45	20.78	7.96
4. IQ	83.75	14.95	88.67	20.91	79.00	16.34	88.33	15.51	89.33	18.12	84.52	17.05	85.80	16.41

Apparatus

The child worked in a well-ventilated room 12 x 20 feet with no windows and a low level of ambient noise. The subject sat before a response-display panel which was 24 x 24 inches. Mounted on the front of the panel was a 6 x 8 inch translucent (polacoat) screen upon which stimuli could be projected from the rear (Fig. 1). The screen was split into halves which were hinged at the top and in contact with heavy-duty microswitches of their lower edge (Fig. 2). When the child pressed one of the screen halves he actuated the microswitch behind it and delivered an electric signal to the electronic programming circuitry and recording devices. Mounted directly above the screen was a small light which glowed bright red when a correct response was made by the subject. The rest of the panel was painted in a matte black finish.

The stimulus projection apparatus consisted of two modified Kodak Carousel 35 mm slide projectors (Model AV-900) mounted behind the response-display panel (Fig. 3). The two projectors were required to create a focus difference between the two stimuli (S+ and S-). One projector is used to present the S- and the other projector to present the S+. The S- projector was fitted with a notched focusing knob with a sprung metal strip against it which allowed a standard number and size of focus changes (Fig. 4). By keeping the S+ projector in focus it was possible to present a series of slides with the S- projector which progressed from extremely out-of-focus (Fig. 5) to in-focus (Fig. 6) over trials. Acker (1969) pointed out that with this system it is possible to adjust the number and size of the steps in such a progression without making more than one set of stimulus slides.

Previous research has not suggested that there was any critical number of steps in a cue-fading progression. However, 20 steps seemed to be chosen most frequently (Acker, 1966; Burfoot, 1969; Gollin and Savoy, 1968) so that was the number of steps included in the training progression in the present study.

Previous research also points out the importance of spatial S-R contiguity in the acquisition of a discrimination (Jeffrey and Cohen, 1964; Murphy and Miller, 1959). This is particularly so with younger children. The rear-projection screen used in the present research maximizes this effect by allowing the subject to respond by touching the actual stimulus (Fig. 7).

Located above each half of the screen on the inside of the panel was a photocell. A hole was punched in the lower portion of the frame of each slide in the S+ projector to indicate which half of the screen the S+ figure would be projected. The photocells were activated by a spot of light from the projector which came through the hole punched in the slide. The activated photocell then decoded the correct position of the S+ figure. Similar decoding apparatus have been described elsewhere (Hively, 1964; Holland, 1961; Sidman and Stoddard, 1969; Touchette, 1969).

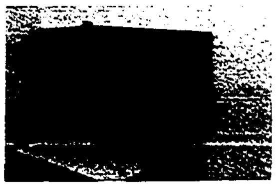

Figure 1

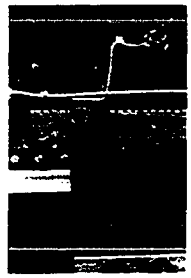

Figure 2

Figure 3

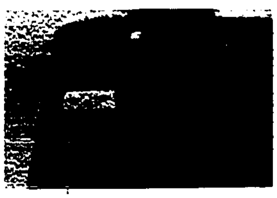

Figure 4

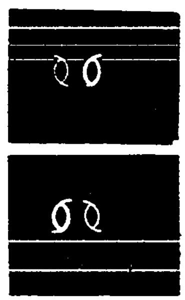

Figure 5

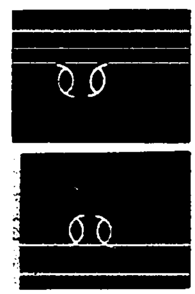

Figure 6

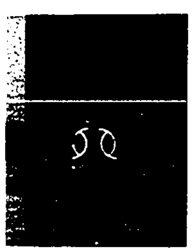

Figure 7

Figure 8

Figures 1 to 8: Photographs showing different aspects of the apparatus.

A correct response turned on a small red light mounted on the outside of the panel directly above the screen. The light and projected stimuli stayed on for 1.5 seconds after the response. Following a 2.0 second dark interval the next pair of stimuli appeared. S- responses were ineffective so that the red light did not come on and the projectors did not advance until a correct response was made.

A temporal account of the responses was maintained on a 20-channel Esterline Angus event recorder and running totals were recorded on a bank of Sodeco counters (Fig. 8). A simplified schematic diagram of the electronic circuitry appears in Appendix A.

Stimuli

There were 80 stimulus slides in each projector slide tray. Since the trays were circular an unlimited number of trials could be obtained without interruption. The actual stimulus on the slide was an abstract figure (Fig. 9) that Fellows (1968) describes in reporting research done on reversal tendencies indicated in primary school children. The research reported a widespread inability of the subjects to distinguish this figure from its mirror image. Gibson et al. (1962) in a similar study also noted reversal errors with these letter-like forms.

Abstract, letter-like figures which have the characteristic of remaining unchanged in spite of a 180° rotation were chosen rather than actual letters such as b and d or p and q which possess the same quality. This was done to

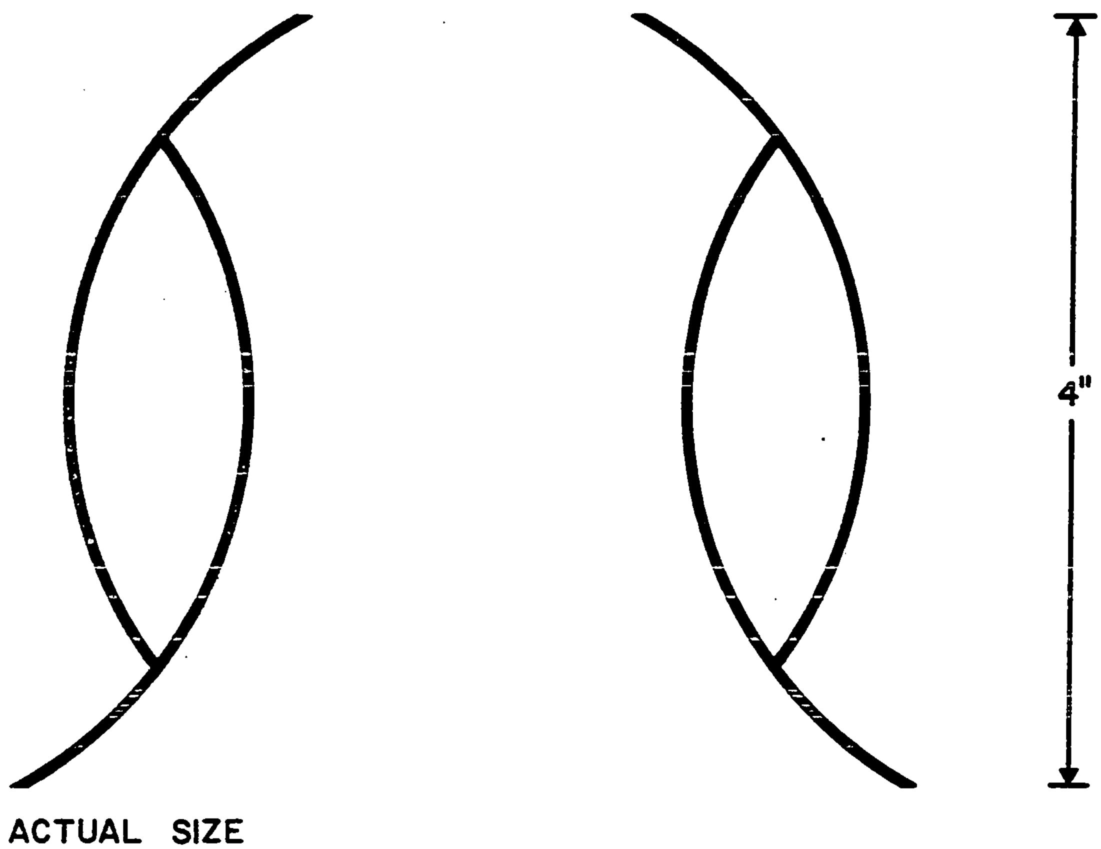

Figure 9: Diagram of stimuli used. The figure on the left was the S+ and the figure on the right was the S-. The stimuli appeared as white outlines on a black background.

eliminate any possible language mediational effect such as described by Kendler and Kendler (1959, 1961, 1962) which might differentially facilitate the learning task.

The figure was photographed on 35 mm film and then mounted on 2 x 2 inch glass mounts to prevent the slides from buckling due to projector heat and creating an uncontrolled change in focus.

The left-right position of the S+ was selected randomly with no more than three consecutive displays in the same position. This condition was decided upon because previous research (Touchette, 1968; White, 1964) has noted that position-based responses are the most probable type of error pattern in the responses of children in a discrimination task. The changing of the left-right positioning of the projected stimuli over trials was accomplished by photographing S- on one half of the slide film for one projector while S+ was photographed on the opposite half of the film for the other projector. By reversing the photographic composition the left-right positioning of the projected images of the stimuli was changed (Fig. 10).

Procedure

The 85 subjects were tested between 0900 and 1500 hours over a period of three weeks. Upon entering the testing room each child was first seated at a desk and given the Raven Colored Progressive Matrices (Sets A, A_B, B).

Following this the subject was shown a large box full of articles (toys, books, candy, games, etc.) with the

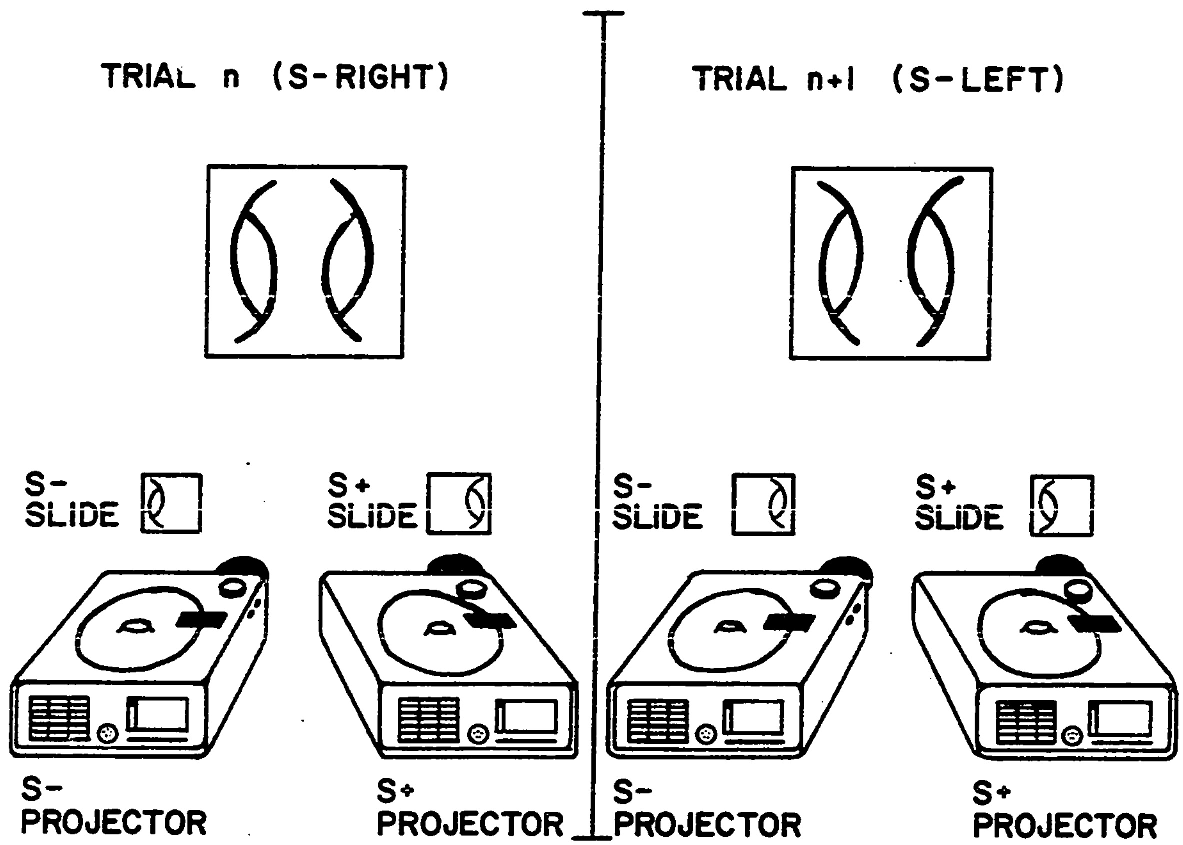

Figure 10: Diagram illustrating the left-right positioning of S+ and S-.

experimenter saying, "We are going to play a game. If you learn to play the game correctly you can pick something out of that box to keep after the game is finished."[2]

The subject was then seated in front of the response-display panel and the experimenter said, "In this game you are going to try to make that red light (experimenter points to light over screen) go on." The first set of stimuli was presented and the experimenter said, "Which picture do you think will make the red light go on?" When the child indicated one of the figures he was told to "push the window."

If the child chose the correct figure the red light came on, the stimuli went off and the projectors advanced to the next pair of stimuli. The experimenter said "Good" and urged the child to "try to make the light go on every time."

If the child chose the wrong figure the red light did not go on and the projectors presented the same stimuli again. The experimenter said, "The light didn't go on that time. Push the other window." After the first trial the experimenter made no further comments.

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[2]Previous research (Burfoot, 1969; Spence, 1970) suggested that intertrial reinforcement of correct responses using material reinforcers such as candy, coins, or tokens tends to be distracting in discrimination learning tasks. In the present study symbolic intertrial reinforcement (light signal) and a material reinforcer at the end of the session was used.

Training Procedures

Errorless. Two different training methods were used to teach the discrimination with the subjects being randomly assigned to either group. With the errorless training group the first 20 trials consisted of a programmed sequence in which the S- progressed gradually from extremely out-of-focus to in focus and the left-right position of S+ was varied randomly over the trials. In effect, the supplementary cue of focus differences was gradually faded over a series of 20 trials. The child began training by making a simple focus discrimination which then gradually transferred to a more difficult figure orientation discrimination. The stimulus shaping or fading procedure allowed the discrimination to progress in a sequence from easy to hard (House and Zeaman, 1960) and reduced the number of S- responses (errors) during training.

Traditional. With the traditional training group the stimulus figures for the training sequence (first 20 trials) were presented so that S+ and S- were both exactly in focus, differing only in orientation. With this training condition the subject was learning the discrimination by a process of trial and error. The left-right position of S+ varied randomly over trials.

Criterion discrimination. Following both the errorless and traditional training sequences a criterion discrimination series was presented to assess the effectiveness of one training procedure as compared to the other. In the criterion discrimination sequence the subject was required to identify the S+ where both figures were in focus and the left-right position was randomly varied over trials (similar to traditional training sequence). The session was terminated during the criterion discrimination sequence when a criterion of 10 consecutive correct responses or 100 trials, whichever occurred first, was satisfied.

Chapter 5

Results

The initial experimental question to be answered was whether discrimination learning performance is related to age and symptomatology in neurologically impaired children. The second experimental question was whether errorless training is more effective than traditional training in neurologically impaired children when the sample was grouped by age and then by symptomatology.

The relationships between the dependent variable (discrimination learning performance) and the independent variables (training method, age, and neurological category) in the present study were examined using a multiple-classification analysis of variance. A two-way analysis of variance was used to test the means of the factors of training procedure and age of subject (2 x 3 factorial design). Another two-way analysis of variance was used to test the relationship between the factors of training procedure and neurological category (2 x 2 factorial design). All factors were assumed to be fixed (Winer, 1962).

A three-way analysis of variance (2 x 2 x 3 factorial design) would have been chosen to evaluate the data were it not for the fact that some of the cell frequencies were too small to use this model.

The organization of the following section will be designed to consider each of the hypotheses in a sequential order. Discrimination learning performance will be examined in relation to age and then symptomatology of the subjects. Errorless and traditional training procedures will then be compared in relation to age and symptomatology of the neurologically impaired children used in the study.

Discrimination Learning Performance

Hypothesis 1 was concerned with the relationship between discrimination learning performance and age of the subjects. The data in Table 3 indicate that the three age groups differed in the ease with which the discrimination task was acquired. The mean scores for the three age groups shown in Table 1 represent the number of trials to criterion. For both training procedures Age Group 3 learned most easily, followed by Group 2, with Group 1 experiencing the most difficulty. The means were tested by a two-way analysis of variance to see if the differences were significant. The analysis demonstrated the presence of main effects ($p < .001$) due to the factor of Age Group membership (see Table 4).

Scheffe's multiple comparison of main effects (Scheffe, 1960) was used to compare the main effects of the three Age Group levels (see Table 5). A significant difference between Groups 1 and 2 ($p < .001$) and Groups 1 and 3 ($p < .001$) were shown but the difference between Groups 2 and 3 was not significant.

The relationship forwarded in Hypothesis 1 was partially supported in that discrimination learning performance in neurologically impaired children did improve

Table 3

Mean Trials to Criterion for Two Training Procedures by Three Age Groups

	Training Procedure (Factor B)		
	Errorless	Traditional	Row means
Age 1 (72-107 months)	74.35	93.57	83.96
Group 2 (108-143 months)	36.00	64.38	50.19
(Factor A) 3 (144-179 months)	20.57	55.09	37.83
Column means	43.64	71.01	

Table 4

Summary of Analysis of Variance for Two Training Procedures by Three Age Groups

Source	df	ms	F
Age Groups (A)	2	14732.90	12.97*
Training Procedure (B)	1	14149.60	12.46*
A x B	2	356.03	.31
Error	79	1135.49	

*p < .001

Table 5

Summary of Scheffe's Multiple Comparisons of Main Effects for Data of Table 2

Age Groups Compared	F
1 - 2	8.28*
1 - 3	10.30*
2 - 3	.78

* $p < .001$

significantly from the first age group (72 - 107 months) to the second (108 - 143 months). There was improvement in the third age group (144 - 179 months) compared to the second but the difference was not significant.

Hypothesis 2 addressed itself to the relationship between discrimination learning performance and diagnostic category of the subjects. The mean number of trials to criterion contained in Table 6 indicate that for both training methods the neurologically impaired children demonstrating "soft" symptoms learned the discrimination with fewer trials to criterion than did the children showing "hard" symptoms. The means were tested by a two-way analysis of variance (see Table 7) which showed that the differences were not significant and there was no interaction effect.

The results demonstrate that, while there is a tendancy in the direction stated by Hypothesis 2, subjects in the "soft" category of neurological impairment were not

Table 6

Mean Trials to Criterion for Two Training Procedures by Two Categories of Neurological Impairment

		Training Procedure (Factor B)		
		Errorless	Traditional	Row means
Neurological Category (Factor A)	Hard	54.48	74.50	64.49
	Soft	33.77	64.63	49.20
Column means		44.13	69.57	

Table 7

Summary of Analysis of Variance for Two Training Procedures by Two Neurological Categories

Source	df	ms	F
Neurological Categories (A)	1	4006.00	2.81
Training Procedure (B)	1	11091.80	7.78*
A x B	1	504.38	.35
Error	81	1426.25	

*p <.01

significantly more proficient at the discrimination learning task than subjects in the "hard" category.

Errorless and Traditional Training Compared by Age Groups

Hypothesis 3 was concerned with the number of subjects, at all age levels, who acquired the discrimination with errorless training compared to the number of subjects who acquired it with traditional training. Table 8 shows the percentage of subjects in each of the three age groups who learned the discrimination with errorless and traditional training respectfully. The percentages are illustrated graphically in Fig. 11.

Table 8

Percentage of Subjects in Three Age Groups Acquiring the Discrimination with Errorless and Traditional Training

		Training Procedure	
		Errorless	Traditional
	1	49	7
Age	2	85	44
Groups	3	100	55

A chi-square test of significance was applied to the proportion of subjects in each age group who acquired the discrimination by either training method. A chi-square value of 48.5 ($p < .001$) indicated that a significant difference between the two training procedures did exist. The hypothesis that observed difference in ease of acquisition across three age

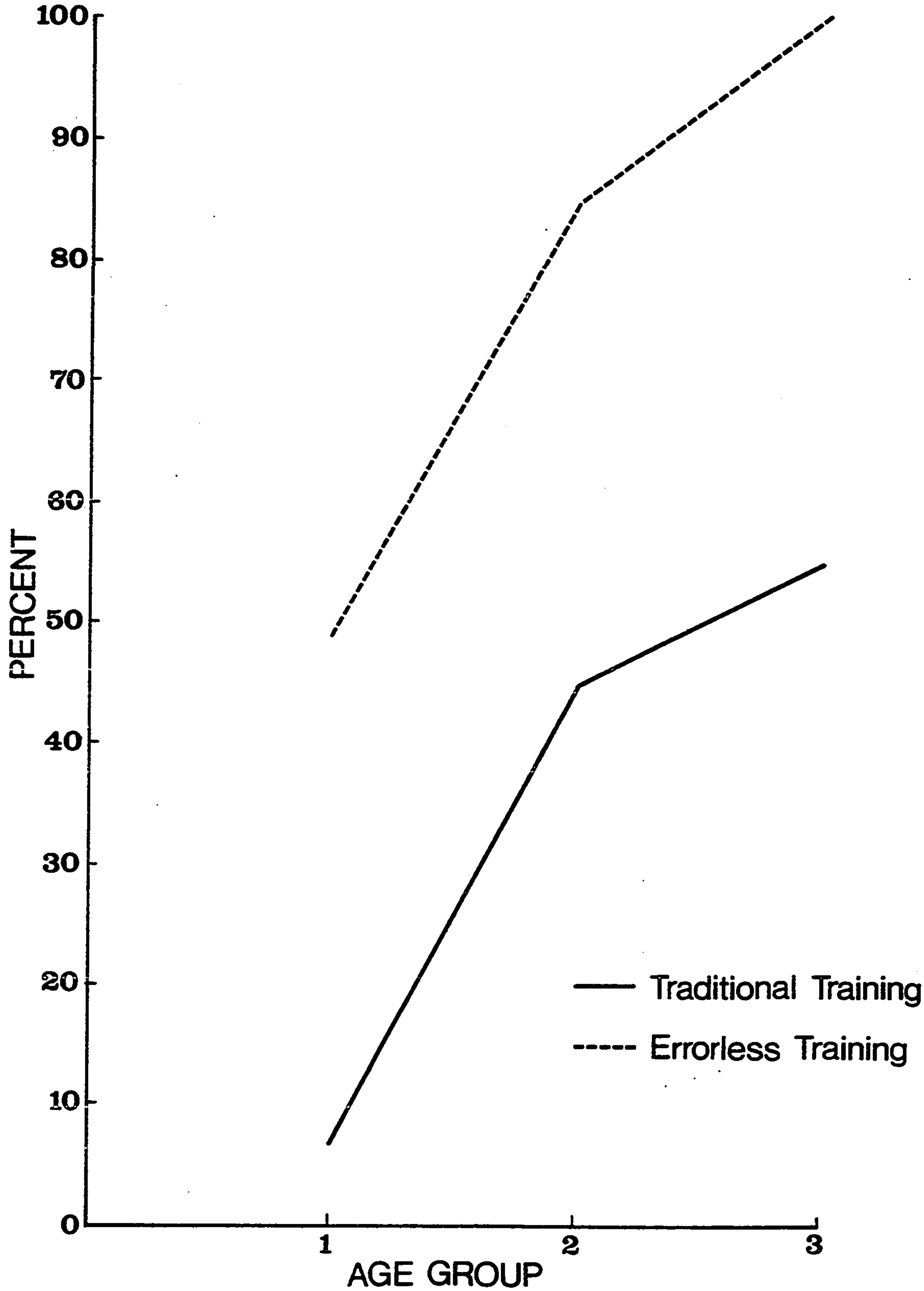

Figure 11: Percentage of subjects in three age groups acquiring the discrimination with errorless and traditional training.

groups of neurologically impaired children were due to different training procedures was supported.

Hypothesis 4 stated that errorless-trained subjects will learn the discrimination more quickly than traditional-trained subjects across three age levels. The mean scores for the two training procedures across the three age groups are contained in Table 3. An examination of the mean trials to criterion show the errorless-trained subjects to have learned the discrimination more quickly (Fig. 12). The mean differences were tested for significance by a two-way analysis of variance. The presence of main effects ($p < .001$) due to the factor of Training Procedure were demonstrated in the analysis (see Table 4). Errorless-trained subjects learned the discrimination more quickly than did traditional-trained subjects.

It is evident from the results of Hypothesis 3 and 4 that across three age levels of neurologically impaired children errorless-training was more effective than traditional-training. The data for Hypothesis 3 indicated that across three age levels more errorless-trained subjects learned the discrimination than traditional-trained subjects while the data from Hypothesis 4 showed that errorless-trained subjects learned the discrimination more quickly than traditional-trained subjects.

Errorless and Traditional Training Compared by Neurological Category

Hypothesis 5 was concerned with the relationship

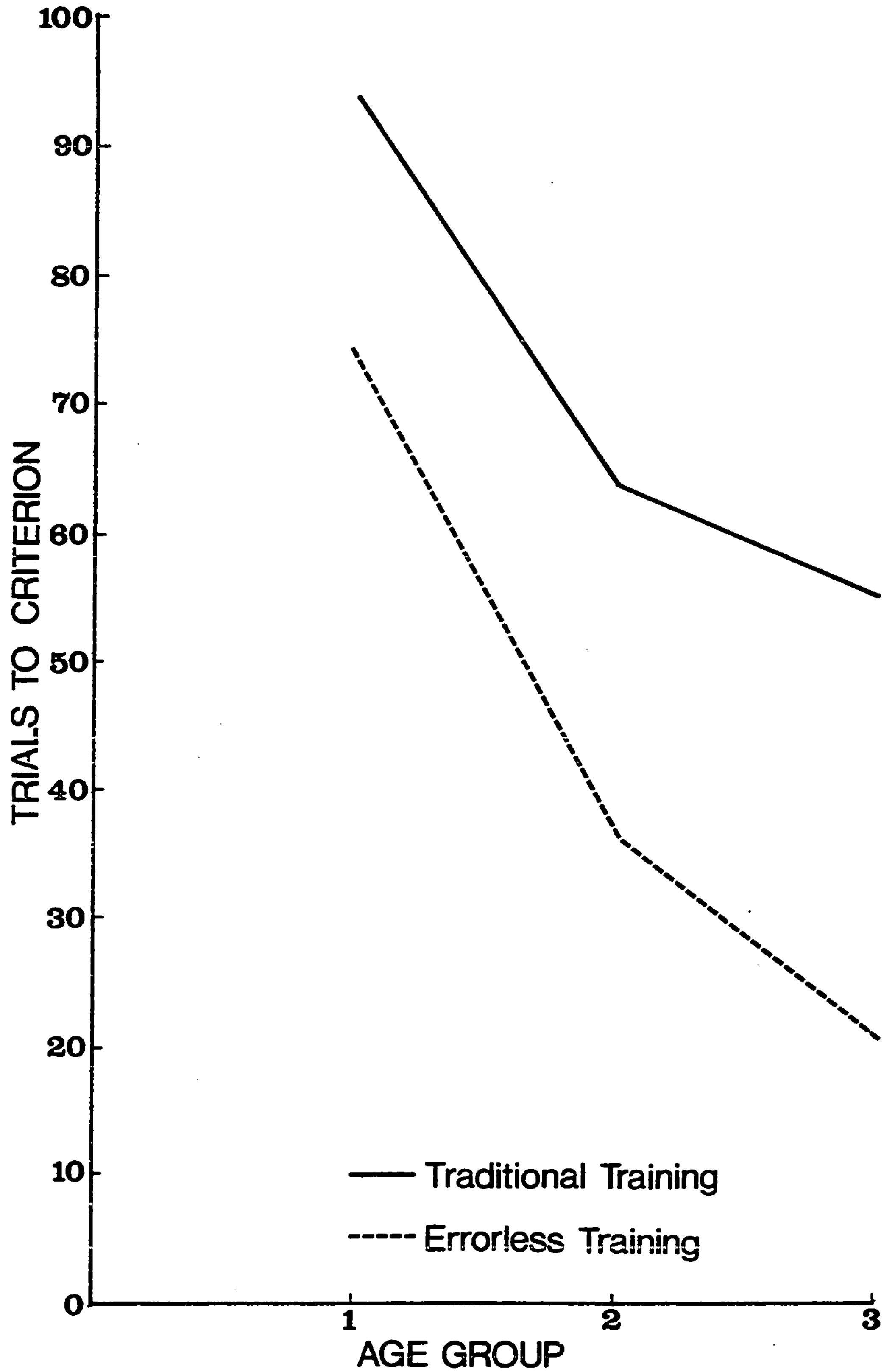

Figure 12: Mean trials to criterion for two training procedures by three age groups.

between the number of subjects in two neurological categories who acquired the discrimination with errorless compared to traditional training. The percentage of subjects in both neurological categories who learned the discrimination with either training procedure are shown in Table 9. More errorless-trained subjects learned the discrimination than traditional-trained subjects in both neurological categories (Fig. 13). A chi-square test of significance, using Yate's correction for continuity, yielded a value of 14.8 ($p < .001$) indicating a significant difference between the proportion of subjects in both neurological categories who learned the discrimination with errorless training as compared to traditional training. Hypothesis 5 was supported. Observed differences in ease of acquisition across two diagnostic categories of neurologically impaired children were due to different training procedures.

Table 9

Percentage of Subjects in Two Neurological Categories Acquiring the Discrimination with Errorless and Traditional Training

		Training Procedure	
		Errorless	Traditional
Neurological	Hard	68	30
Category	Soft	85	45

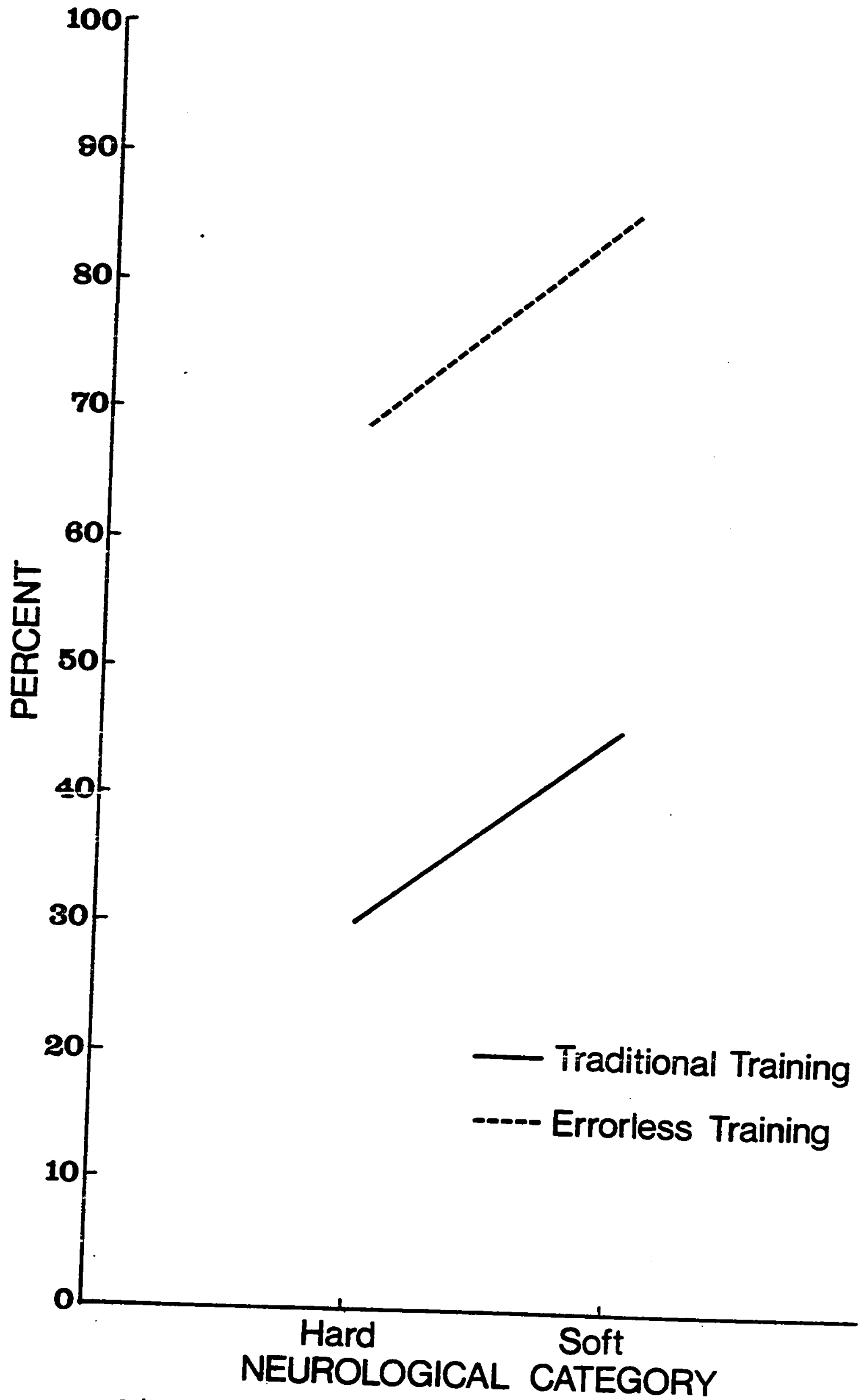

Figure 13: Percentage of subjects in two neurological categories acquiring the discrimination with errorless and traditional training.

Hypothesis 6 related to the quickness with which the discrimination was learned with either training procedure across two neurological categories. The mean trials to criterion are contained in Table 6. The mean scores, shown graphically in Fig. 14, suggest that the errorless-trained subjects learned the discrimination more quickly. A two-way analysis of variance demonstrated the presence of main effects ($p < .01$) due to the factor of Training Procedure (see Table 7). There were no interaction effects. Errorless-trained subjects learned the discrimination more quickly than traditional-trained subjects.

The data for Hypothesis 5 and Hypothesis 6 indicated that across two neurological categories more errorless-trained subjects learned the discrimination than traditional-trained subjects and the errorless-trained subjects learned the discrimination more quickly. For neurologically impaired children grouped according to "hard" or "soft" symptomatology the efficacy of errorless training has been demonstrated in the acquisition of a discrimination.

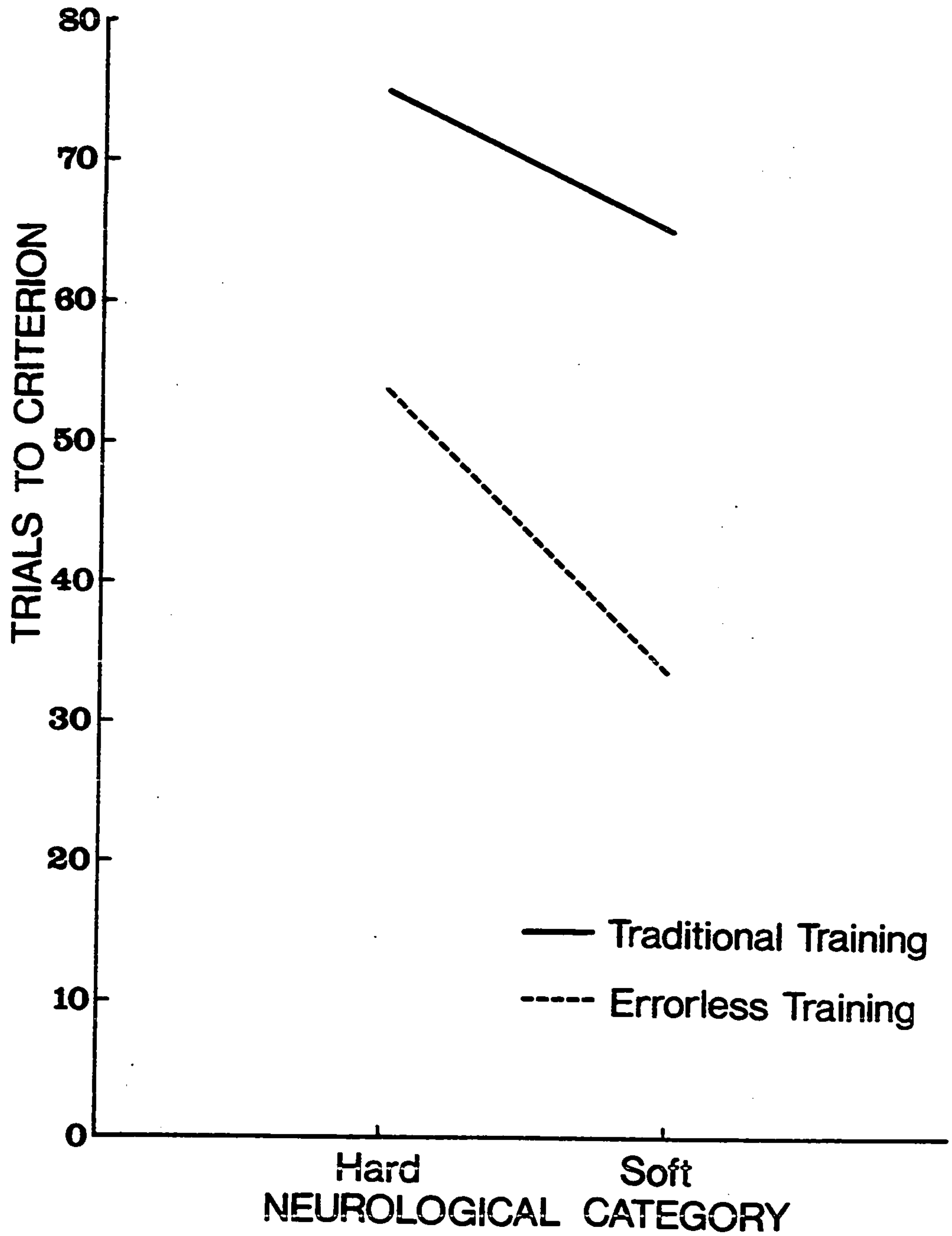

Figure 14: Mean trials to criterion for two training procedures by two categories of neurological impairment.

Chapter 6

Discussion

Summary of Results

Based on data gathered from 85 children attending the Glenrose School Hospital significant improvement in discrimination learning proficiency was noted in neurologically impaired children as they increased in age from 72 months to 143 months. Beyond this age and up to 179 months discrimination learning performance improved also, but not significantly.

A tendency was noted in the direction of neurologically impaired children demonstrating "soft" symptomatology being more proficient at the discrimination learning task than neurologically impaired children demonstrating "hard" symptomatology but the differences were not significant.

A significantly greater number of subjects were able to learn the discrimination by errorless-training than traditional training across three age levels. The errorless-trained subjects also learned the discrimination more quickly.

When the sample was grouped according to neurological category it was demonstrated that significantly more neurologically impaired children could learn the discrimination with errorless-training than traditional-training and, also, they could learn the discrimination faster.

Thus, the effectiveness of errorless training was demonstrated with neurologically impaired children regardless of the age of the child or neurological category.

Zeaman-House attention model. One of the main theoretical concerns of the present research was the utility of the Zeaman-House attention deficiency theory as applied to discrimination learning in neurologically impaired children. Zeaman and House (1963) proposed that in acquiring a discrimination a subject must learn to attend to the relevant stimulus dimension and then learn to respond to the positive cue on that dimension.

In reporting their work with moderately retarded children Zeaman and House (1963) stated that the secret of successful training lies in the engineering of attention. In discrimination training tasks they suggest that methods should be sought for increasing the attention value of the relevant cues. The present study examined one such method, errorless training, to see if it did facilitate discrimination learning in neurologically impaired children.

The effectiveness of errorless training, as demonstrated in the present research, suggests that the Zeaman-House attention deficiency theory does seem appropriate in examining the learning problems presented by neurologically impaired children. The suggestion is that by increasing the stimulus value of visual material being used with neurologically impaired children perhaps many of the perceptual and attentional deficits demonstrated by these children can be compensated for.

Distractibility. Distractibility is a frequent clincial description used when referring to neurologically impaired children (Frierson and Barbe, 1967; Johnson and Myklebust, 1968). However, if distractibility is seen as an arbitrary shift in attention and the contextual conditions are not examined it may be a label of little educational utility. Much of the literature on distractibility appears contradictory because of different definitions of distractibility, different samples being examined and different variables being controlled.

A considerable amount of educational practice has been built around the work of Strauss and Lehtinen (1960). The suggestion was that since brain-injured children were distractible the educator should strive to reduce the amount of stimulation in the child's environment.

Cruikshank (1966) suggested that basic to the phenomenon of figure-background disturbance in cerebral palsied children is the factor of "hyperdistractibility." He described the children as "highly distracted by any stimuli in the environment" and suggests that "such behavior apparently stems from the inability of the child to refrain from reacting to isolated stimuli or groups of stimuli whether or not such stimuli or such reactions are related to the specific task at hand (p. 185)."

It seems that the contextual conditions which facilitate attending behavior might be examined more closely. For example, Brown (1966a, 1966b) showed performance in retarded and probably brain injured children to be more dependent upon familiar social and physical situations than on degree of visual or auditory extraneous stimulation. Similar results were reported with normal nursery school children (Brown and Semple, 1970).

The present research also questions the importance previously placed on the distracting effects of extraneous stimuli. The results suggest that with neurologically impaired children poor discrimination performance may be due to an inability to organize the relevent stimuli of the task presented. Just as this deficiency in using orienting responses was noted with retarded children by Zeaman and House (1963) the neurologically impaired children in the present study showed discrimination learning problems related to initial inattention to the stimulus dimensions of the problem. When the discrimination stimuli were presented in such a fashion as to increase the initial probability of the subjects observing certain relevant stimulus dimensions discrimination performance was facilitated.

Kastner and Diller (1968) report results which indicate a similar deficiency in spina bifida children. They used three age levels of children (5-7, 8-10, 11-15 years) and examined reversal learning in children with neurological impairment (spina bifida) compared with a non-neurologically involved disabled group (congenital amputations). They found that a large number of the young children in the spina bifida group failed to make the initial discrimination. Kastner and Diller suggest that "the major problem seems to center around a lack of ability in organizing relevant cues in a problem-solving situation (p. 660)." The results of the present study suggest that the acquisition of the discrimination in Kastner and Diller's work would have been facilitated if errorless training methods had been employed.

Perhaps many of the discriminations considered too difficult for young children to learn by conventional training methods could be successfully trained with errorless methods. Moore and Goldiamond (1964) showed that in a match-to-sample task where triangles differed slightly in degree of rotation preschool children could learn the discrimination only if errorless procedures were used. Similarly, Sidman and Stoddard (1967) were able to teach retarded children to make discriminations between circles and ellipses which differed only slightly by using fading techniques. Stoddard and Sidman (1967) demonstrated that with normal children this difficult circle-ellipse discrimination was more effectively trained with errorless techniques.

The present research demonstrates how a difficult discrimination of orientation could be learned by 49 percent of the youngest group of neurologically impaired children with errorless training while only 7 percent of the subjects were able to learn it with traditional training. In the second age group 85 percent of the errorless-trained subjects and 44 percent of the traditional-trained subjects learned the discrimination. All of the subjects in the errorless group at age level three acquired the discrimination while 55 percent of the traditional group reached success. The effectiveness of errorless training in the acquisition of a difficult visual discrimination with neurologically impaired children is evident across all age levels. It seems that by increasing the probability of the child responding to the relevant dimension of the stimuli perceptual and attentional deficits concomitant with neurological impairment can be compensated for.

Educational Implications

Perception of orientation. There are specific areas of perceptual development where young children have difficulty. The discrimination of differently orientated forms is a very difficult discrimination for young children and consequently it is a discriminatory skill which seems to lag behind the development of visual shape perception in general. However, it is an important skill for humans "since it is absolutely necessary for adequate performance on certain socially essential tasks, such as reading and writing (Fellows, 1968, p.115)."

In learning to read a child is confronted with the problem of responding differentially to figures which differ only in orientation. The first step towards an analysis of reversal errors was made by Davidson (1935) who found that confusion of the letters, b,d,p,q tended to persist in children up to the age of 7 1/2 years. Vernon (1957) reports finding 12 percent of children aged seven to eight years demonstrating reversal errors of this sort.

Rudel and Teuber (1963) found that children aged three to nine years were readily able to learn a discrimination of either vertical and horizontal rectangles or upright and inverted U-shapes. However, many of the children had considerable difficulty with the discrimination of oblique rectangles or left-right reversed U-shapes. Rudel and Teuber used a neurological model to explain the difference in the relative difficulty of these discriminations. However, Acker (1966) demonstrated that the left-right discrimination was no more difficult than the up-down discrimination of U-shapes when errorless training is employed. The results of the present research support Acker's work.

As with any skill that shows gradual improvement with age there has been a tendency to regard the discrimination of orientation as being a function of age or of some maturational mechanism. For example Vernon (1957) concludes that a child's difficulty with the orientation of forms is the " . . . result of lack of maturation (p. 27)." While there is most likely some truth to this it is not very helpful to the educator. It is necessary to look for environmental variables which facilitate a child learning to discriminate orientation.

Jeffrey (1958) reported that 11 out of 14 children aged three years eleven months to four years nine months could not learn to respond differentially to two differently oriented stick-figures by a trial-and-error method. The two stick figures differed from each other in that one had its left arm raised and the other its right arm. The two figures were presented successively to the child, in a random sequence, and the child was required to respond to one by calling it "Jack" and the other by calling it "Jill." Jeffrey found that verbally instructing the child to notice the differences between the figures had no effect on performance. Jeffrey then tried having the child respond by pressing buttons which were located in direct line with the raised arm of each figure. It was found that now all of the subjects administered this button pressing task quickly learned the discrimination.

Within the theoretical frame of reference of the present study one could hypothesize that the reason the children could learn the discrimination after the response buttons were installed was that the buttons helped focus the child's attention to the relevant cue (i.e. raised arm) of the task. Once the relevant cue was identified the discrimination was quickly learned.

The results of Jeffrey's work and the present research suggest that contrary to the opinions of Davidson (1935) and Vernon (1957) the child's discrimination of orientation is sensitive to training. This has practical implications in the remedial treatment of poor readers who have discrimination problems similar to those of a young child (Fellows, 1968).

Reading problems. Educators are becoming increasingly aware that inadequate reading ability might better be viewed as a symptom with neurological dysfunctioning children rather than a discrete clinical entity in itself (Abrams, 1970; Ebersole, Kephart and Ebersole, 1968; Hewett, Mayhew and Rabb, 1967; Silver and Hagin, 1967).

Bateman (1970) regards learning to read as a process consisting of two stages. The first stage consists of the child learning to make differential responses to visual stimuli. The second stage is where the child attaches meaning to the symbols which have been identified in the first stage. Bateman contends that children who have trouble in reading usually are in need of remediation in the first stage.

Lyle (1969) points out the difficulty that poor readers, and particularly those with neurological difficulties, have in making discriminations such as b-d, p-q, saw-was, 69-96, etc. Lyle, in comparing equated groups of 54 retarded readers and 54 controls, concluded that letter and sequence reversals are associated with reading retardation. With reversals being a considerable factor in reading problems it seems important to have access to specific techniques which help compensate for these special learning deficiencies.

Childhood development in general may be viewed as a type of spiral process where each stage of development is dependent on the stage proceeding it. It would follow that if some of the earliest stages of development were not well formed the ensuing stages would not be complete, thus creating developmental gaps or lags which are so often spoken of in neurologically impaired children. It is suggested that some of these formative developmental stages, with special reference to perceptual-visual areas, might have a greater chance of successful development with errorless training techniques. The present research has shown this to be the case in training the discrimination of orientation with neurologically impaired children.

Adverse effect of failure. There often seems to be a certain degree of circularity operating with neurologically impaired children. These children, due to a combination of perceptual and attentional deficits interacting with non-compensating methods of instruction, develop incorrect habits of learning. These incorrect habits of learning, although seemingly small and insignificant when viewed individually, develop in a cumulative fashion until they create actual learning failures (e.g. reading problems). As a result of these failures the child may start to develop a poor image which then even lessens the chance of success. Finally, continuous failure becomes too much to cope with and creates an emotional overlay. These emotional problems, in turn, further reduce the chances of success.

The importance of the adverse effect of failure in learning disabilities is emphasized by Hirt (1970) who stated "Because of the fear of failure these children experience, they want to have the highest degree of security that is possible for them." Gever (1970) suggested that failure experience, perhaps paradoxically, should not be weighed as a result but rather as an etiological and sustaining agent of learning disorders. He pointed out that the precise effect of failure in the learning process is still unclear but that, particularly in children with learning disabilities, undoubtedly, being wrong produces a degree of frustration, discomfort and tension which mounts in relation to the frequency of incorrect responses.

Similar to this is the phenomenon of "failure-set" described by Zeaman and House (1960). They found that when retardates suffered prolonged failure on a problem which proved to be insoluble they were then unable to solve even the simplest problem, although they previously had been able to do so.

Gever (1970) made the following suggestion for approaching the problem of failure and learning disabilities:

> Hence, good educational procedure often dictates a maximization of success, particularly when the student has experienced few such rewards. Programmed learning designs account for this factor by use of frequent and immediate positive reinforcement (p.34).

Related to this is a study done by Freibergs and Douglas (1969) where they found that hyperactive boys were as successful as normal boys in learning a new concept under 100 percent reinforcement but were debilitated under a 50 percent schedule of reinforcement. One hundred percent reinforcement served to increase the attending behavior of the hyperactive boys and, thus, facilitate their learning the task.

Results similar to this were noted in the present study. The errorless training technique used with half of the subjects greatly increased the number of successful choices they made and reinforced them on a 100 percent schedule. With the trial-and-error group the subjects were reinforced for every correct choice but often went for a considerable number of unsuccessful trials (resulting in no reinforcement) before they made a correct choice. This was particularly so if the subject made position-based responses, such as pressing the screen that was correct last trial, or responded according to some right-left sequence (e.g. right, right, left, left, right, right, etc).

During periods such as these, when rate of success and reinforcement were low, behavioral differences were observed in the trial-and-error group subjects. Some of the subjects would become quite frustrated and press the response screens very hard or be verbally aggressive toward the apparatus. Many threatened to quit the task and one subject actually fled the experimental room.

None of these behaviors were observed in the errorless group. The prevailing approach to the task appeared to be one of interest and amusement. A number of the subjects, upon reaching criterion, asked if they might continue doing the task. The amount of overt verbalization by the errorless subjects seemed less than the traditional subjects. Whereas the content of the verbalizations of the traditional subjects tended to be aggressive or irrelevant the verbalizations of the errorless subjects tended to be more of a self-directing nature. The errorless subjects often gave themselves verbal instructions related to making the correct choice in the discrimination task.

Applications and Limitations of Errorless Training

In the present study an errorless technique was used to train the discrimination of orientation in neurologically impaired children. The importance of this particular discrimination in learning to read has been discussed earlier. The remediation of letter reversal problems in beginning readers is an obvious extension of the procedures used in this research. However, it is quite likely that other elementary reading skills might be more efficiently taught with errorless training techniques. For example, primary word recognition skills might be acquired with greater ease using errorless techniques. Large print and pictorial cues might be gradually faded until only the word in small type remained. While this method could be used with the learner's first introduction to formal reading material it is likely to be most effective in teaching word recognition skills to students who, because of previous failure and unsuccessful experiences, have come to regard reading as an aversive situation.

O'Conner and Hermelin (1963) used a method similar to this to gradually shift the control of responses in moderately retarded children from one stimulus to other stimuli. They shifted the verbal response from a picture to a word in large print and then gradually reduced the size of the print. They demonstrated that children learned to recognize the words with this fading method in significantly less trials than children in a control group could.

While errorless training techniques have been shown to be most effective in some situations it would not be generally desirable to train all discriminations without errors. Terrace (1966) warns against the lack of frustration tolerance that would result from a steady diet of errorless discrimination learning. Terrace points out that when pigeons were trained a color discrimination under a 100 percent reinforcement schedule and then abruptly switched to an intermittent schedule their behavior became very erratic and there was a noticeable decrement in performance stability.

With children the effect would be most likely similar. Intermittent reinforcement is known to maintain a response over a longer period of time. However, this is with the provision that the discrimination response has already been acquired. Errorless discrimination techniques are more appropriately used to train a discrimination where there has been a previous history of failure. Once the discrimination is acquired it would be important to then progressively develop a tolerance for non-reinforcement.

Another aspect of errorless training which limits its use to specific situations is the amount of work required in preparing the stimulus materials. Touchette (1968), however, concerning himself with the training of retardates states:

> Tedious though it may be to establish a graduated series of training stimuli which insure continuity of stimulus control, the startling effectiveness and economy of the program, once perfected, amply justify the work necessary to develop it (p. 48).

In a clinical context, then, errorless training is most useful if viewed as a remedial technique which can be applied to specific deficit areas (e.g. reading reversals) rather than as a general preferred mode of discrimination training. The present research demonstrates the applicability of errorless training techniques to some of the learning problems presented by neurologically impaired children.

Limitations of the Present Study

Most of the problems that occurred were related to the sample itself. The small sample size was a major limitation. Although the sample used represented the entire Glenrose School Hospital population fitting the selection criteria, the subjects were not evenly distributed according to age and diagnostic category. This meant that there were many more subjects demonstrating "hard" neurological signs than "soft" signs. Also, there were more children in both the young and middle age groups than there were in the older age group.

The result was that some of the cell frequencies were rather small when the data was organized for a two-way analysis of variance and were too small to allow a three-way analyses of variance to be done.

Similarly, each of the general "hard" and "soft" neurological categories were comprised of a number of separate diagnostic entities. This meant, for example, that the category of subjects demonstrating "hard" symptomatology included cerebral palsy, convulsive disorders, meningomyelocele, etc. Even within one of the primary diagnostic groups, such as cerebral palsy, there were various types included (spastic, athetoid, ataxic & mixed) with varying degrees of limb involvement (diplegia, hemiplegia, quadriplegia). Accordingly, the conclusions drawn from the present research can only be regarded as general statements and not specific to any particular diagnostic category.

The functioning of the projection apparatus created a small amount of difficulty. The circuit was designed so that the two projector lamps would be automatically turned off after each response the subject made to darken the screen before the next pair of stimuli were presented. The rapid, repeated heating and cooling of the projector lamp filaments meant relatively short periods of time before they burned out and needed replacing. If this happened while a subject was operating the apparatus it necessitated an interruption of two or three minutes while the projector lamp was replaced. A better arrangement for extinguishing the light between trials would have been using motor-driven shutters on the projectors. These devices are available commercially but are quite expensive.

Suggestions for Further Research

Some of the directions which follow-up studies could take became evident in previous discussion. For example, a number of shaping or fading techniques (colour, intensity, size, position, contrast and focus) have been used to transfer control between stimuli. Focus fading was the method chosen for the present study because the apparatus required would be familiar and convenient in most schools. However, there has been no experimental comparison made of the relative effectiveness of any of these methods using a common sample. Similarly, an examination of the effects of different numbers of steps in the fading progressions used would be useful. The number of steps in the training progressions are usually arbitrarily chosen but there may be some optimal progression length.

It would be interesting to examine retention of a discrimination trained by errorless and traditional techniques at different points in time after acquisition. Touchette (1968) demonstrated better retention with errorless trained subjects. However, he used a different discrimination, different training method and different sample than the present study. Can the same be said for neurologically impaired children on an orientation discrimination?

Using conditions similar to the ones in the present research it would be useful to compare errorless and traditional training on their relative abilities to facilitate generalization. In other words will the ability to discriminate other figures differing only in orientation be different after errorless and traditional training?

Cruikshank, Bice and Wallen (1957) undertook a major study of the figure-background relationship in cerebral palsied children. They noted that the spastic group of children made significantly more background responses than either athetoid or unhandicapped groups. Further, the spastic children did not demonstrate any appreciable modification in their performance with increased chronological age. In the present study cerebral palsy was considered a general group with no further breakdown according to type. It would be very interesting to see if there were differences between the spastics and athetoids in the ability to perceive orientation. Also, would errorless training increase the number of figure responses in a figure-background discrimination with spastic children?

In the present study mention was made of behavioral differences noted between the errorless and traditional subjects. It would be useful to videotape performance so that objective comparisons might be made. Heart rate and galvanic skin response measures might also be taken.

Finally, in response to Bortner's (1968) observation that "It is clear that the concept of attention is not yet clear (p. 70)," perhaps further clarification might be obtained by comparing errorless and traditional performance under various conditions where visual and auditory distractors are present. Similarly, considering work done by Brown and Semple (1970) suggesting that attention difficulties in children may be related to social conditions, further research might be done examining errorless and traditional training procedures when social variables are considered. The results could be relevant to normal younger children in early stages of learning where perceptual problems are suspected.

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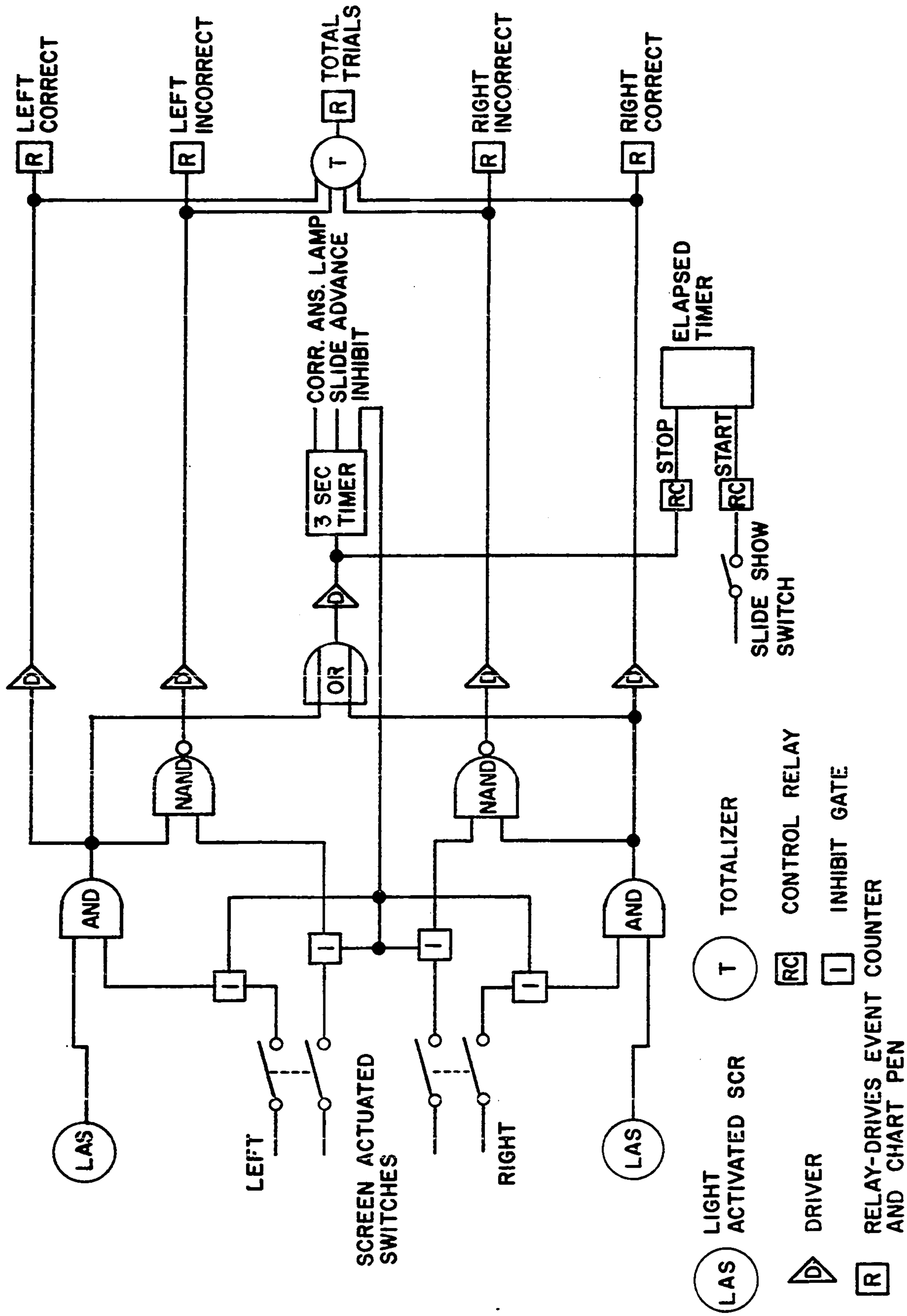
APPENDIX A



Simplified Diagram of Electronic Circuitry

Appendix B

Trials to Criterion for Two Training Procedures by Two Categories of Neurological Impairement and Three Age Groups

	Training Procedure										
Neurological Category	Errorless						Traditional				
Hard	10	18	35	56	100	100	10	10	100	100	100
	10	20	38	63	100		10	18	100	100	100
	10	26	44	68	100		10	47	100	100	100
	10	29	47	100	100		10	100	100	100	100
	13	32	53	100	100		10	100	100	100	100
	17	35	55	100	100		10	100	100	100	100
						N=31					N=30
Soft	10	17	62				10	100	100		
	10	18	100				10	100			
	10	20	100				10	100			
	10	25					25	100			
	16	41					56	100			
						N=13					N=11
Age Group											
72-107 mo.	13	53	63	100	100	100	10	100	100	100	100
	20	56	68	100	100	100	100	100	100	100	100
	29	62	100	100	100		100	100	100	100	
						N=17					N=14

Age Group	Errorless								Traditional						
	10	10	17	20	35	47	100		10	10	47	100	100	100	
108-143	10	10	18	26	41	55	100		10	18	100	100	100		
mo.	10	17	18	32	44	100			10	25	100	100	100		
								N=20							N=16
	10	16	38						10	10	100	100			
144-179	10	25							10	10	100	100			
mo.	10	35							10	56	100				
								N=7							N=11