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Abstract

Sixty-four moderately and severely retarded individuals enrolled in four sheltered workshops learned to assemble a 15 piece and a 24 piece bicycle brake. Training procedures utilized information obtained from the basic psychological research on discrimination learning. One-half of the subjects worked with the parts of the training task brake as they came from the factory (Form only). The others worked with parts that were color coded (Color Form). Coding consisted of painting that surface of each part that is facing the subject when it is placed in the proper position for assembly. All groups worked with the parts of the transfer task brake as they came from the factory (Form only). Half of the subjects learned the tasks to a criterion of six correct out of eight consecutive trials, the other half performed 20 trials beyond criterion on the training task brake (overlearning). The Color Form groups learned the training task brake significantly faster than the Form Only groups. No significant overlearning effect was found. (Author)

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Marc William Gold
Department of Special Education
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Department of Health, Education, and Welfare

U.S. Office of Education
Bureau of Education for the Handicapped

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SUMMARY

Sixty-four moderately and severely retarded individuals enrolled in four sheltered workshops learned to assemble a 15 piece and a 24 piece bicycle brake. Training procedures utilized information obtained from the basic psychological research on discrimination learning. One-half of the subjects worked with the parts of the training task brake as they came from the factory (Form-only). The others worked with parts that were color coded (Color-Form). Coding consisted of painting that surface of each part that is facing the subject when it is placed in the proper position for assembly. All groups worked with the parts of the transfer tas)rake as they came from the factory (Form-only). Half of the subj .ts learned the tasks to a criterion of six correct out of eight consecutive trials, the other half performed 20 trials beyond criterion on the training task brake (overlearning). The Color-Form Groups learned the training task brake significantly faster than the Form-Only Groups. No significant overlearning effect was found.

INTRODUCTION

Background

Mental retardation, as an occasional neighborhood problem, has always been an integral part of our society. But it has been only within the last one hundred years that there has been national concern and action about the retarded (Robinson & Robinson, 1965). This is evidenced by such legislative milestones as the Barden-LaFollette Amendment of 1943 (PL 78-113), the Vocational Rehabilitation Amendment of 1954 (PL 83-565), and the numerous acts of major importance enacted during the 1960's.

The result of these events is the development of a technology to study the characteristics and needs of the retarded. Among the disciplines involved are education, psychology, and rehabilitation. Education and rehabilitation have devoted the majority of their research to utilitarian problems, working primarily in classrooms, sheltered workshops and clinics. Psychology, however, has most often involved itself with studies designed to look at isolated aspects of behavior, in a laboratory setting. The result has been the accumulation of two bodies of knowledge: (1) information that is relevant but unclear and, (2) information that is precise but not in applicable form.

One conspicuous exception to this dichotomy is the work done utilizing operant procedures (Crosson, 1969; Crosson & deJung, 1967; Huddle, 1967). These studies clearly represent attempts to apply a theoretical model to an applied situation, resulting in a body of information that is relevant, clear and applicable.

The present study is an initial attempt to develop a research methodology with a particular emphasis on stimulus control. The methology is intended to bridge the gap between the laboratory and the applied setting.

Research Model

Basic research in discrimination learning with the mentally retarded has resulted in a body of information describing some learning characteristics of this population in controlled situations. From this research, a number of clear effects have emerged that are both replicated and produced by clearly defined manipulations. Consistent behaviors have been obtained in different situations and with a variety of retarded populations.

The particular model that has been most useful in the area of retardate discrimination learning is the Attention Theory of Zeaman and House (1963), which has generated much empirical information about stimulus and training procedures. It differs from other quantitative discrimination theories, such as those of Atkinson (1958), Burke and Estes (1957), Bush and Mosteller (1951) and Restle (1955), in that they assume that the subject samples relevant stimuli on every trial. The Zeamans postulate that the relevant cues are not attended to on every trial, but that the subject must learn a chain of two responses: (1) attending to the relevant dimension and (2) approaching the correct cue on that dimension.

The effects of dimensional learning cannot be observed directly on the first problem or set of problems. It is in the solution of subsequent problems that the effects are observed. Consequently, the paradigm generally used in discrimination learning includes training and transfer. Using this paradigm, the present study extends investigation of two effects, number of relevant dimensions and amount of learning, as applied in a complex assembly task.

The term dimension, as used in discrimination learning, refers to properties of the classes of stimuli, that is, color form, etc. When a child learns to respond to red instead of green he is attending to the color dimension. If he learns to respond to a triangle he is attending to the form dimension. When the child learns to respond to red and then transfers, or shifts, to a new set of problems where orange and blue are used and blue is correct, he has made an intradimensional (ID) shift, that is, he has shifted to a new set of problems where the relevant dimension is the same, but the instrumental response differs.

In one kind of ID shift, red and green might be used both for training and for transfer, but if red is correct for training, then green becomes correct for transfer. This is a reversal (R) shift. Reversal shifts and ID shifts are generally compared with extradimensional (ED) shifts. If, after learning a color relevant problem, like those just described, the child is transferred to a problem where triangle is correct, this constitutes a shift from the color dimension to the form dimension, and is called an ED shift.

When two stimuli such as red and triangle, from different dimensions, are always together and correct, the stimuli are said to be redundant. Both cues and dimensions (or either) can be redundant.

Paradigms utilizing different kinds of shifts and redundancies are used to study the various effects including overlearning. Overlearning is administered when a subject is given training beyond some predetermined criterion point at which a high level of performance has been reached, and where it is assumed learning has taken place.

Application of Model and Rationale

The facilitating effects of overlearning on transfer, and of cue redundancy have been replicated and are consistent in the literature (Blank, 1966; Campione, Hyman & Zeaman, 1965; Eimas, 1964; Eimas, 1965; Furth & Youniss, 1964; Heal, 1966; House & Zeaman, 1960; Marsh, 1964; Ohlrich & Ross, 1966; Tighe & Tighe, 1965; Uhl, 1966; Youniss & Furth, 1965; Zeaman & House, 1963). However, most experimentation to date, involving discrimination learning, has taken place in a laboratory setting. Replication of these effects has not yet been demonstrated in an applied situation. In the laboratory the emphasis is on the isolation of definable characteristics. The complex interaction in a normal setting, such as a classroom, is systematically eliminated for clarification of the variables under study. The combination of variables used is not chosen for any practical reason but to achieve an understanding of the variables themselves. Before such information can be put to use in a classroom or workshop, where its value is ultimately realized, it needs to be first the subject of applied research. Interactions with variables that are controlled in the laboratory but operate in a classroom may make direct applications inappropriate.

Sheltered workshops as applied settings were of major interest because of the paucity of research on training procedures, the apparent applicability of Attention Theory, and the personal interests of the experimenter. Discrimination learning was the area of basic research used because of its relevance to training procedures and to the teaching of retardates in general (Scott, 1966). The procedures adopted followed widely accepted workshop practices except where this interfered with good research methodology. This was done to provide data that would be both experimentally controlled and have direct application.

The training normally given to workshop clients emphasizes the area of social development and adjustment. Lack of techniques is given as the primary reason for not providing programs which also emphasize skill development and task oriented training.

Little has been done to utilize information in a systematic attempt to improve the training and function of retardates in the workshop setting. Although the field of discrimination learning is quite young, enough has been learned to provide a wealth of information for workshop training procedures. Areas of experimentation such as retention, incidental learning, and the variables investigated in the present study could provide information useful in the procurement and selection of contracts, program design, placement, and all other aspects of the habilitation process.

The information is equally relevant to educational programs. Understanding the effects of relevant and irrelevant dimensions in a typical classroom learning task, for example, could do much to increase the teacher's ability to utilize the learning characteristics of her students. Concepts such as the establishment of a predetermined criterion of performance for a lesson, the use of overlearning and the effects of meaningfulness of cues, have tremendous potential in programming classroom material.

REVIEW OF RESEARCH

Basic Research

The effects of various kinds of shifts and degrees of learning are well documented and consistent. Relevant to the present study is the finding that overlearning facilitates transfer on an ID shift. Heal (1966) found that overlearning facilitated an ID shift on a color-form discrimination problem, using normal kindergarten children and adult retardates. This is consistent with the findings of Furth and Youniss (1964) with gradeschool children, also using a color-form problem. Overlearning has been found to facilitate an ID shift (reversal) in moderately retarded children (Campione, Hyman & Zeaman, 1965; Ohlrich & Ross, 1966); in young children (Blank, 1966; Furth & Youniss, 1964; Marsh, 1964; Tighe & Tighe, 1965; Youniss & Furth, 1965) and with college students (Uhl, 1966), all using color and form except for the Blank study which involved a size sorting discrimination problem.

These studies suggest that the facilitating effect of overlearning on ID shifts is perhaps a general phenomenon. Most of them show the effects of overlearning by comparing its effects on ID and ED shifts. Overlearning tends to impair ED shifts. In the present study it was assumed that the shift from color-form to form-only is an ID rather than an ED shift. This assumption is discussed below.

Another consistent finding is that learning rate increases as a function of the number of relevant dimensions. In a discussion of discrimination learning Zeaman and House (1963) describe a hierarchy of stimulus dimensions and combinations based on experiments with retardates. From the easiest to the hardest this hierarchy is as follows: junk (multidimensionally different stimuli); color-form object (three-dimensional color-form stimuli); form (color absent or held constant); color-form pattern (two-dimensional color-form stimuli) and color (form absent or held constant). Performance consistent with this hierarchy would support the use of color for the training of a form assembly task.

Eimas (1964) found that retarded children utilized a stimulus compound (more than a single relevant dimension) in a simultaneous discrimination task which was solvable by a component (a single dimension) alone. He interprets this to mean that retardates were able to utilize a considerable amount of the stimulus information provided. He found the same results with kindergarten children (1965). The utilization of compound stimuli by trainable retardates was also found by Zeaman and House (1963). They further observed that form as a component tends to be stronger than color. In a discussion of three experiments, they state that the form component resisted the competition of the compound to a greater extent than the color component in one of two comparisons made. No difference was reported in the other comparison. This suggests that the use of a color-form compound does not impair transfer to the form-only task, that is, if the color component makes up part of the color-form compound but is not the primary cue, then the subject has the benefit of a compound stimulus in the training problem but has to make only an ID shift when color is dropped out. This also lends support to the assumption that removal of the color dimension does not constitute an ED shift.

House and Zeaman (1960), manipulating the number of relevant dimensions, found that training on a simple task will facilitate more rapid learning on a more difficult task. Discrimination was established between stimuli differing in color and form, presented in either of two ways: as flat patterns on gray backgrounds; or as cut-out three-dimensional objects. Easy-to-hard sequences were more efficient than hard discrimination trials only, as measured by total trials required to learn the hard discrimination.

Applied Research

Perusal of studies involving sheltered workshops and vocational evaluation and training problems indicates a major emphasis on the evaluation of specific skills and abilities, and their predictive value (Burdett, 1963; Ladas, 1961; Meadow & Greenspan, 1961; Tobias, 1960; Wagner & Hawver, 1965). In most cases, however, only those skills and abilities that are social in nature, are discussed in terms of actual training (Acker & Thompson, 1960; Cowan & Goldman, 1959; Kolstoe, 1960; White & Redkey, 1956). There are a few reports of attempts to manipulate training procedures. Bitter and Bolanovich (1966) and Neuhaus (1964) utilized audio-visual devices in workshop training programs. These studies were demonstrative rather than experimental but indicated a fruitful line for research.

Huddle (1967), working with institutionalized retardates, utilized a 16 piece television rectifier assembly to study the effects of competition, cooperation, and monetary reward on work performance. He found that payment of monetary rewards had a significant effect on performance. Reward, however, was perfectly confounded with experimenter and institution, making his data difficult to interpret. Perhaps the most important aspect of Huddle's study is the attempt to combine the attributes of both basic and applied settings to find ways of implementing information already known regarding reinforcement contingencies.

Crosson and deJung (1967) studied the effects of operant procedures on severely retarded males, using three simple workshop tasks. Their study indicated the need for further research in the application of operant techniques to the acquisition of vocational behaviors. The techniques employed produced adequate performance on simple tasks by severely retarded individuals (mean IQ = 24; S.D. = $\pm$7).

The most complex assembly work done by retardates and reported in the literature was done at Murdoch Center, Butner, North Carolina. Tate and Baroff (1967) trained retardates (mean IQ = 52, range = 40-60) to assemble electronic relay panels. They did not use an experimental design, but worked at developing training procedures. Their program demonstrates the value of carefully scrutinizing present levels of expectancy regarding the retarded, and of seeking more complex subcontract work than is presently found in sheltered workshops for the retarded.

The literature revealed no direct attempts to investigate findings from discrimination learning as applied to a workshop task. A general purpose of the present study is to develop a structure and methodology for such study.

Specification of Variables

The independent variables under Number of Relevant Dimensions were (1) form-only and (2) color-form. For Amount of Learning, the independent variables were (1) learning (criterion) and (2) overlearning. Learning was defined as reaching a performance criterion of six correct out of eight consecutive trials. Overlearning consisted of 20 trials beyond criterion.

The dependent variables were (1) trials to criterion, (2) manipulation errors to criterion and (3) discrimination errors to criterion. Of the 25 steps involved in assembling the training task, 15 were manipulative, that is, were solved by appropriately moving parts into place, and 10 were discriminative, that is, were solved by determining which way a part was to be placed. Of the 33 steps involved in assembling the transfer task, 23 were manipulative and 10 were discriminative.

Hypotheses of Present Study

I. Overlearning facilitates intradimensional transfer on a complex workshop assembly task.

II. The use of cue redundancy facilitates learning of a complex assembly task.

III. The use of a cue redundancy on the training task facilitates transfer to a single relevant dimension task.

METHOD

Pilot Work

A pilot study was run to find tasks of appropriate difficulty to minimize floor and ceiling effects, that is, tasks that were neither too easy nor too difficult to provide meaningful data. The tasks decided upon were two different types of bicycle brakes.

A modified form of task analysis was employed to establish training and scoring procedures, and an apparatus was designed and built. A second pilot study was done to refine procedures to gain information for decisions regarding criterion, amount of overlearning, and reinforcement, and to estimate how long the study would take. An estimate of population variance was obtained to aid in the decision regarding sample size.

Administrative considerations included securing a U. S. Office of Education Small Grant, obtaining the cooperation of four sheltered workshops, and the hiring and training of four experimenters.

Subjects

Subjects (Ss) were 64 retarded adolescents enrolled in four sheltered workshops. Descriptive data for the population is presented in Table 1. Workshop directors were asked to select the 18 to 20 lowest performing clients, excluding from selection clients with severe sensorial or physical handicaps, and clients with full scale or performance IQs above 60. Use of minimal selection criteria was in keeping with the applied nature of the study. Following selection, 16 Ss from each workshop were randomly assigned to groups with the restriction that four subjects from each workshop were in each group. Information concerning age, sex, IQ, clinical type and length of time in the workshop was obtained for descriptive purposes only.

Three Ss were dropped during the first week of the experiment. One was dropped because of job placement resulting in termination as a workshop client. A second because of complete refusal to participate.

The third S was dropped because the project director, upon observing the thickness of his hands and the shortness of his fingers, believed the S incapable of handling the small pieces of the transfer task. To test this, he was given three parts from the transfer task and told to pick them up and to turn them over. He could not do so, necessitating his removal from the study. As a point of interest, this S was brought to criterion on the training task. His performance was within the range of the Ss in the group to which he had previously been assigned. Having reached criterion on the training task, the experi-

TABLE 1

Descriptive Characteristics of Subjects

Group	IQ		CA (in years)		Workshop Experience (in months)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Form-Only-Criterion	47.75	5.89	21.81	5.05	33.25	26.59
Form-Only-Overlearning	46.31	4.11	21.31	3.94	33.06	28.27
Color-Form-Criterion	48.06	4.99	22.06	6.63	31.69	29.81
Color-Form-Overlearning	46.62	5.90	22.06	5.18	26.00	28.60

menter started him on the transfer task. As had been predicted, he was unable to perform even the simplest manipulations.

Replacements for Ss dropped from the experiment were drawn at random from the original pool of Ss in the workshop where the replacement was necessary.

Apparatus

The apparatus consisted of a 15 inch by 42 inch tray containing 15 compartments, one for each part of the training task (Figure 1). Each compartment can be divided so that the tray then contains enough compartments for the transfer task. Each of the compartments is 15 inches long. The dividers are one inch high. A one-half inch divider runs parallel to the front of the tray, three inches back. The purpose of this divider is to separate the parts that are being used for a trial from the parts to be used in subsequent trials.

The training task was a Bendix, RB-2, coaster brake, consisting of 15 parts (Figure 2). Two groups of Ss worked with the parts as they came from the factory (Form-Only Groups). The other two groups worked with parts that were color coded (Color-Form Groups). Coding consisted of painting that surface of each part that is facing the S when it is placed in the proper position for assembly. The transfer task was an Oxford, #584, rear, men's, lightweight, caliper brake, consisting of 24 parts (Figure 3). All groups worked with the parts of the transfer assembly as they came from the factory (Form-only). There was a quantity of each part in its respective compartment so as to further approximate workshop conditions and so that there was no interruption within trial blocks, for disassembly.

Experimenters

Four experimenters (Es) were used in the experiment, one at each workshop. Four Ss from each workshop were in each group, making the effects of workshops and Es constant across groups. Although these variables were confounded, this was the only practical arrangement due to the distance separating the workshops. Further, statistical checks were made to identify any workshop-experimenter effects by including this as a variable in the analyses.

The Es were recruited from among volunteers in the workshops and acquaintances of the workshop directors. Previous experience and training included some business schooling for all Es, and some volunteer work with retarded children for two of them. None of the Es had had specific training for work with the retarded.

Figure 1. Tray

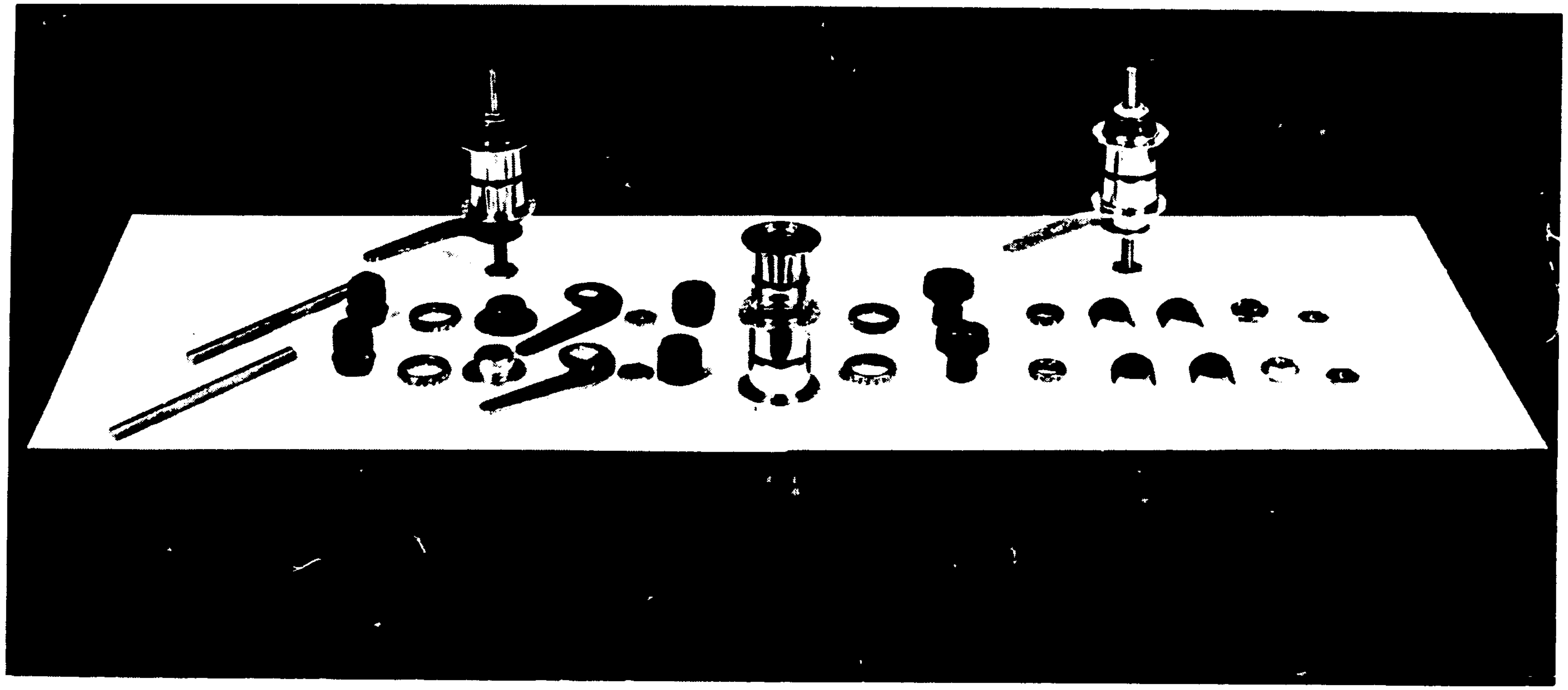

Figure 2. Training Task Brake

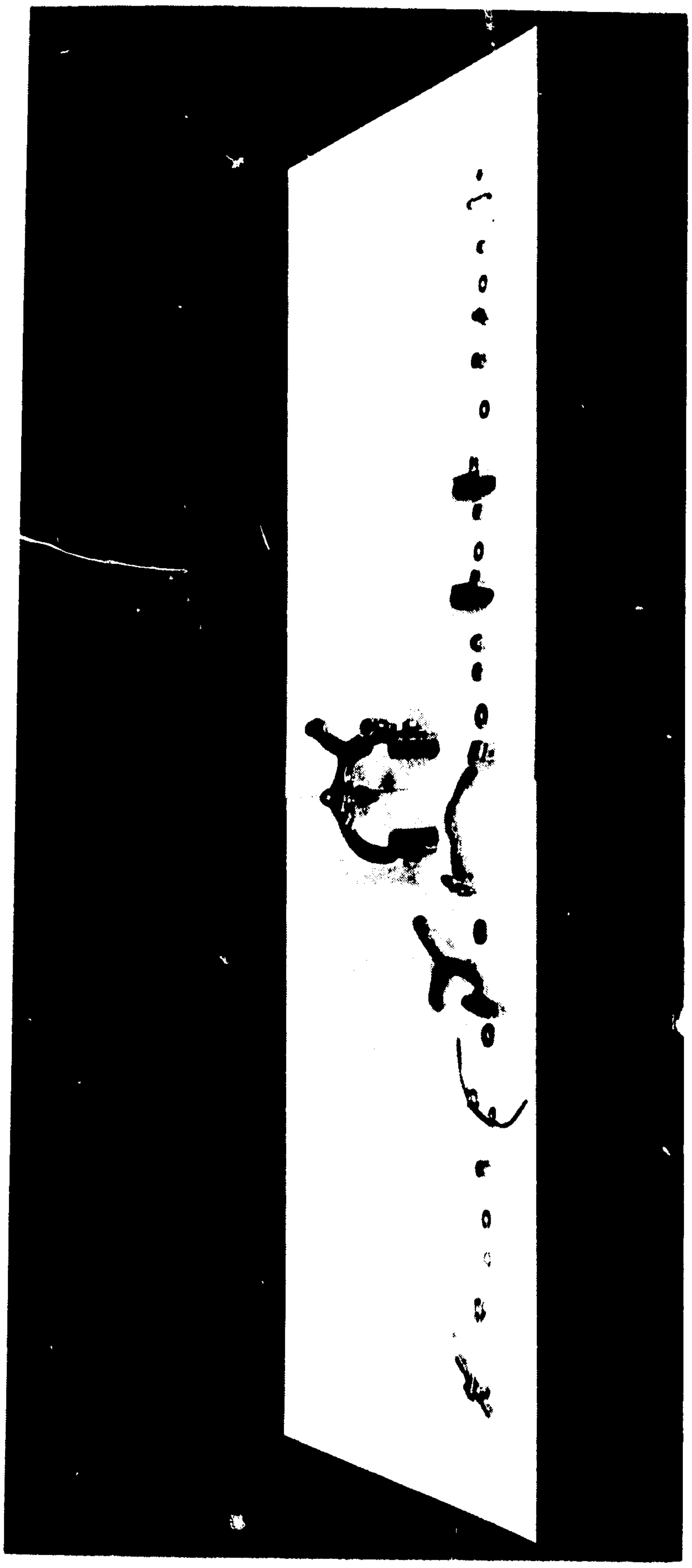

Figure 3. Transfer Task Brake

The experimenter training period consisted of six half-day sessions. Training included assembly and disassembly of the brakes, demonstration procedures, recording and correction procedures. To test inter-experimenter reliability the Es judged five trials on the training task brake performed by a retardate not being used in the study. Of a total of 500 judgements (trials x steps x experimenters) there were 12 disagreements. A judgement was considered in disagreement if it contrasted with the judgements of the other Es. It should be noted that errors had to be corrected as the S proceeded, making this test less than conclusive.

Some time was spent discussing the many incidental problems which might arise. Examples of such problems are: what to do when an S continues to ask if he did something right; what to do if an S needs assistance on a manipulation step and how to score such steps. Much of this part of the training procedure was based on anecdotal records kept during the pilot studies. To maintain control and maintenance of experimenter consistency, the project director spent an average of half a day on alternate days with each E throughout the experiment.

Procedure

The S was seated at a table on which the tray was placed, with four disassembled brakes in the compartments. The E was seated beside him. Before the S's first trial on the training task, and before the S's first trial on the transfer task the entire procedure was demonstrated once by E. The demonstration consisted of the E bringing one of each part forward, in front of the compartment divider, so that one set of parts was in position, then assembling the unit. Errors were made, according to a standardized demonstration format, and verbal cues that would be given when the S made an error were used. The most frequently used cue was, "Try another way." The purpose of the demonstration was to show the subject how to respond to the few verbal cues used, and not to teach the task. Both tasks used essentially the same verbal cues (Tables 2 and 3).

The first day of the experiment for each S consisted of one trial performed by the E (demonstration) and three trials by the S. On all subsequent days, the S did four trials. Each S began the transfer task on the day following criterion, or overlearning, on the training task.

For subjects failing to reach criterion it was decided to stop at 55 trials and give a score of 55. This happened with one subject and only on the transfer task.

Data collection consisted of placing a plus (+) or a minus (-) in cells corresponding to steps of the task. The form used was a matrix

TABLE 2

DEMONSTRATION PROCEDURE

Training Task

Part		Manipulation	Verbal Cue
1.	(axle)	Pick up	-
2.	(expander)	Turn wrong, right. Thread to 1 inch.	"Try another way." "Good." "Stop."
3.	(bearing)	Push on.	-
4.	(cap)	Put on.	-
5.	(arm)	Put on wrong, right. Hold down.	"Try another way." "Good."
6.	(nut)	Thread on. Turn assembly over.	"Make it tight." "Turn it over."
7.	(sub.)	Put on wrong, right.	"Try another way." "Good."
8.	(hub)	Put on wrong, right. (Be sure to look through it.)	"Try another way." "Good."
9.	(bearing)	Put on.	-
10.	(drive)	Put on.	-
11.	(bearing)	Put on.	-
12.	(cone)	Thread part way on. Turn over.	"Stop." "Turn it over."
13.	(shoe)	Put it in.	-
14.	(shoe)	Put it in. Lift Turn, shake, etc. (seat) Grasp, turn over. Finish cone.	- "Lift" - "Turn it over." -
15.	(nut)	Thread on.	"Good."

TABLE 3

DEMONSTRATION PROCEDURE

Transfer Task

Part		Manipulation	Verbal Cue
1.	(shaft)	Pick up.	-
2.	(guide)	Put on wrong, right.	"Try another way." "Good."
3.	(washer)	Put on.	-
4.	(washer)	Put on.	-
5.	(nut)	Thread on.	-
		Turn over.	"Turn it over."
6.	(spring)	Put on table wrong, right.	"Try another way." "Good."
		Put on.	-
7.	(washer)	Put on.	-
8.	(arm)	Put on wrong, wrong, right.	"Try another way." (twice) "Good."
9.	(washer)	Put on.	-
10.	(arm)	Put on wrong, right.	"Try another way." "Good."
11.	(washer)	Put on.	-
12.	(nut)	Thread on.	-
13.	(lock)	Thread on.	-
14.	(shoe)	Put in, hold.	-
15.	(washer)	Put on.	-
16.	(nut)	Thread on.	-
17.	(shoe)	Put in wrong, right, hold.	"Try another way." "Good."
18.	(washer)	Put on.	-
19.	(nut)	Thread on.	-
		Turn over.	"Turn it over."
20.	(bolt)	Put in	-
21.	(washr)	Put on.	-
22.	(nut)	Thread on.	-
		Put assembly down.	"Put it down."
23.	(adj.)	Pick up.	-
24.	(nut)	Thread on.	-
		Pick up assembly wrong, right.	"Try another way." "Good."
		Insert subassembly wrong, right.	"Try another way." "Good."
			"Good."

on which the columns represented steps of the task, and the rows represented trials (Tables 4 and 5). A minus was given when the E had to intervene. A self-correction procedure was not used due to the nature of the tasks. That is, if a part did not fit, the S would self-correct, resulting in a plus being given where a discriminative error was made.

Several levels of reinforcement were used. Overall reinforcement consisted of paying each S the same amount which he was paid for doing his regular work. This varied between workshops and between clients in the same workshop. Immediate reinforcement was given after the S had corrected an error. When an error was made, the E said, "Try another way." After the correction the E said, "Good." The reinforcer "good" was also given at the end of each trial. A completed assembly constituted a trial.

To correct manipulative problems, it was sometimes necessary to give more than verbal assistance. These assists were recorded both as errors and assists, but because of the nature of the assistance, were not corrected and reinforced as was the case with other errors.

TABLE 4

Data Collection Form--Training Task

Name________________

Group_______________

Trial	Date	axle	expander	stop	bearing	cap	arm	seat	nut	over	sub.	hub	bearing	drive	bearing	cone	stop	over	shoe	shoe	lift	seat	grasp	over	seat	nut	order	assist	errors	Comments
1																														
2																														
3																														
4																														
5																														
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15																														
16																														

The actual forms consisted of 28 rows.

TABLE 5

Data Collection Form--Transfer Task

Name______________________

Group_____________________

Trial	Date	shaft	guide	w,w,n	over	spr.tb.	spr.on	washer	arm I	washer	arm II	washer	nut	lock	shoe	hold	w,n	shoe	hold	w,n	over	bolt	hold	w,n	down	adj.,n	pickup	put on	order	assist	errors	Comments
1																																
2																																
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The actual forms consisted of 28 rows.

RESULTS

A 2 X 2 X 2 X 4 (Stage by number of Relevant Dimensions by Amount of Learning by Experimenters) factorial analysis of variance was performed on each of the following dependent variables: trials to criterion; manipulation errors to criterion; and discrimination errors to criterion. Subjects, the replication factor, was a random factor. All other factors were fixed. Complete analysis of variance tables are included as the Appendix. The confounded effects of experimenter and workshop were included as a variable in the analyses to check the effectiveness of the controls. No significant main effects of, or interactions with this variable were found and are not further discussed.

Trials to Criterion

Figure 4 presents mean trials to criterion for the Form-Only and Color-Form Groups, summed across Amount of Learning and Stage (training and transfer). As can be seen, the Color-Form Groups learned the two tasks in significantly fewer total trials than the Form-Only Groups ($F_{1,48} = 9.84$, $p. < .01$).

The mean trials to criterion, summed across all groups, as a function of training and transfer (Stage) are, respectively, 25.53 and 21.80. Since the relative difficulty of the two tasks was not determined, this Stage main effect, though significant, is uninterpretable ($F_{1,48} = 8.56$, $p. < .01$).

Figure 5 presents mean trials to criterion for the Form-Only and Color-Form Groups, on training and transfer. Using Scheffe's procedure the only significant interaction between Stage and Number of Relevant Dimensions is a function of the superior performance of the Color-Form Groups on the training task ($F_{15,48} = 73.35$, $p. < .01$). The data did not indicate that training with color and form relevant affected performance on the transfer task.

Manipulation Errors to Criterion

Figure 6 presents mean manipulation errors (moving parts into place) to criterion, summed across groups, by Stage. A significant main effect, showing fewer manipulation errors on the transfer task, was found ($F_{1,48} = 65.52$, $p. < .01$). Because the comparative level of difficulty of manipulation errors for both tasks is not known, the effect is uninterpretable. Similar performance in terms of manipulation errors suggests that this part of both tasks was similar for all groups.

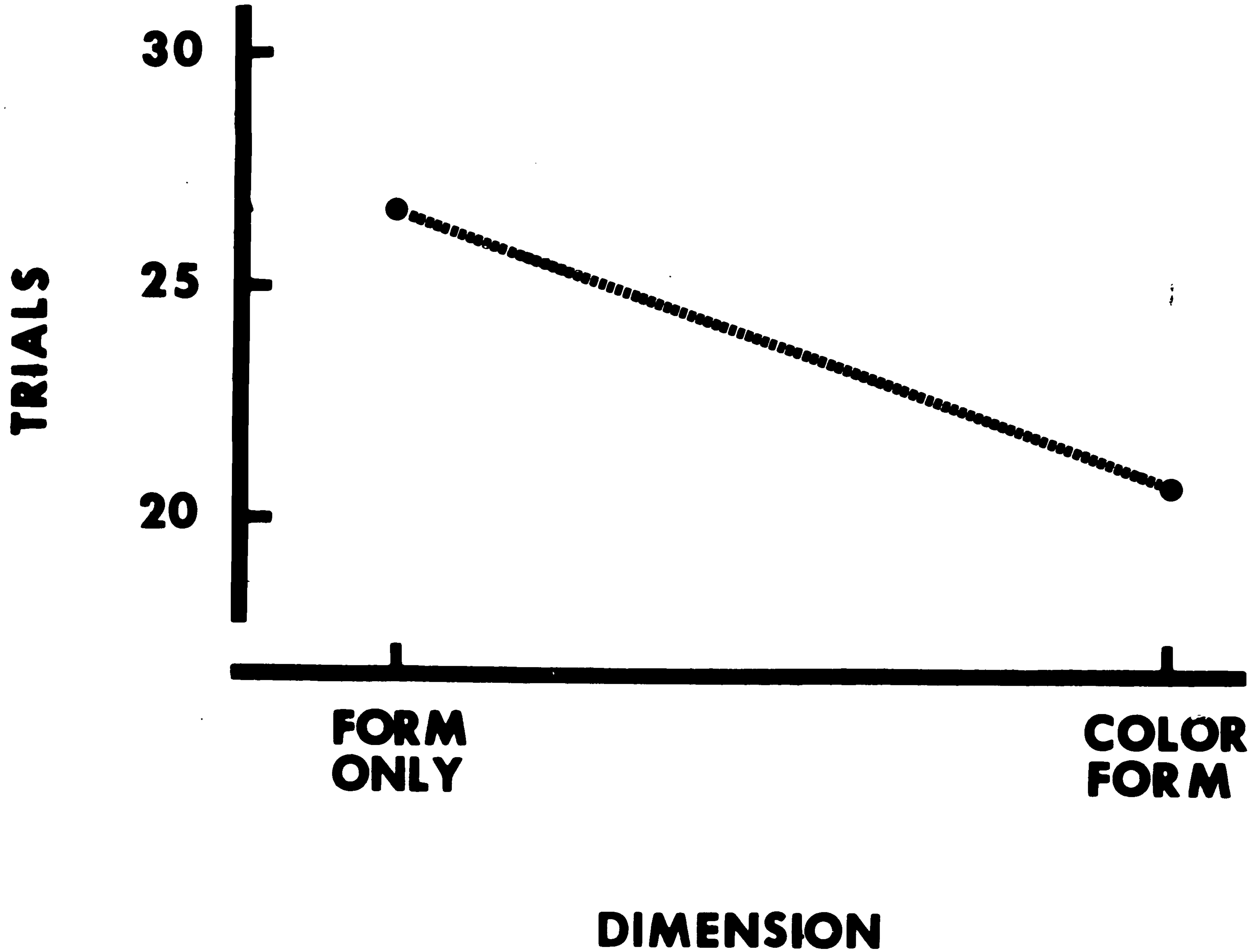

Figure 4. Number of trials to criterion for the Form-Only and Color-Form Groups.

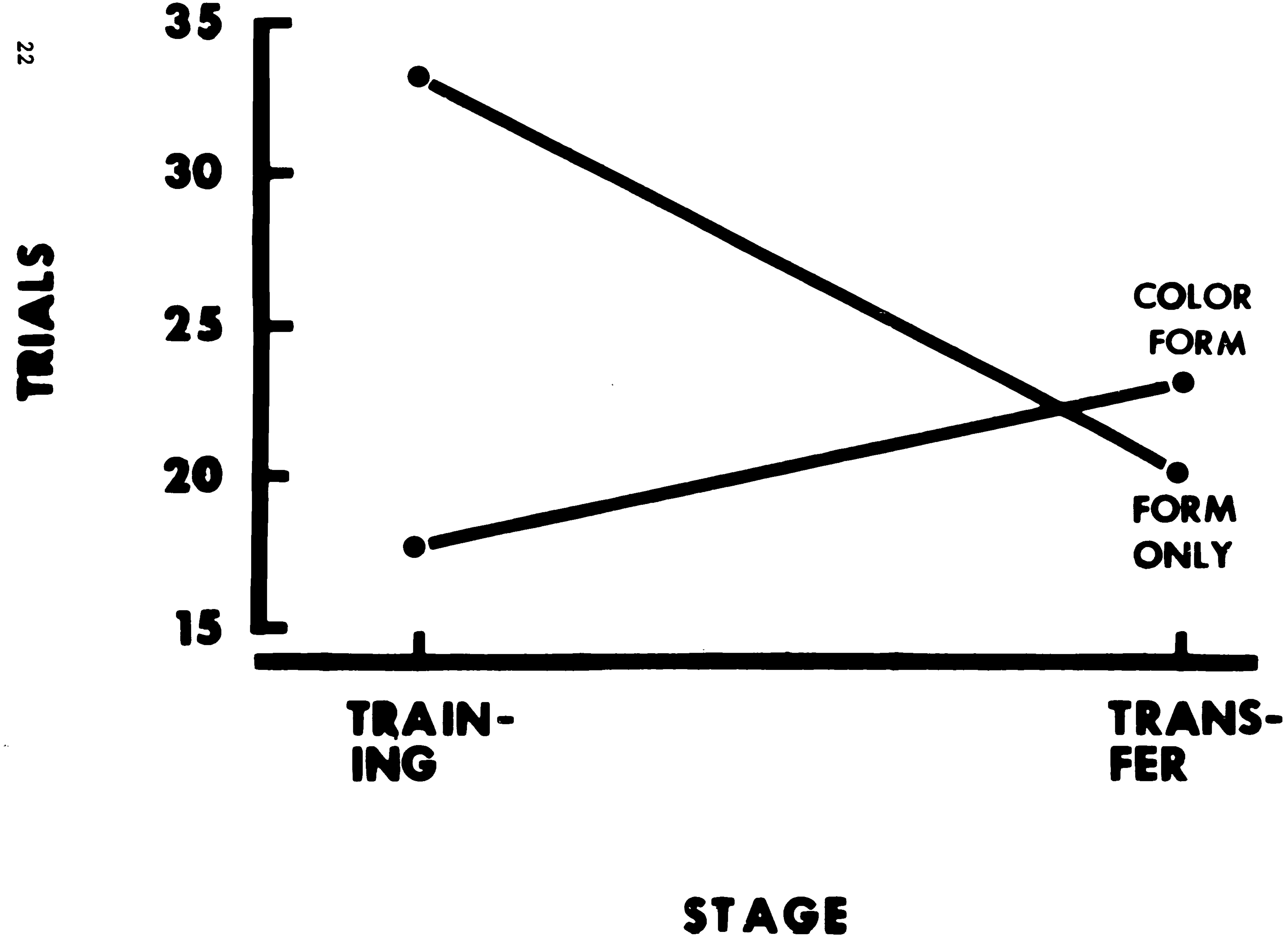

Figure 5. Trials to criterion on training and transfer for the Form-Only and Color-Form Groups.

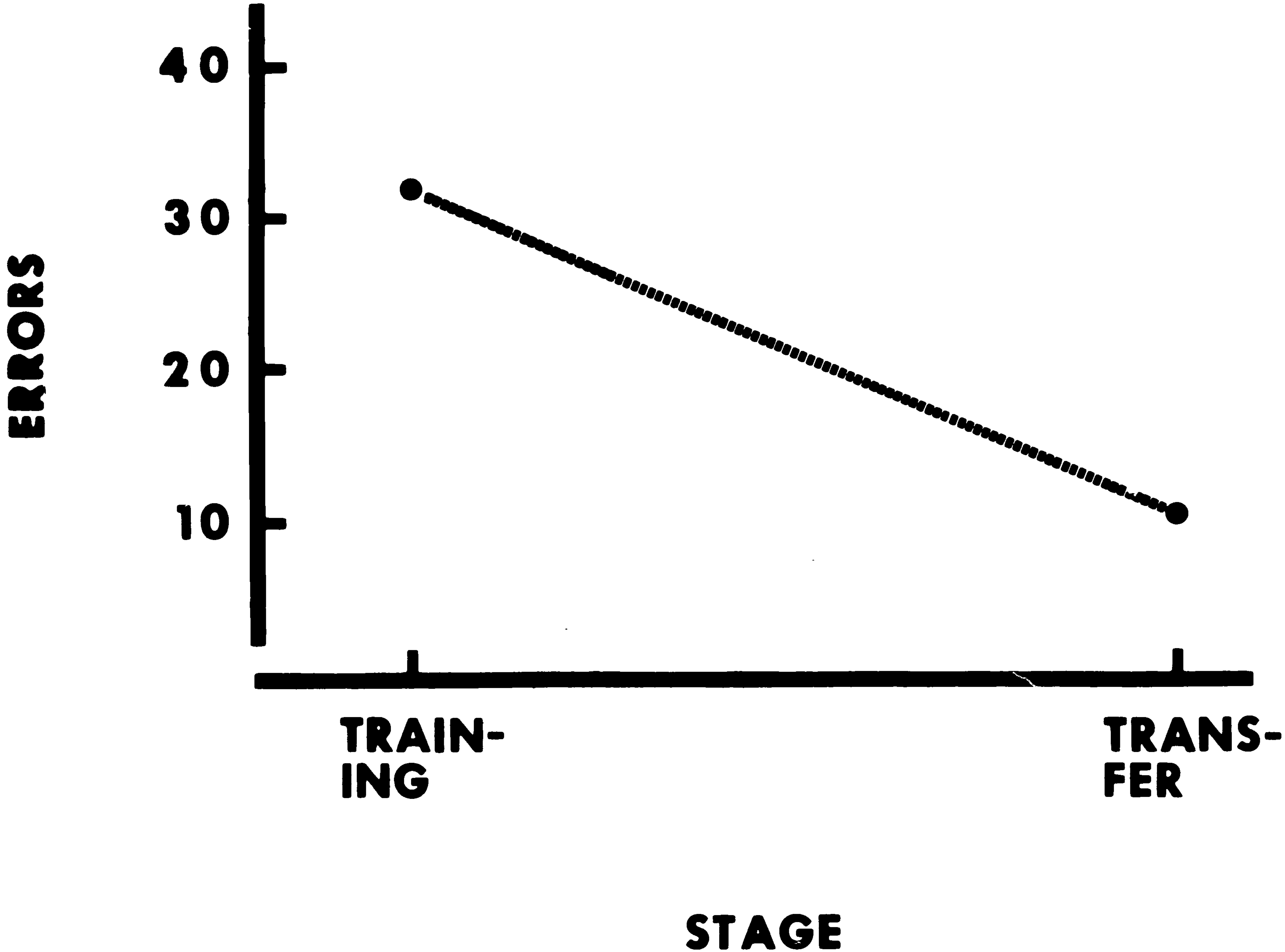

Figure 6. Manipulation errors to criterion for all the groups.

Discrimination Errors to Criterion

Figure 7 illustrates the overall superior performance of the Color-Form Groups, in terms of discrimination errors. This is reflected in a significant main effect of Number of Relevant Dimensions ($F_{1,48} = 8.75$, $p. < .01$). No significant Stage main effect was found for discrimination errors to criterion ($F_{1,48} = .34$, n.s.). However, Figure 8 illustrates the significant interaction between Stage and Number of Relevant Dimensions ($F_{1,48} = 51.96$, $p. < .01$). This interaction is shown in more detail in Figure 9 which shows the significant higher order interaction, Stage by Number of Relevant Dimensions by Amount of Learning ($F_{1,48} = 7.2$, $p. < .01$). Using Scheffe's test, this three-way interaction is shown to be solely a function of the superior performance of the Color-Form Groups on the training task ($F_{15,48} = 61.93$, $p. < .01$).

In summary, the Color-Form Groups performed significantly better, than the Form-Only Groups. This difference was a result of the superior performance by the Color-Form Groups during training. In this study an effect of cue redundancy on transfer was not found.

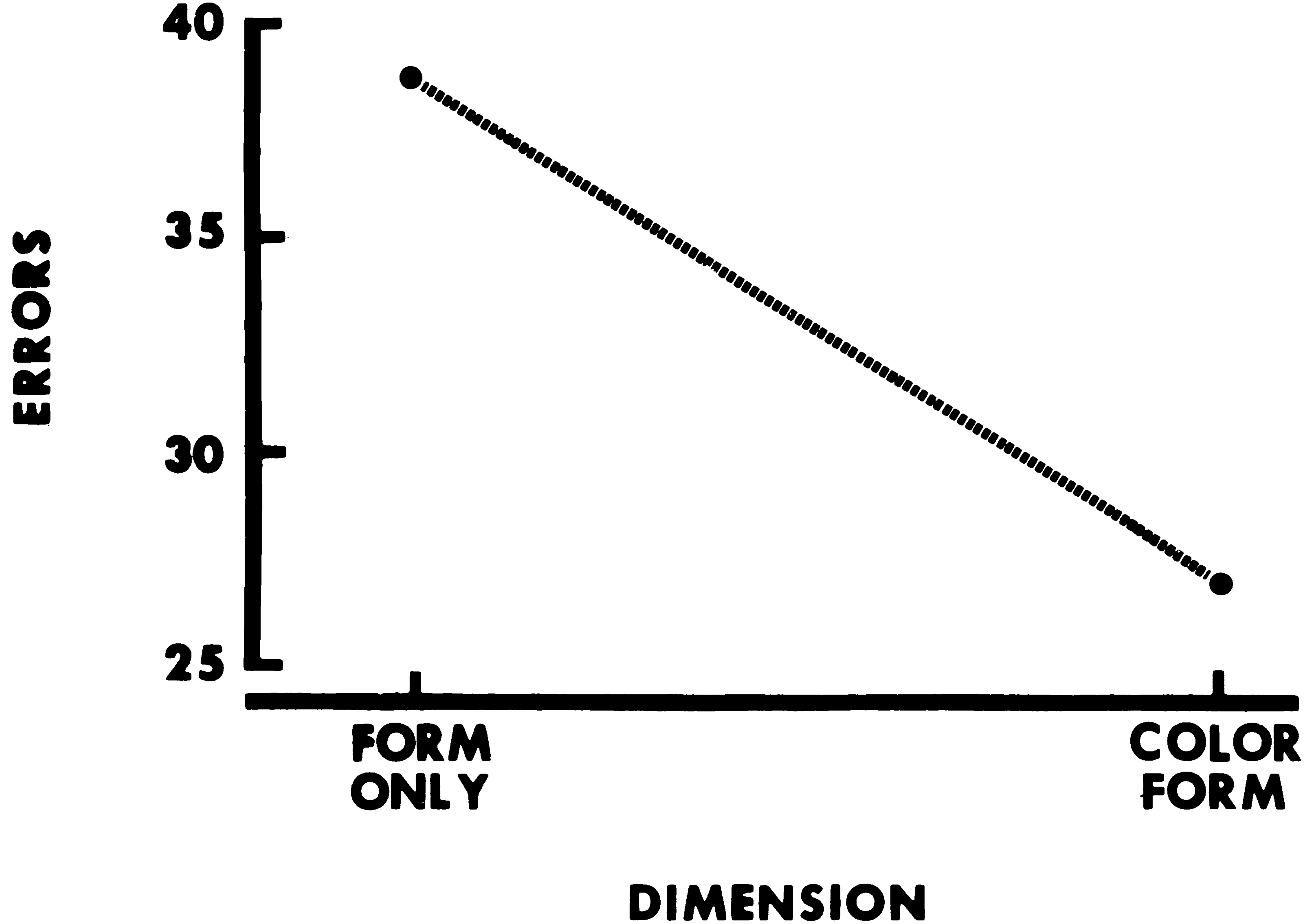

Figure 7. Discrimination errors to criterion for the Form-Only and Color-Form Groups.

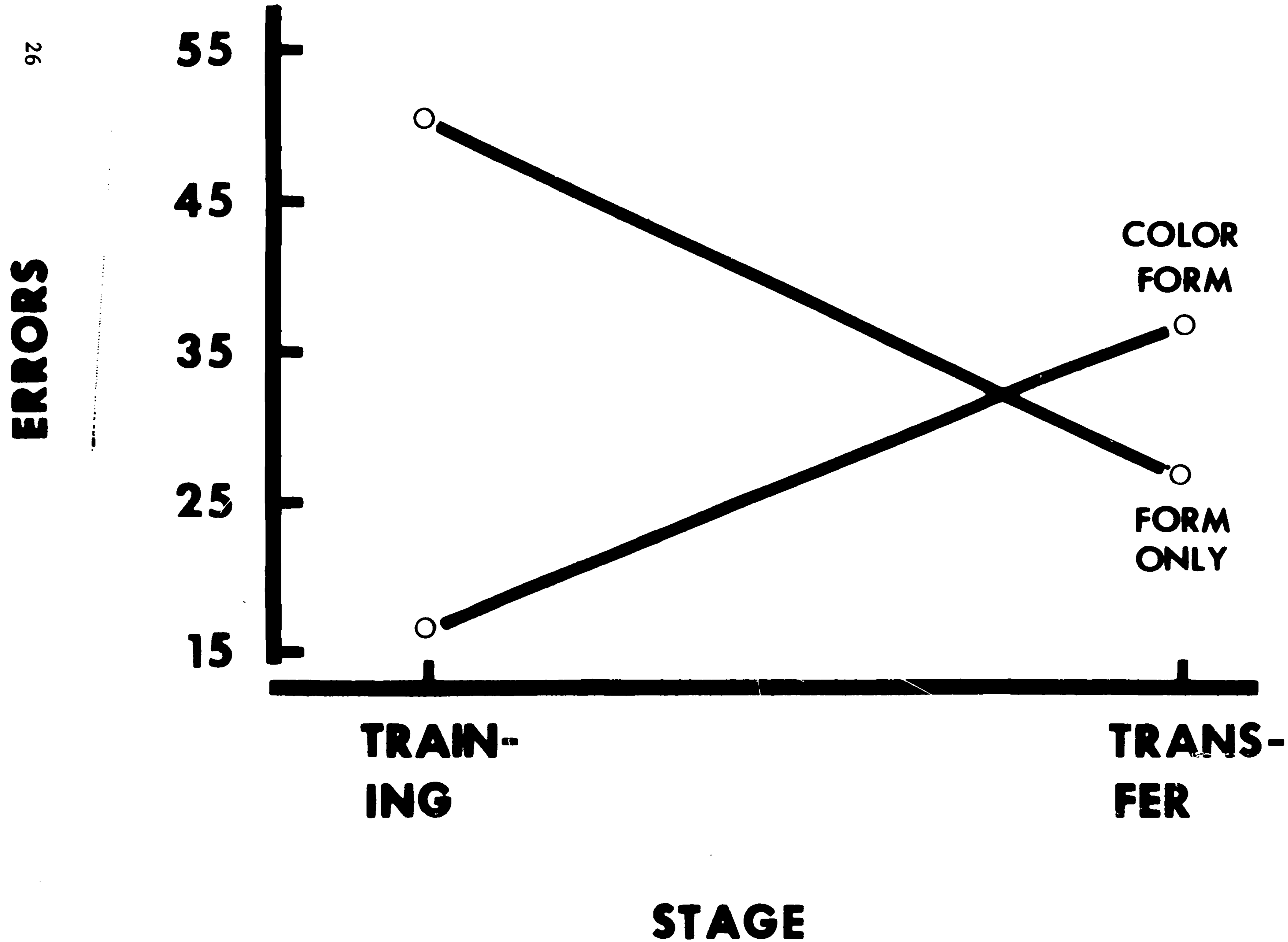

Figure 8. Discrimination errors to criterion on training and transfer for the Form-Only and Color-Form Groups.

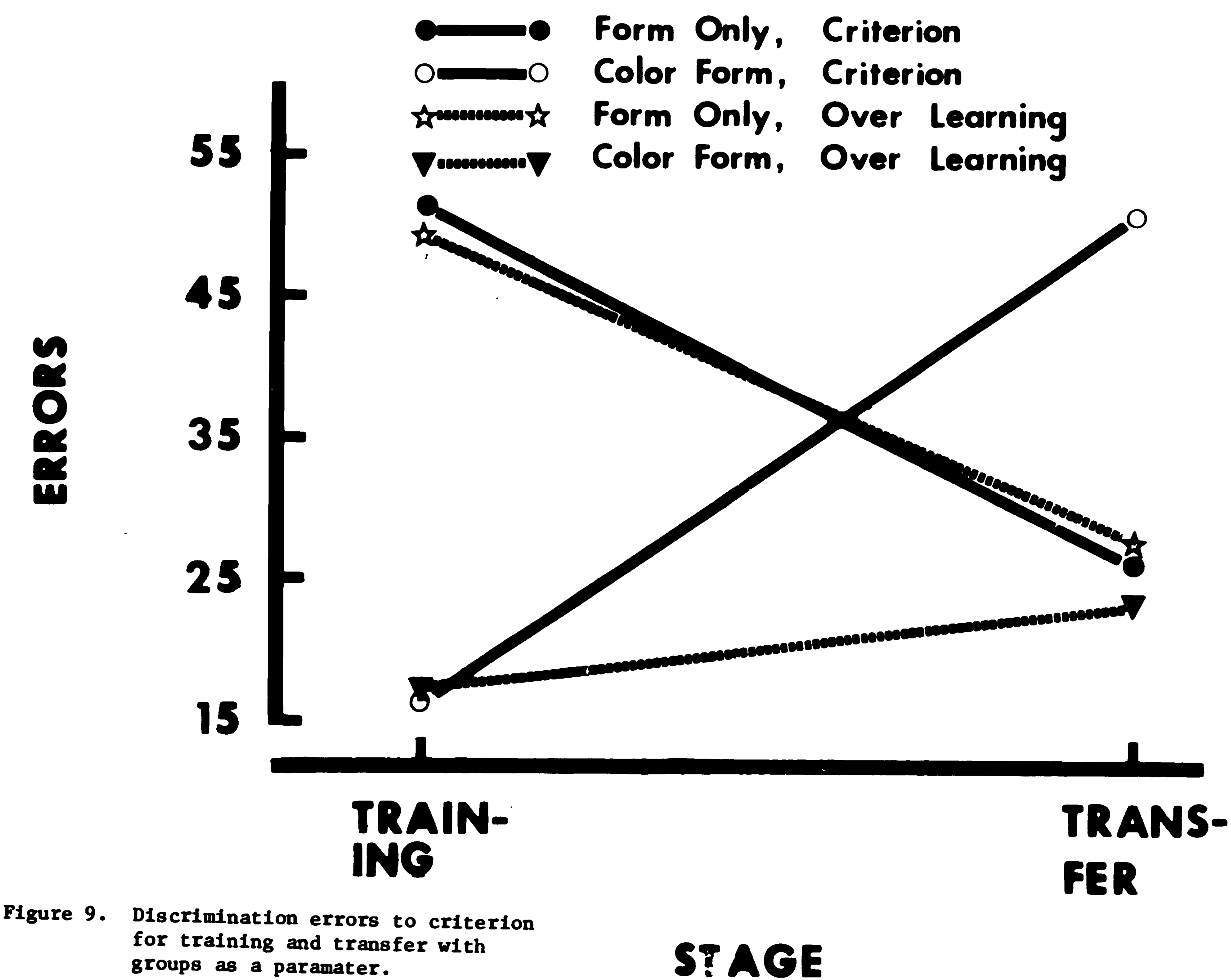

Figure 9. Discrimination errors to criterion for training and transfer with groups as a paramater.

DISCUSSION

Hypothesis I - Overlearning facilitates intradimensional transfer on a complex workshop assembly task.

An overlearning effect had been expected. It was not found. Using the rigid criterion of six correct out of eight consecutive trials might have prevented an overlearning effect from being found. Overlearning has been defined in the present study as 20 trials beyond criterion. Many of the steps, for both tasks, were learned during the early trials and were overlearned by the time criterion was achieved. Because of this the overlearning operation could not be effective and a significant Amount of Learning main effect or interaction might not have been found. That is, had the criterion been lowered, there would have been less "experience" to wash out the effect. Operationally, overlearning may have occurred on many steps of the training task before criterion was reached. In subsequent studies criterion should be lowered to minimize this effect and to clarify the effects of overlearning. In addition, two parts (shoes) should be left out of the training task brake. This would result in the elimination of nine manipulation steps and should further clarify the effects of overlearning on the transfer task.

Hypothesis II - The use of a cue redundancy facilitates learning of a complex workshop task.

The addition of a color cue to a task that did not already have one made the task much easier to learn. This supports findings from basic research in discrimination learning with the retarded and suggests a powerful tool for training procedures in sheltered workshops. For example, complex tasks such as electronic circuit board assemblies use color coded parts and are assembled by putting the parts in a particular place on the board. The relevant dimensions for solving the problem are position and color, and are redundant. The present study suggests that tasks which utilize more than a single relevant dimension might be within the capabilities of the retarded, at least so far as the discriminations are concerned. Such tasks have been thought to be too difficult because of the fine discriminations involved.

Another possible use of cue redundancy is to color code for training purposes, and remove the redundancy when criterion is reached. Using the training task of the present study as an example, clients could be trained with the color-coded brake, and then moved into production of the same assembly without the color coding. How a retardate will perform when the color is removed should be the subject of a subsequent study, but pilot work suggests that removal of the redundant cue after criterion has been reached will not result in a large decrement in performance. If such a procedure proves effective, the result could be to cut training time in half on those contracts that lend themselves to color-coding.

Hypothesis III - The use of a cue redundancy on the training task facilitates transfer to a single relevant dimension task.

Hypothesis III was not supported. The theoretical foundation for this hypothesis was based on interpretation of several studies and not on the studies themselves. The rationale was that the shift from Color-Form to Form-Only was an ID shift and that the shift from a compound to a single relevant dimension represented an easy-to-hard sequence. The nonsignificant findings regarding Hypothesis III are not surprising in view of the ambiguous nature of the rationale.

The data, while not supporting the hypothesis, do present an interesting comparison. The performance of the Color-Form-Overlearning Group on the transfer task was virtually the same as the two Form-Only Groups. This might be interpreted to mean that the use of color, as a cue redundancy with form, does not inhibit transfer to a form-only task when overlearning is given. Failure to find a meaningful effect might have been due to attenuation of the overlearning effect and should be clarified in subsequent studies. With nine manipulation steps removed the proportion of discriminative steps will increase. This, coupled with a reduction in the criterion requirement, should provide a much clearer picture of the effects of a color redundancy on a form-only transfer task, and its interaction with overlearning.

SUMMARY AND IMPLICATIONS

In summary, 64 moderately and severely retarded individuals enrolled in four sheltered workshops learned to assemble a 15 piece and a 24 piece bicycle brake. Training procedures utilized information obtained from the basic psychological research on discrimination learning. One-half of the subjects worked with the parts of the training task brake as they came from the factory (Form-only). The others worked with parts that were color coded (Color-Form). Coding consisted of painting that surface of each part that is facing the subject when it is placed in the proper position for assembly. All groups worked with the parts of the transfer task brake as they came from the factory (Form-only). Half of the subjects learned the tasks to a criterion of six correct out of eight consecutive trials, the other half performed 20 trials beyond criterion on the training task brake (overlearning). The Color-Form Groups learned the training task brake significantly faster than the Form-Only Groups. No significant overlearning effect was found.

An important outcome of this study is the discrepancy demonstrated between the capabilities of moderately and severely retarded individuals and what is presently expected of them in sheltered workshops. While certain manipulations produced an increase in learning rate, even the lowest performing groups and individuals did far better than was expected of them by the workshop personnel.

Expectancies held by workshop personnel are a function of their training and experience. Workshops are staffed primarily by professionals from the field of vocational rehabilitation. As a function of their training, these professionals direct the large part of their activity toward the social aspects of the work environment. By admission, they do little in the way of cognitive and skill development, not because they negate the importance of such emphasis, but because they do not have the necessary training to do so.

The level of functioning of sheltered workshop clients, then, remains essentially unchanged, apart from the improvement gained through the alleviation of maladaptive social behavior. Workshops presently accept sub-contracts that require little in terms of ability. A result is a low level of habilitative training and a low level of remuneration. This restriction in selecting contracts is a major cause of the unprofitable operation of most sheltered workshops. Increasing sheltered workshop income, both for the clients and the workshop would allow for improved services and programs, and a better life for those served.

The discrepancy between retardate capability and workshop personnel expectancy is clearly illustrated by describing the initial contacts made for the present study. When contact was first made with the workshops to be involved in the study, the directors were shown the training task brake and asked if they felt their clients were capable of assembling it. All four directors said their most able clients would be incapable of the task, even on an assembly line. Assembly of the transfer task brake was regarded as even more difficult. The most limited clients, with the one exception, acquired the task.

Subjects were not timed in the present study, but some general information regarding time was obtained both from the pilot studies and the present study. A typical training session of four assemblies lasted less than one-half hour. This tended, after the first session to be less than 20 minutes. Using 20 minutes as the trial block time and the grand mean for all subjects for each task, 23 trials, the average time taken to reach criterion on each of the two tasks was less than two hours.

Workshop personnel, for the most part, balk at the idea of working on a one-to-one basis, training clients for a new contract. Lack of sufficient staff, and success with group methods are given as reasons. However, the kinds of contracts presently found are of a simple nature, and consequently, easily learned. To implement more habilitative and intensive training programs, profitable and complex contracts are necessary. Such contracts would provide funds for sufficient personnel to support a sophisticated training program, making the process circular.

In the present study, even the lowest performing group exceeded the expectancies of the workshop personnel. In addition to this significant performance, it should be noted that manipulation of training procedures produced even better performance. It is not good enough to merely elevate expectancies for the retarded. Procedures must be developed and implemented to realize and challenge these new expectancies. The present experiment might represent one step in such a program.

The author is presently planning a series of studies designed to develop new strategies and techniques for training the retarded in a workshop setting. The following is a list of the kinds of studies to be included:

1. Effects of cue redundancy on transfer.
2. Effects of varying amounts of overlearning.
3. Institutional replication of the present study.
4. Effects of removal of the color dimension following criterion.

5. Effects of training or no training on acquisition of an electronic circuit board.
6. Long term retention study.
7. Incidental learning study.
8. Effects of various kinds and schedules of reinforcement on performance as distinguished from acquisition.

In conclusion, the establishment of systematic training procedures developed within a theoretical framework, appears to be a fruitful means of approaching the habilitation of the mentally retarded. With information from studies such as the present study, the retarded in sheltered workshops should attain increasing levels of sophistication regarding work.

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APPENDIX A

Analysis of Variance Tables

Trials to Criterion

A - Stage
B - Number of Relevant Dimensions
C - Amount of Learning
D - Experimenter
E - Subject

Source	DF	Sum of Squares	Mean Square	F Ratio
Within Subjects				
A	1,48	446.26	446.26	8.56 **
AXB	1,48	2840.70	2840.70	54.48 **
AXC	1,48	192.57	192.57	3.69
AXD	3,48	375.40	125.13	2.40
AXBXC	1,48	89.45	89.45	1.72
AXBXD	3,48	47.21	15.74	.30
AXCXD	3,48	264.46	88.15	1.69
AXBXCXD	3,48	171.84	57.28	1.10
Error within	48	2502.62	52.14	
Between Subjects				
B	1.48	1158.01	1158.01	9.84 **
C	1,48	255.95	255.95	2.17
D	3,48	183.59	61.20	.52
BXC	1,48	228.45	228.45	1.94
BXD	3,48	160.27	53.42	.45
CXD	3,48	362.71	120.90	1.03
BXCXD	3,48	504.46	168.15	1.43
Error between	48	5650.62	117.72	

** Significant at the 1% level of confidence.

APPENDIX A

Analysis of Variance Tables

Manipulation Errors to Criterion

A - Stage
B - Number of Relevant Dimensions
C - Amount of Learning
D - Experimenter
E - Subject

Source	DF	Sum of Squares	Mean Square	F Ratio
Within Subjects				
A	1,48	14641.88	14641.88	65.52 **
AXB	1,48	59.13	59.13	.26
AXC	1,48	15.82	15.82	.07
AXD	3,48	951.52	317.17	1.42
AXBXC	1,48	334.76	334.76	1.50
AXBXD	3,48	453.90	151.30	.68
AXCXD	3,48	355.34	118.45	.53
AXBXCXD	3,48	1715.52	571.84	2.56
Error within	48	10726.62	223.47	
Between Subjects				
E	1,48	341.26	341.26	.94
C	1,48	273.20	273.20	.75
D	3,48	2150.34	716.78	1.98
BXC	1,48	1268.82	1268.82	3.50
BXD	3,48	980.02	326.67	.90
CXD	3,48	554.71	184.90	.51
BXCXD	3,48	2569.96	856.65	2.36
Error between	48	17415.12	362.82	

** Significant at the 1% level of confidence.

APPENDIX A

Analysis of Variance Tables

Discrimination Errors to Criterion

A - Stage
B - Number of Relevant Dimensions
C - Amount of Learning
D - Experimenter
E - Subject

Source	DF	Sum of Squares	Mean Square	F Ratio
Within Subjects				
A	1,48	99.76	99.76	.34
AXB	1,48	15159.76	15159.76	51.96 **
AXC	1,48	1158.01	1158.01	3.97
AXD	3,48	768.59	256.20	.88
AXBXC	1,48	2104.38	2104.38	7.21 **
AXBXD	3,48	489.71	163.24	.56
AXCXD	3,48	1034.84	344.95	1.18
AXBXCXD	3,48	380.34	126.78	.43
Error within	48	14003.12	291.73	
Between Subjects				
B	1,48	4500.63	4500.63	8.75 **
C	1,48	1575.01	1575.01	3.06
D	3,48	566.21	188.74	.37
BXC	1,48	1345.51	1345.51	2.62
BXD	3,48	804.84	268.28	.52
CXD	3,48	1577.59	525.86	1.02
BXCXD	3,48	2206.71	735.57	1.43
Error between	48	24693.12	514.44	

** Significant at the 1% level of confidence.

APPENDIX B

Raw Data

	Training			Transfer		
Subject	Trials to Criterion	Manipulation Errors to Criterion	Discrimination Errors to Criterion	Trials to Criterion	Manipulation Errors to Criterion	Discrimination Errors to Criterion
1	39	59	98	24	19	36
2	23	34	24	24	13	28
3	50	17	60	11	6	10
4	39	35	54	16	7	34
5	41	22	86	12	0	21
6	40	29	75	37	9	42
7	22	12	19	12	3	5
8	24	19	25	15	5	21
9	26	26	47	25	13	36
10	48	33	64	26	17	31
11	15	8	8	14	1	12
12	39	33	55	34	6	32
13	26	15	35	23	10	35
14	31	33	68	21	6	23
15	13	14	10	13	13	23
16	51	52	101	22	12	30
17	19	29	29	14	8	16
18	18	27	21	11	6	9
19	38	30	54	18	11	35
20	36	29	36	20	6	23
21	43	65	100	17	12	22
22	40	35	39	12	1	11
23	43	40	49	25	9	44
24	44	27	66	18	10	41
25	38	44	64	21	12	29
26	40	28	73	18	7	18
27	48	72	70	29	9	45

APPENDIX B

Raw Data

	Training			Transfer		
Subject	Trials to Criterion	Manipulation Errors to Criterion	Discrimination Errors to Criterion	Trials to Criterion	Manipulation Errors to Criterion	Discrimination Errors to Criterion
28	27	26	54	17	8	23
29	14	4	10	14	0	18
30	41	43	62	14	5	25
31	19	38	31	42	12	45
32	29	21	29	24	15	40
33	20	23	9	30	31	76
34	27	49	50	30	26	78
35	12	20	11	14	4	14
36	21	53	22	24	17	52
37	13	22	13	25	4	30
38	10	15	7	18	4	22
39	25	60	14	35	25	74
40	11	17	9	14	8	33
41	25	56	22	38	23	65
42	44	172	32	55	26	137
43	16	26	10	25	16	22
44	13	28	20	26	10	39
45	17	29	19	20	18	34
46	12	7	16	27	15	36
47	11	15	9	39	17	51
48	19	32	2	33	19	48
49	12	23	6	20	16	24
50	21	63	26	17	17	18
51	16	26	26	17	5	25
52	26	70	24	37	23	49
53	20	14	29	19	5	17
54	18	14	30	15	2	16

APPENDIX B

Raw Data

	Training			Transfer		
Subject	Trials to Criterion	Manipulation Errors to Criterion	Discrimination Errors to Criterion	Trials to Criterion	Manipulation Errors to Criterion	Discrimination Errors to Criterion
55	8	9	2	10	3	7
56	33	25	47	22	5	47
57	13	31	8	11	6	13
58	11	20	8	10	10	11
59	11	15	14	16	4	14
60	15	27	1	28	18	43
61	28	61	30	14	12	18
62	19	16	8	13	14	16
63	10	10	12	18	4	15
64	13	12	4	32	12	36