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ABSTRACT

To investigate whether trained flexibility would generalize to a novel discrimination task and to novel preferred and nonpreferred dimensions, 40 institutionalized retarded children and adults (IQ 50-77) were trained on five two-choice simultaneous-discriminations. Control subjects were trained with a preferred dimension relevant, the others (flexibility subjects), with a nonpreferred dimension relevant. Combinations were replicated factorially to assess transfer involving the same dimensions as those used in training, or transfer involving novel dimensions. Dimensions used were color, angular-orientation, form, and spatial-configuration. Flexibility acquired in the two-choice simultaneous-discriminations generalized to the matching-to-sample task and was independent of the stimulus dimensions used in training. At the beginning of training, subjects' discrimination learning performance was affected by dimension preferences; at the end of training, performance of flexibility-trained subjects was unaffected by dimension preferences. (Author/KW)

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IMRID Behavioral Science Monograph No. 17

ROLE OF DIMENSION PREFERENCE IN THE DISCRIMINATION TRANSFER OF THE MENTALLY RETARDED: TRAINING OF FLEXIBILITY

by

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1971

ROLE OF DIMENSION PREFERENCE IN THE DISCRIMINATION TRANSFER OF THE MENTALLY RETARDED: TRAINING OF FLEXIBILITY

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When an experimentally naive child's or mentally retarded adult's dimension preference conflicts with the relevant dimension of a multidimensional discrimination task, learning efficiency is impaired. Previous research had shown that retarded individuals who were trained systematically to respond to a nonpreferred dimension acquired flexibility, i.e., the ability to solve discriminations equally easily with either a preferred or a nonpreferred dimension relevant to solution. The research reported here was designed to investigate whether trained flexibility would generalize to a novel discrimination task and to novel preferred and nonpreferred dimensions.

Forty experimentally naive institutionalized retarded children and adults (mean chronological age = 16.45 years, range 9-15 years; mean IQ score = 59.03, range 50-77) were trained on five two-choice simultaneous-discriminations. One-half of the subjects (control subjects) were consistently trained with a preferred dimension relevant; the other half (flexibility subjects), with a nonpreferred dimension relevant. These 2 X 2 treatment combinations were replicated factorially to assess transfer involving the same dimensions as those used in training, or transfer involving novel dimensions. Thus, one-half of the subjects were given both training and transfer with color and angular-orientation dimensions.

The remaining half were given training with form and spatial-configuration dimensions and transfer with color and angular-orientation dimensions. The problems for training were two-choice simultaneous-discriminations, and the transfer test was a multidimensional, two-choice matching-to-sample task.

Flexibility acquired in the two-choice simultaneous-discriminations generalized to the matching-to-sample task and was independent of the stimulus dimensions used in training. At the beginning of training the retarded subjects' discrimination learning performance was affected by dimension preferences as it is with young nonretarded children. By the conclusion of training the discrimination learning performance of flexibility-trained subjects, like that of more mature nonretarded subjects, was unaffected by dimension preferences.

The assumptions of indirect extinction and indirect acquisition of the Zeaman and House (1963) theory of discrimination learning were called into question.

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TABLE OF CONTENTS

PAGE

ACKNOWLEDGMENTS. ii

TABLE OF CONTENTS. iii

LIST OF TABLES iv

LIST OF FIGURES. vi

INTRODUCTION 1

METHOD 12

Subjects. 12

Apparatus and Materials 13

Procedure 16

Experimental Treatments and Design. 22

RESULTS. 23

DISCUSSION 33

REFERENCES 44

APPENDIXES 52

A REVIEW OF RESEARCH 53

B STIMULUS MATERIALS 73

C SUPPLEMENTARY ANALYSES 78

D RAW DATA 84

BIBLIOGRAPHY 88

LIST OF TABLES

TABLE		PAGE
1	Means and Standard Deviations (SD) for Chronological Age (CA) and IQ for Subjects in Eight Experimental Subgroups	14
2	Schematic Representation of Dimension Preference, Training, and Transfer Problems	18
3	Means and Standard Deviations (SD) for Transformed Errors and Trials in Training	24
4	Analysis of Variance Summary Table: Transformed Errors and Trials on Training Problems as a Function of Dimension Set and the Relevant Dimension in Training and Transfer	26
5	Means and Standard Deviations (SD) for Transformed Errors and Trials in the Transfer Task.	29
6	Analysis of Variance Summary Table: Transformed Errors and Trials on the Transfer Task.	31
7	Repartitioned Analyses of Variance Summary Table: Transformed Errors and Trials in Transfer to the Same Dimensions and Transfer to Novel Dimensions. . .	32
8	Analysis of Variance Summary Table: Transformed Errors on Training Problems as a Function of Relevant Training Dimension and Dimension Set.	79

TABLE		PAGE

9 Analysis of Covariance (IQ) Summary Table: Transformed Errors on Training Problems as a Function of Relevant Training Dimension and Dimension Set 80

10 Analysis of Variance Summary Table: Transformed Trials on Training Problems as a Function of Relevant Training Dimension and Dimension Set 81

11 Analysis of Covariance (IQ) Summary Table: Transformed Trials on Training Problems as a Function of Relevant Training Dimension and Dimension Set 82

12 Analysis of Covariance (IQ) Summary Table: Transformed Errors and Trials on the Transfer Task 83

13 Raw Data 85

LIST OF FIGURES

FIGURE		PAGE
1	Mean transformed trials on successive training problems as a function of relevant dimension and dimension set.	28
2	Mean transformed trials on transfer to same or novel dimensions as a function of relevant dimensions in training and transfer	30
3	Stimulus sets for dimension preference problems	74
4	Stimulus sets for training problems	75
5	The four possible stimulus displays in a training problem	76
6	Example stimulus display from the matching-to-sample transfer problem	77

Introduction

This study evolved from an unexpected finding from an earlier study of discrimination learning in the mentally retarded. The following review attempts to present the historical context within which the present study was conceived and to relate its implications to our current knowledge of the discrimination learning process in the mentally retarded.

The original impetus for the line of inquiry was Kendler and Kendler's (1959) finding that five- to seven-year-old children learned a reversal shift no faster than a nonreversal shift. This was in contrast to previous research which had indicated that adults executed a reversal or intradimensional shift more easily than a nonreversal or extradimensional shift (Buss, 1953, 1956; Kendler & D'Amato, 1955; Kendler & Mayzner, 1956; Harrow & Friedman, 1958), and led the Kendlers to reanalyze their data. They then found that children who learned the preshift problem rapidly performed like adults, i.e., learned a reversal shift more rapidly than a nonreversal shift. In contrast, children who learned the preshift problem slowly learned the subsequent nonreversal shift more easily than the reversal shift, a result consistent with the then-available literature on infrahuman shift behavior (Kelleher, 1956). The Kendlers speculated that the children of their study might have been in a transitional stage of conceptual development, a stage lying between primitive, animal-like, nonmediated learning and the mediated learning that characterizes human adults.

To account for apparent phylogenetic and ontogenetic changes in the relative difficulty of reversal and nonreversal shift phenomena, the

Kendlers formulated two pretheoretical models (Kendler & Kendler, 1962). They proposed a single-stage (S-R) model to account for the discrimination shift behavior of young children (and animals), and a two-stage (S-r-s-R) mediational model to account for the discrimination shift behavior of older humans.

The two-choice discrimination shift task is the simplest situation to which the Kendlers' models apply. A discrimination shift involves the successive acquisition of two discrimination problems. In the preshift problem the two stimuli differ simultaneously on two dimensions, e.g., color and form. One dimension is relevant, i.e., the subject is consistently rewarded for responses to one of the attributes of that dimension and consistently not rewarded for responses to the other. The remaining dimension is irrelevant, i.e., the subject is rewarded for responses to either attribute on that dimension when it is associated with the correct attribute of the relevant dimension. After learning the preshift problem the subject is required to change the basis of his response. In a reversal shift the preshift relevant dimension continues to be relevant, but the attribute-reward contingencies are reversed. In a nonreversal shift the preshift irrelevant dimension becomes relevant, and the preshift relevant dimension becomes irrelevant. Reversal and nonreversal shifts are special cases of intra- and extradimensional shifts (see Wolff, 1967, for a discussion of other shift paradigms).

The Kendlers' (1962) single-stage model assumes, as does Spence's (1936), a direct association between the physical stimulus attribute and the instrumental response. According to this model, if fortuitous intermittent reinforcement of the preshift positive attribute were eliminated, a nonreversal shift should be easier to learn than a reversal shift, because ". . . at the time of the shift the difference between the strength of the dominant incorrect habit and the to-be-correct habit is much greater for the reversal, as compared to the nonreversal shift [Kendler & Kendler, 1962, p. 7]." According to the two-stage mediational model, the physical attribute and instrumental response of the preshift problem are associated by means of an implicit mediating response identifying the relevant dimension. In a reversal shift the subject may use the same mediating response, having to learn only a new instrumental response. In a nonreversal shift the subject must learn a new mediating response in addition to a new instrumental response. Thus, a reversal shift should be easier than a nonreversal shift, because the latter involves more S-r and s-R associations, or because a mediating response is more difficult to extinguish than an instrumental response. Although recognizing that the validity of the "mediational mechanism" does not depend upon the identification of the mediator, the Kendlers generally consider the mediator to be a verbal label for the stimulus dimension (Kendler & Kendler, 1962) or a response activated by covert verbal responses (Kendler, 1964, p. 433). Nevertheless, they have not risked total exclusion of other possible mediators such as perceptual orienting responses (Kendler, Glucksberg, & Kesten, 1961).

The Kendlers' argument that younger children are nonmediators and older children are mediators received support from several studies in which a nonreversal shift was found to be easier than a reversal shift for preschool children (Kendler, Kendler, & Wells, 1960; Marsh, 1964; Tighe & Tighe, 1965), or in which an increasing probability of reversal shift in optional shift paradigms was found as a function of increasing chronological age (Kendler, Kendler, & Learnard, 1962). It was argued by others, however, that the apparent lack of mediation by young children was due to methodological problems of the earlier paradigms used to assess mediation, rather than to an inherent lack of mediation (Eimas, 1965). With a slight modification in the method of presenting the shift problem it was demonstrated that young children (Caron, 1970; Dickerson, 1966; Dickerson, Wagner, & Campione, 1970; Fritz & Blank, 1968) and even infra-human subjects (Shepp & Eimas, 1964) could execute a reversal or an intra-dimensional shift more rapidly than a nonreversal or an extradimensional shift. Attempts to discredit the developmental position on purely methodological grounds have used children at restricted age levels. When, however, the modified paradigm was used (Kendler & Kendler, 1966, 1970), or when the original and modified paradigms both were used (Tighe & Tighe, 1967) with samples of children from a broad range of age levels, the empirical fact was reasserted that the ease of reversal shifts increases with age and, by inference, mediation increases with age.

The state of knowledge at that point led to the question: If mediation expresses itself as a developmental change in either the frequency or difficulty of reversal shifts in humans, then what factors, other than methodological ones, contribute to the expression of mediation? While the above developments were taking place there was an increasing recognition that certain individual differences variables might have a significant impact on apparent mediational behaviors inferred from the transfer shift paradigms.

One of these individual differences variables is dimension preference (for an extensive review of this literature, see Appendix A). It has been demonstrated on a number of occasions over the past few decades that children have fairly strong and reliable preferences to respond to one stimulus dimension rather than to another among those commonly used in discrimination learning research, and further, that dimension preferences seem to change with the increasing maturation of children (Brian & Goodenough, 1929; Colby & Robertson, 1942; Corah, 1964, 1966; Doehring, 1960; Harris, Schaller, & Mitler, 1970; Kagan & Lemkin, 1961; Mitler & Harris, 1969; Odom & Mumbauer, 1971; Suchman & Trabasso, 1966; Trabasso, Stave, & Eichberg, 1969). Assuming that dimension preferences might affect the results of transfer-shift paradigms, Heal, Bransky, and Mankinen (1966) demonstrated that Kendler and Kendler's (1959) findings could have resulted from a correspondence between subjects' dimension preferences and the relevant dimension of the pre- and postshift conditions to which they were assigned. That dimension preference has in fact a significant impact on discrimination learning and transfer has since been demonstrated with both nonretarded children and retarded adults in studies involving a variety of stimulus dimensions and discrimination paradigms (Brown, 1970a, 1970b; Campione, 1969; Caron, 1969; Dahlem & McLaughlin, 1969; Heal et al., 1966; Heal, George, & Bransky, 1970; James, O'Brien, & Brinley, 1969; Mankinen & Heal, 1965; Smiley & Weir, 1966; Trabasso et al., 1969; Wilcock & Venables, 1968; Wolff, 1966). Kendler and Kendler (1969) have argued, however, that dimension preference theoretically should have no biasing effect on shift performance in completely counterbalanced designs used in their developmental studies (Kendler & Kendler, 1968; Kendler & Kendler, 1970; Kendler et al., 1962). But Caron (1969) has argued that the effects of dimension preference might not be eliminated by counterbalancing if the effects of dimension preference are attenuated with increasing age. Caron (1969) suggested that the relative strengths of dimension preferences might be a function of the amount of previous discrimination experience with different dimensions. Children who have had extremely variable amounts of experience with the various dimensions would be expected to have variable dimension preferences. Adults, for whom most common dimensions are presumably overlearned and at nearly equivalent attentional levels (a position consistent with findings of Odom & Mumbauer, 1971), would be expected to have no interfering dimension preferences. That is, the effects of any operationally manifest preferences should be minimal relative to the attentional response learned in the preshift problem. During the shift the rate of instrumental response extinction would presumably exceed that of dimensional response extinction, resulting in the common finding that reversal shifts are easier than are nonreversal shifts for adults.

While these issues were being developed, it was noted (Mankinen, 1968; Mankinen & Heal, 1965) that more optional reversal shifts were executed by six-year-old children who were experimentally sophisticated (Heal, 1966) than were executed by those who were naive (Kendler et al., 1962). Other investigations have found that previous problem solving facilitates reversal shifts (Saravo & Gollin, 1968; Saravo & Kolodny, 1969). Furthermore, Caron (1969), Tighe (1965), and Tighe and Tighe (1970) have found a similar facilitation of reversal shifts as a function of unreinforced pre-experimental experience with the dimensions of the shift task. These findings suggested that developmental increases in reversal shift performance might be due to experiential factors associated with increasing chronological age, rather than with maturation per se, and might be subject to experimental manipulation. This possibility was addressed in the form of two related questions: (a) What effect would differential discrimination learning experience with various stimulus dimensions have on mediation inferred from optional shift behavior? (b) What effect would such experience have on dimension preference itself?

To answer these questions Mankinen and Heal (1965) trained experimentally naive mentally retarded individuals with a learning set paradigm involving five two-choice, simultaneous-discrimination problems, each followed by an optional shift test problem. One-half of the subjects (train-preferred) were trained with their preferred dimension relevant to solution and their nonpreferred dimension irrelevant on all five problems; the remaining subjects (train-nonpreferred) were trained with their nonpreferred dimension relevant and their preferred dimension irrelevant. The initial training discrimination problem was relatively easy for the train-preferred subjects, 87% of whom executed reversal shifts in the optional shift test. These performance characteristics remained stable over all five problems. In contrast, the initial training problem was relatively difficult for the train-nonpreferred subjects, only 37% of whom made reversal shifts on the first optional shift task. By the conclusion of training, however, the train-nonpreferred subjects were solving the discrimination problem as easily as their train-preferred counterparts; moreover, all train-nonpreferred subjects were executing reversal shifts in the optional shift test. Because the performance characteristics of the train-nonpreferred subjects were so similar to those of the train-preferred subjects, it was surprising to find that they had not appreciably changed their original dimension preferences. On the final training problem they continued to respond to their previously preferred dimension on the first few trials until making their first error, after which they abruptly shifted to the nonpreferred dimension. It appeared that the train-nonpreferred subjects might have developed the flexibility to solve a discrimination problem using either their preferred or nonpreferred dimensions.

It had not been clear whether such flexibility resulted from a change in the functional effectiveness of a nonpreferred dimension as a result of experience in responding to that dimension or from experience in problem solving itself, i.e., learning set. These two factors had been necessarily confounded in training. It was expected that if problem-solving experience itself were sufficient to produce such flexibility, then train-preferred subjects should have been able to learn easily a problem with their nonpreferred dimension relevant.

Mankinen and Lucker (1966) attempted to evaluate the relative contributions of problem-solving training in general versus problem-solving training with a nonpreferred dimension. The train-preferred subjects and the train-nonpreferred subjects were returned to the laboratory 30 days after the training of the Mankinen and Heal (1965) study and were assigned factorially to subgroups: one-half of each original training group was tested on a two-choice simultaneous discrimination problem with the preferred dimension relevant, while the other half was tested on the same problem with the nonpreferred dimension relevant. The train-nonpreferred-test-preferred subjects, train-nonpreferred-test-nonpreferred subjects and the train-preferred-test-preferred subjects did not differ from one another, indicating that train-nonpreferred subjects had retained a flexibility in their ability to respond either to the previously preferred or to the previously nonpreferred dimensions. Train-preferred subjects were significantly less able to respond to their nonpreferred dimension, suggesting that problem-solving experience is insufficient of itself to facilitate flexible problem solving.

The results of these experiments (Mankinen & Heal, 1965; Mankinen & Lucker, 1966) appeared to provide substantial support for Caron's (1969) position. Although the dimension preferences of the train-nonpreferred subjects had not been altered significantly, the strength of the attentional predisposition to their nonpreferred dimension had been brought to a level commensurate with that of the strength of attention to their preferred dimension, and so preempted attention in the final discrimination as to make the execution of a reversal shift highly probable.

These two experiments had been conceived and executed within a general conceptual framework sympathetic to the Zeaman and House (1963) theory of discrimination learning in the retarded; dimensional preferences were assumed to reflect the initial probabilities of observing certain dimensions relative to others. Zeaman and House's (1963) view has been that retardates suffer from low initial probabilities of observing certain dimensions rather than from inability to acquire instrumental responses to cues within dimensions. The results of the two studies taken together, however, seemed incompatible with the theory's assumption that as the probability of attending to the relevant dimension increases there must necessarily be a simultaneous decrease in the probability of attending to the irrelevant dimension(s). One interpretation of the data is that the probability of attending to a preferred irrelevant dimension had not, as the theory assumes, decreased in any way proportionately to the increase in the probability of attending to the nonpreferred relevant dimension, at least as such probability changes could be inferred from the subjects' behavioral responses on subsequent tasks. It is difficult to conceive from that theoretical viewpoint how such a behavioral outcome could occur, unless the probabilities of attending to the preferred and nonpreferred dimensions had become approximately equated near 50%, since Zeaman and House's (1963) theory involves a closed probability system in which the probabilities of observing all dimensions are interdependent and must sum to unity. A second interpretation assumes that the rate parameter, θ_0, governing the rate of change in the observing response to a given dimension, had changed. Thus, the probability of attending to a nonpreferred dimension could increase sufficiently to control attention following a single nonreinforced observing response to the preferred dimension. Changes in rate parameters governing the observing responses, however, are incompatible with Zeaman and House's theory, which assumes these parameters to be invariant. Counterarguments to these interpretations might be offered on two grounds: (a) that the task was too insensitive to reflect real changes in the probability of attending to the preferred dimension, since the data reflected a ceiling effect in responding to a preferred dimension; (b) that the increase was in fact balanced by a decrease in the probability of attending to other dimensions, e.g., position, which were not being recorded. Obviously, no data can directly reject this second explanation, since it is virtually impossible to assess decrements in attention and responding to the many dimensions which conceivably might be exercising control over the subject's behavior.

Aside from theoretical implications, this study was designed primarily to explore further the apparent flexibility resulting from training with a nonpreferred dimension, specifically whether flexibility would generalize across learning tasks and from a familiar nonpreferred to a novel nonpreferred stimulus dimension. All of the subjects, experimentally naive mentally retarded children and young adults, were trained on a series of two-choice, simultaneous-discrimination problems similar to those used by Mankinen and Heal (1965). One-half of these subjects were trained with a preferred dimension relevant (control group), and the other half were trained with a nonpreferred dimension relevant (flexibility training group). To determine whether flexibility training would generalize to a new task, subjects were tested, following training, with a matching-to-sample task in which a preferred or nonpreferred dimension was relevant for appropriate subgroups. To determine whether flexibility training would generalize to novel dimensions, one-half of the subjects were trained with a set of dimensions different from those used in the matching-to-sample test. One-half of a fully counterbalanced design was used, the dimensions of the transfer test being the same for all subjects. It was predicted that the effects of flexibility training would be fully generalizable within the domain of dimensional and task variation employed, i.e., that the subjects trained with a nonpreferred dimension relevant would learn the novel-dimensions-transfer test with a nonpreferred dimension relevant more efficiently than would train-preferred controls. In addition to exploring the generalizability of the flexibility training effect, such a predicted outcome was seen as providing an indirect test of the assumptions underlying Zeaman and House's theory as previously discussed. Their theory does not provide for <u>increments</u> (assuming criterion learning) in attention to any dimension other than the consistently reinforced relevant dimension.

Method

In broad sequential outline this experiment involved the initial screening of subjects for defective color vision and the assessment of their dimension preferences. The subjects were assigned to treatment conditions and then given a series of two-choice simultaneous-discrimination training problems, concluded with a multidimensional matching-to-sample transfer test.

Subjects

The subjects were 40 residents from two institutions for the mentally retarded. IQ scores ranged from 50 to 77 with a mean of 59.03.

These scores were derived primarily from the Stanford-Binet Intelligence Test (1960), the Wechsler Intelligence Scale for Children, and the Wechsler Adult Intelligence Scale. Scores for 4 subjects were derived from the Wechsler-Bellevue Intelligence Scale and the Kent Series of Emergency Scales (Psychological Corporation). Chronological ages (CA) ranged from 9 to 25 years with a mean of 16.45 years. The subjects were free of gross sensory-motor anomalies, including color blindness. The means and standard deviations (SD) of IQ and CA for the 8 subgroups appear in Table 1. Eleven subjects were excluded from the final sample of 40 subjects: 7 for having inconsistent dimension preferences, 2 for failure to learn the dimension preference problems, and 2 who scored in the impaired range on a color-vision test.

Apparatus and Materials

In the dimension-preference problems and in the training problems, stimuli were presented on 11-inch by 14-inch flash cards. Each flash card contained two 4-inch square stimulus frames outlined in heavy black lines. The stimulus frames were located 13/16 inch from the bottom of the card and were separated from each other by 1-7/8 inches. In addition to these two stimulus frames the transfer pretraining cards and the transfer cards contained a 4-inch square sample frame centered above the two bottom frames, 13/16 inch from the top of the card. Stimuli from the four stimulus dimensions were placed within the stimulus frames and the cards protected with transparent nonglaring vinyl plastic. Stimulus materials used in the experiment are displayed in Appendix B.

Table 1

Means and Standard Deviations (SD) for Chronological Age (CA) and IQ for Subjects in Eight Experimental Subgroups

Relevant Dimension		Transfer	CA		IQ	
Training	Transfer	Dimension	Mean	SD	Mean	SD
Preferred	Preferred	Same	17.80	2.95	57.40	6.39
		Novel	15.80	3.19	59.00	9.06
	Nonpreferred	Same	17.00	2.83	58.40	5.94
		Novel	15.20	3.11	60.40	8.74
Nonpreferred	Preferred	Same	15.40	4.62	58.60	5.68
		Novel	19.40	2.70	62.00	12.00
	Nonpreferred	Same	12.40	2.41	59.00	7.42
		Novel	18.60	3.98	57.40	5.13

Dimension Set I. Dimension Set I consisted of attributes from the dimensions of color and angular orientation. Eighteen discriminably different colors were selected so that no two problems contained the same color hues. The color attributes were represented by

.5-inch x 3.0-inch strips of colored construction paper centered in the stimulus frames. Attributes of the angular-orientation dimension were represented by the angles of the colored strips from an imaginary horizontal axis passing through the middle of the stimulus frame. The absolute values of the angles differed by 10-degree steps, and the two values used in any problem differed by at least 30 degrees. One angular value (0 degrees) was used in two problems, once in a dimension preference problem, and again in a training problem; otherwise, the angular values of all problems were different.

Dimension Set II. Dimension Set II consisted of attributes from the dimensions of form and spatial configuration. A form attribute was represented by four forms, e.g., four circles, cut from black construction paper. Each form did not exceed the perimeter of a 15/16-inch square. Sixteen different form attributes were thus constructed. The dimension of spatial configuration was constructed by positioning the four identical forms in different patterns within an imaginary 4-inch x 4-inch grid within the stimulus frames.

Sequencing of stimuli. In all problems the positive (rewarded) relevant attribute varied unsystematically between left and right positions with the restrictions that it remain in no position more than three consecutive trials and that it be associated with each position on 50% of the trials. When an irrelevant dimension was represented, the irrelevant attributes were associated equally with each position and with the positive and negative attributes of the relevant dimension, and were, thus, uncorrelated with reward. Irrelevant attributes were associated with the same relevant attributes or a given position for no more than three consecutive trials.

Procedure

Subjects were tested individually over several sessions. In the initial session subjects were first tested for color-blindness (American Optical Company's H-R-R Pseudoisochromatic Plates), and then were given a series of dimension-preference problems to determine their dimension preferences. In this and subsequent daily sessions, subjects were given from one to three training problems, subject to scheduling limitations, for a total of five training problems. In the final session, only a transfer pretraining problem and a transfer problem were administered.

General testing procedure. Following color-blindness screening the experimenter showed the subject a large posterboard displaying six possible rewards: 1, 5, and 10 nickels; 2, 5, and 10 assorted small candy bars. The subject was told that he could win either a candy prize or a money prize, whichever he liked, but that the size of the prize would depend on the number of chips he had won over the entire series of games comprising the experiment. The subject was then given a stack of chips, and the experimenter explained that on each trial two pictures would be presented, one of which was always a "winner," the other a "loser." The experimenter explained that to win the game, the subject must put his finger on the winner enough times in a row, and that every time he picked the loser he would forfeit a chip. The subject was given a stack of 50 chips at the beginning of the dimension-preference session and at the beginning of each training problem, and 100 chips at the beginning of the transfer session. At the conclusion of the dimension-preference session and each training problem, the subject's remaining chips were set aside and could no longer be forfeited. At the conclusion of the dimension preference session and at the beginning of subsequent sessions, the subject was again shown the prize display and told that he already had enough chips for the smallest prize and was working for a bigger prize. Verbal feedback, e.g., "That's right," or "O.K.," for correct responses, and "That's the wrong one. You owe me a chip," or "Oops! You gotta give me a chip," for incorrect responses, was provided on all trials except on unreinforced choice trials of the dimension-preference problems. These general instructions and procedures followed for all problems, with minor modifications for explaining the matching-to-sample transfer task.

Dimension-preference assessment. Three dimension-preference problems each were successively administered from Dimension Sets I, then II, to determine, respectively, subject's relative preference for color versus angular orientation and for form versus spatial configuration. The order of the six problems was the same for each subject. A two-choice dimension-preference problem is illustrated in Table 2. The two dimensions are represented schematically by X and Y, respectively, with the two attributes from each dimension represented by X1, X2, Y1, and Y2, respectively. In Stage I of the problem the X and Y attributes were consistently paired with each other as redundant stimulus compounds, i.e., X1 was consistently paired with Y1 and X2 with Y2. The first Stage I compound selected by the

Table 2

Schematic Representation of Dimension Preference, Training, and Transfer Problems

Display	Dimension Preference	Training	Transfer
	Stage I		
1	X1-Y1(+) vs. X2-Y2(-)	X1-Y1(+) vs. X2-Y2(-)	X1-Y1 X1-Y1(+) vs. X2-Y2(-)
2	X2-Y2(-) vs. X1-Y1(+)	X2-Y2(-) vs. X1-Y1(+)	X1-Y1 X2-Y1(-) vs. X1-Y2(+)
3		X2-Y1(-) vs. X1-Y2(+)	X1-Y2 X1-Y1(+) vs. X2-Y2(-)
4		X1-Y2(+) vs. X2-Y1(-)	X1-Y2 X2-Y1(-) vs. X1-Y2(+)
.			X2-Y1 X1-Y1(-) vs. X2-Y2(+)
.			X2-Y2 X1-Y1(-) vs. X2-Y2(+)
.			X2-Y1 X2-Y1(+) vs. X1-Y2(-)
.	Stage II X1-Y2 vs. X2-Y1		X2-Y2 X1-Y1(-) vs. X2-Y2(+)
			X2-Y2 X2-Y1(+) vs. X1-Y2(-)

Note.—The possible cue settings, but not the order of presentation, are depicted in this table. Of the 16 cue settings in the transfer problem, half are depicted, the position of the response attribute representing the Y dimension being held constant.

subject was designated correct. Stage II, involving a single unreinforced "choice trial," immediately followed the Stage I acquisition criterion of 4 consecutive correct responses within 48 trials. On the final trial of the criterion run and on the Stage II choice trial, the subject was instructed to "pick the same one." On the Stage II choice trial, the redundant stimulus compounds were split and re-paired as X1Y2 and X2Y1. The dimension to which the subject had responded in Stage I was determined in Stage II from his choice of the new compound containing either X1 or Y1. For example, on the first trial of one preference problem the subject had to choose between a yellow stimulus whose angular orientation was 70 degrees from horizontal and a green stimulus whose angular orientation was 20 degrees. On subsequent trials he was presented these same two stimulus compounds; only their position varied between left and right stimulus frames. If he chose 70-degrees-yellow on the first trial, his choice was accepted as correct, and he was required to select this compound consistently to attain criterion. When criterion had been reached, he was required to choose between two new stimulus compounds, 20-degrees-yellow and 70-degrees-green. If he chose 20-degrees-yellow, he was assumed to have been responding to color. If he chose 70-degrees-green, he was assumed to have been responding to angular orientation. The subject was regarded to have a consistent dimension preference if he solved all three dimension-preference problems within each Dimension Set on the basis of a single dimension. Seven subjects were excluded because of inconsistent preference for color or angular orientation. The one subject with an inconsistent preference for form or spatial configuration was retained, since he had been assigned the same dimensions in training and transfer, and neither condition involved form or spatial-configuration dimensions. Two subjects failed to learn Stage I of the first dimension-preference problem and were discarded, since subsequent training problems were more difficult.

Training problems. The subject was trained with five two-choice simultaneous-discrimination problems. In each problem the subject had to choose between two stimuli which differed simultaneously on two dimensions, e.g., schematically, the X and Y dimensions in Table 2, which shows the four possible stimulus arrangements. The X dimension was relevant, i.e., the subject was consistently rewarded for responses to the positive attribute, X1(+), and unrewarded for responses to the negative attribute, X2(-). The Y dimension was irrelevant, i.e., the subject received reward for responses to the Y1 and Y2 attributes of this dimension only when they were associated with X1(+). Special training was provided if the subject failed to meet an acquisition criterion of 8 consecutive correct responses within 56 trials. For special training the experimenter showed the subject two of the four training cards, e.g., the X1Y1(+) versus X2Y2(-) card, and the X2Y1(-) versus X1Y2(+) card. The experimenter pointed out which two stimulus compounds were "always correct" and which two were "always wrong." When the subject was able to point to the correct and incorrect compounds accurately, the training problem was resumed for 20 additional trials or until the subject responded correctly 8 consecutive times. No subject failed to learn within five special training attempts, the criterion for exclusion from the experiment.

Transfer pretraining. Transfer pretraining consisted of a simple matching-to-sample problem in which the stimuli were one or two black one-inch squares. If the sample stimulus was one square, the subject had to pick the response stimulus with one square rather than the one with two squares. The subject was instructed to look first at the top picture and then to point to one of the two bottom pictures which ". . . looks most like the top picture." This problem, learned to a criterion of four consecutive correct responses, insured that differences in learning the matching-to-sample transfer problem reflected the dimensional response tendencies of the subject, rather than differences in rates of learning the principle of matching-to-sample.

Transfer problem. The transfer test consisted of a matching-to-sample problem in which the sample stimulus and the two possible matching-response stimuli varied simultaneously on the dimensions of color and angular orientation. Table 2, which shows one-half of the possible 16 stimulus arrangements, illustrates the transfer problem schematically. In the example problem, X is the relevant dimension, Y the irrelevant dimension. The subject was required to respond to the matching stimulus by selecting the response stimulus which contained the same relevant attribute that the sample stimulus contained. Thus, whenever X1 appeared in the matching stimulus, the subject had to select the response stimulus containing X1; whenever X2 appeared in the matching stimulus, he had to select the response stimulus containing X2. Responding by matching the response stimulus to the irrelevant Y attribute of the sample stimulus resulted in chance performance. Criterion of acquisition was 8 consecutive correct responses within 100 trials.

Experimental Treatments and Design

The subjects were approximately matched on IQ and assigned unsystematically to eight treatment combinations. One-half of the subjects (control group) were trained on five problems with a preferred dimension relevant; the remaining half (flexibility group) were trained with a nonpreferred dimension relevant. One-half of the subjects in each training group were given the transfer problem with a preferred dimension relevant; the other half with a nonpreferred dimension relevant. These 2 X 2 treatment combinations (preferred versus nonpreferred dimension relevant in training or transfer) were replicated factorially to assess transfer involving the same dimensions as those used in training or transfer involving novel, untrained dimensions. Thus, one-half of the subjects were given both training and transfer with the color and angular-orientation dimensions. The remaining half of the subjects were given training with form and spatial-configuration dimensions and transfer with color and angular-orientation dimensions.

The design for analysis of training data was a 2 X 2 X 2 X 5 repeated-measures design with the following factors: Training (preferred versus nonpreferred dimension relevant), Dimension Set (Set I, color and angular orientation versus Set II, form and spatial configuration), Transfer (preferred versus nonpreferred dimension relevant), and Problems (5 problems, repeated-measures factor). Two dependent variables were analyzed: (a) transformed ($\sqrt{X + 1/2}$) errors within 48 trials excluding an error on the first trial, and (b) transformed ($\sqrt{X + 1/2}$) trials, exclusive of the criterion run. Nonlearners were assigned a trials score of 56 trials.

The design for the analysis of transfer data was a 2 X 2 X 2 factorial design with the following factors: Training (preferred versus nonpreferred dimension relevant), Transfer Dimensions (same versus novel), and Transfer (preferred versus nonpreferred dimension relevant). Two dependent variables were analyzed: (a) transformed ($\sqrt{X + 1/2}$) errors to criterion, and (b) transformed ($\sqrt{X + 1/2}$) trials exclusive of the criterion run. Nonlearners were assigned a trials score of 100 trials.

The stimulus sets used in the training problems were counterbalanced in a Latin square, so that each stimulus set was equally represented in each successive problem of the training sequence. Two experimenters administered the treatments. The author collected data on four of the five subjects in each of the eight treatment combinations; the second experimenter collected data on one subject in each treatment combination. Subjects from the two institutions were assigned unsystematically to conditions.

Results

Analyses of Training

Error and trial data for the eight treatment combinations appear in Table 3. Two analyses of variance were performed on the 2 X 2 X 2 X 5 design: Training X Dimension Set X Transfer X Problems. The results are summarized in Table 4. Since the analyses of errors and trials yielded identical results, only the trials analysis will be discussed here. The significant main effect for Training (F = 66.36, 1/32 df, $p < .001$) indicated that the subjects trained with a nonpreferred dimension relevant

Table 3

Means and Standard Deviations (SD) for Transformed Errors and Trials in Training

Relevant Dimension: Training	Relevant Dimension: Transfer	Transfer Dimension		Problem 1	2	3	4	5
Transformed Errors								
Preferred	Preferred	Same	Mean	0.81	1.22	0.71	1.14	0.81
			SD	0.23	0.88	0.00	0.71	0.23
		Novel	Mean	1.08	1.04	0.99	0.81	0.71
			SD	0.82	0.51	0.40	0.23	0.00
	Nonpreferred	Same	Mean	0.81	1.22	0.71	1.48	1.09
			SD	0.23	0.88	0.00	1.46	0.62
		Novel	Mean	0.99	0.81	1.04	1.45	0.81
			SD	0.40	0.23	0.73	1.23	0.23
Nonpreferred	Preferred	Same	Mean	4.01	2.00	0.81	2.36	0.71
			SD	1.59	1.84	0.23	2.04	0.00
		Novel	Mean	4.31	3.09	1.79	1.80	1.22
			SD	0.38	1.30	0.61	1.05	0.88
	Nonpreferred	Same	Mean	4.44	2.10	2.09	1.68	1.54
			SD	0.69	1.46	2.04	1.90	1.85
		Novel	Mean	3.57	3.42	1.78	2.39	1.95
			SD	1.65	1.43	0.95	1.73	0.94

Table 3 (continued)

Relevant Dimension: Training	Relevant Dimension: Transfer	Transfer Dimension		Problem 1	2	3	4	5
Transformed Trials								
Preferred	Preferred	Same	Mean	1.20	1.92	0.91	1.60	1.09
			SD	0.58	1.67	0.28	0.97	0.38
		Novel	Mean	1.74	1.27	1.42	0.99	0.71
			SD	1.76	0.60	0.61	0.40	0.00
	Nonpreferred	Same	Mean	1.30	1.90	0.71	2.26	1.66
			SD	0.51	1.46	0.00	2.91	1.10
		Novel	Mean	1.22	1.09	1.53	1.88	0.99
			SD	0.71	0.38	1.30	1.57	0.40
Nonpreferred	Preferred	Same	Mean	6.44	2.98	1.09	3.92	0.91
			SD	2.41	3.05	0.62	3.30	0.28
		Novel	Mean	6.77	4.65	2.74	2.42	1.74
			SD	1.17	1.91	1.31	1.14	1.45
	Nonpreferred	Same	Mean	6.51	3.30	2.74	2.35	2.17
			SD	0.96	2.65	2.92	2.91	3.00
		Novel	Mean	5.40	5.01	2.48	3.52	2.73
			SD	2.28	2.29	1.09	2.62	1.34

Table 4

Analysis of Variance Summary Table: Transformed Errors and Trials on Training Problems as a Function of Dimension Set and the Relevant Dimension in Training and Transfer

Source	df	Errors Mean Square	Errors F	Trials Mean Square	Trials F
Between Subjects	39				
Training (A)	1	93.35	72.50*	225.82	66.36*
Dimension Set (B)	1	1.37	1.07	1.40	0.41
Transfer (C)	1	1.96	1.52	2.26	0.66
A x B	1	1.85	1.43	5.71	1.68
A x C	1	0.37	0.29	0.09	0.03
B x C	1	0.17	0.13	0.25	0.07
A x B x C	1	0.12	0.09	0.02	0.00
Error	32	1.29		3.40	
Within Subjects	160				
Problems (D)	4	12.36	11.16*	34.47	12.42*
A x D	4	11.68	10.55*	28.13	10.13*
B x D	4	0.49	0.44	1.69	0.61
C x D	4	0.53	0.48	1.88	0.68
A x B x D	4	1.40	1.27	3.47	1.25
A x C x D	4	0.61	0.55	1.52	0.55
B x C x D	4	0.84	0.76	2.36	0.85
A x B x C x D	4	0.62	0.56	1.82	0.66
Simple Effects					
Probs/Train-P	(4)	0.52	0.47	1.26	0.45
Probs/Train-NP	(4)	23.47	21.18*	61.28	22.07*
Error	128	1.11		2.78	
Total	199				

* $p < .001$.

required more trials to learn the problems than did the subjects trained with a preferred dimension relevant.

Significant F-ratios were also obtained for both the Problems main effect ($F = 12.42$, 4/128 df, $p < .001$) and the Training X Problems interaction ($F = 10.13$, 4/128 df, $p < .001$). Analysis of the simple effects was performed by repartitioning the sums of squares and degrees of freedom for the Problems and Training X Problems effects. The results showed no change in performance over problems for the subjects who had been trained with a preferred dimension relevant ($F < 1$, 4/128 df). A floor effect was operating for these subjects, as illustrated in Figure 1. The subjects who were trained with their preferred dimension relevant made very few errors even on their first training problem. The subjects who were trained with a nonpreferred dimension relevant, however, improved significantly over successive problems ($F = 22.07$, 4/128 df, $p < .001$).

Analysis of Transfer

Error and Trial data for the subjects in the eight treatment combinations appear in Table 5. Trial data for the eight treatment combinations are illustrated in Figure 2. Analyses of variance on errors and trials were performed on the 2 X 2 X 2 design: Training X Transfer X Transfer Dimensions. The results of these analyses are summarized in Table 6. The effects of transfer to the same dimension used in training versus transfer to novel dimensions were analyzed separately by repartitioning along the Transfer Dimensions factor. Tests of significance were done by using the overall error terms of the unpartitioned analyses.

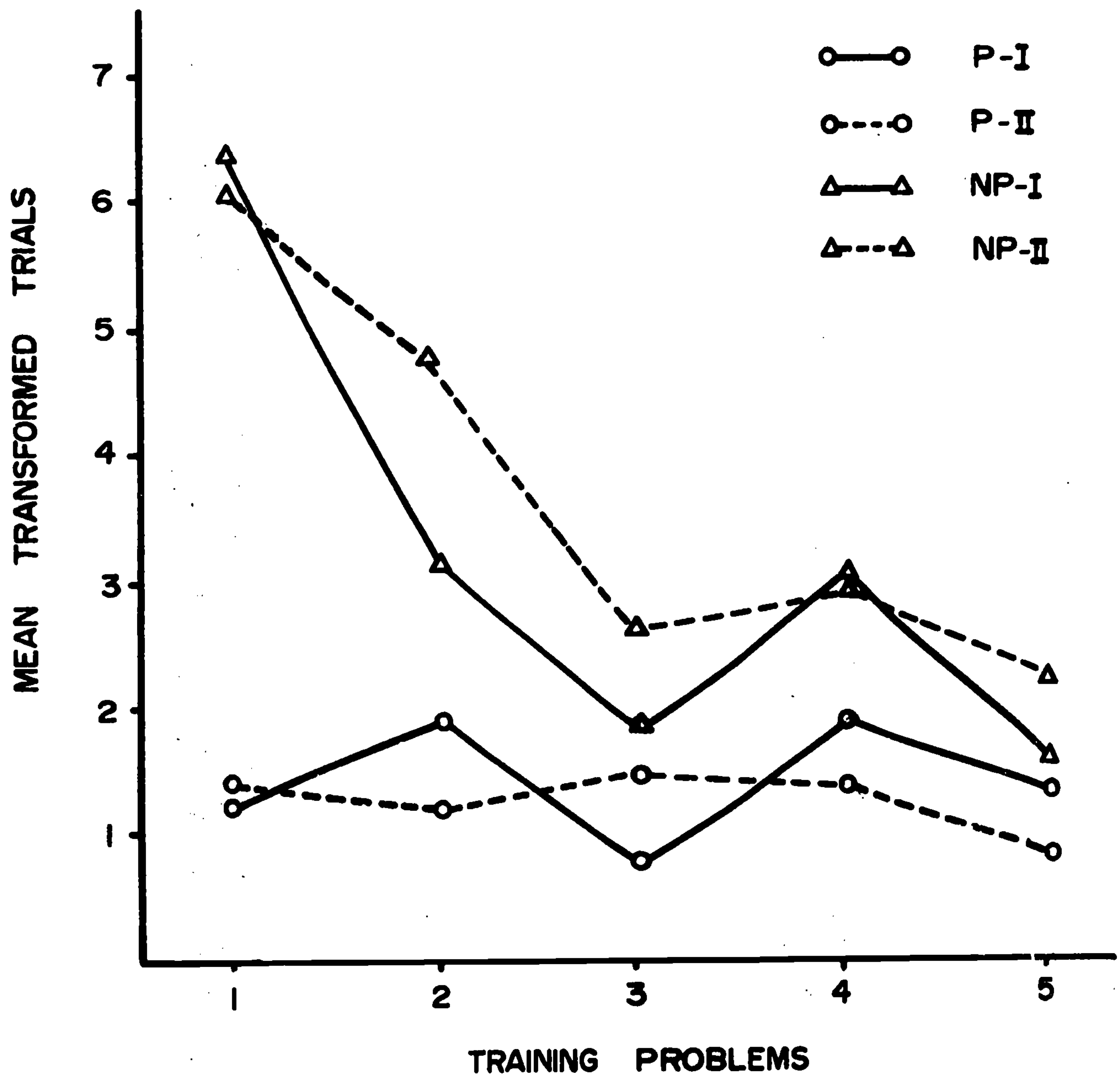

Figure 1. Mean transformed trials on successive training problems as a function of relevant dimension and dimension set.

Table 5

Means and Standard Deviations (SD) for Transformed Errors and Trials in the Transfer Task

Relevant Dimension: Training	Relevant Dimension: Transfer	Transfer Dimension	Errors: Mean	Errors: SD	Trials: Mean	Trials: SD
Preferred	Preferred	Same	0.81	0.23	0.99	0.63
		Novel	0.88	0.39	1.04	0.73
	Nonpreferred	Same	3.77	2.81	5.29	3.60
		Novel	5.99	2.52	8.49	3.44
Nonpreferred	Preferred	Same	2.73	2.52	4.31	3.59
		Novel	0.91	0.28	1.27	0.78
	Nonpreferred	Same	1.56	0.92	2.46	1.75
		Novel	2.07	1.24	3.19	1.85

The results of the parallel analyses on errors and trials are summarized in Table 7.

The Training X Transfer interactions were significant for both errors and trials, whether transfer was to the same dimension or to novel dimensions. The simple effects were tested by repartitioning the sums of squares and degrees of freedom for the Training X Transfer interaction and the Training main effect.

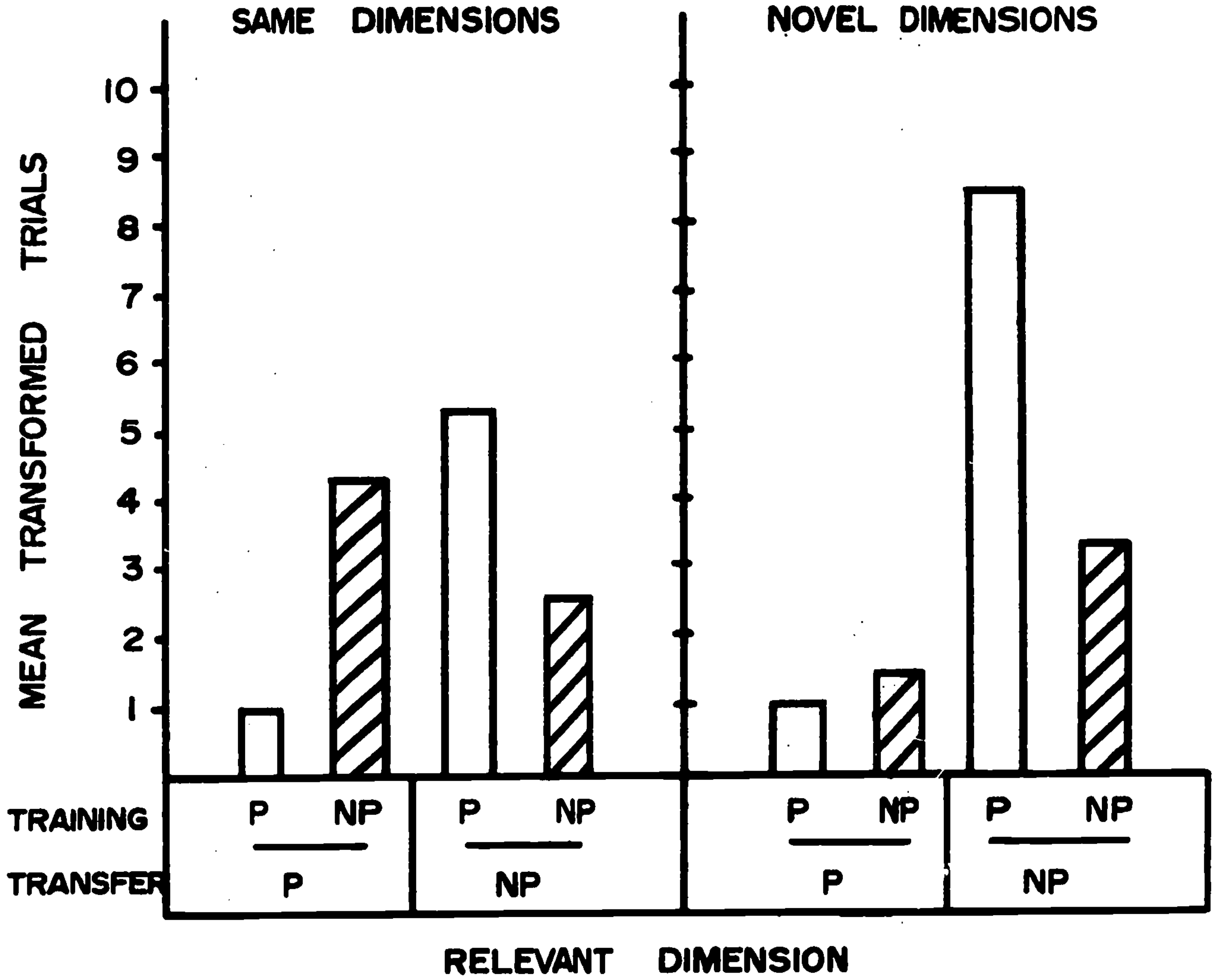

Figure 2. Mean transformed trials on transfer to same or novel dimensions as a function of relevant dimensions in training and transfer.

Table 6

Analysis of Variance Summary Table: Transformed Errors and Trials on the Transfer Task

Source	df	Errors Mean Square	Errors F	Trials Mean Square	Trials F
Training (A)	1	10.95	3.77	13.04	2.29
Dimensions (B)	1	0.61	0.21	0.55	0.10
Transfer (C)	1	40.47	13.95**	87.25	15.28**
A x B	1	8.05	2.78	19.30	3.38
A x C	1	40.78	14.06**	85.31	14.94**
B x C	1	12.48	4.30*	29.97	5.25*
A x B x C	1	0.02	0.01	0.23	0.04
Error	32	2.90		5.71	
Total	39				

* $p < .05$.

** $p < .01$.

Transfer involving the same dimensions. The parallel analyses of errors and trials yielded somewhat equivocal results. When transferred to a preferred dimension, the difference in errors between train-preferred subjects and train-nonpreferred subjects was not significant. The nonsignificant difference favored the train-preferred subjects ($F = 3.16$, 1/32 df, $.05 < p < .10$). When transferred to a nonpreferred dimension the difference in errors between groups was significant favoring superiority of the train-nonpreferred subjects ($F = 4.22$, 1/32 df, $p < .05$).

Table 7

Repartitioned Analyses of Variance Summary Table: Transformed Errors and Trials in Transfer to the Same Dimensions and Transfer to Novel Dimensions

Source	df	Errors		Trials	
		Mean Square	F	Mean Square	F
Transfer to Same Dimensions					
Training (A)	(1)	(0.11)	0.04	(0.31)	0.05
Transfer (C)	1	4.00	1.38	7.47	1.31
A x C	(1)	(21.28)	7.33*	(47.20)	8.27**
Simple Effects					
A/C_1 (P)	1	9.16	3.16	27.56	4.83*
A/C_2 (NP)	1	12.23	4.22*	19.95	3.49
Error	32	2.90		5.71	
Transfer to Novel Dimensions					
Training (A)	(1)	(18.89)	6.51*	(32.03)	5.61*
Transfer (C)	1	48.94	16.87**	109.75	19.22**
A x C	(1)	(19.51)	6.73*	(38.34)	6.71*
Simple Effects					
A/C_1 (P)	1	0.00	0.00	0.14	0.03
A/C_2 (NP)	1	38.40	13.23**	70.23	12.30**
Error	32	2.90		5.71	

Note.--The sums of squares for A and A x C are algebraically equal to the sums of squares for A/C_1 and A/C_2.

* $p < .05$.

** $p < .01$.

When transferred to a preferred dimension the difference between groups in the number of trials required to reach criterion was significant, favoring superiority of the train-preferred subjects ($F = 4.83$, 1/32 df, $p < .05$). When transferred to a nonpreferred dimension, the difference in trials was not significant ($F = 3.49$, 1/32 df, $.05 < p < .10$).

Transfer to novel dimensions. The parallel errors and trials analyses yielded essentially identical results. When transferred to a preferred dimension, there were no differences between train-preferred subjects and train-nonpreferred subjects. However, when transferred to a nonpreferred dimension, train-nonpreferred subjects learned the problem in fewer trials ($F = 12.30$, 1/32 df, $p < .005$) and with fewer errors ($F = 13.23$, 1/32 df, $p < .005$) than did train-preferred subjects.

Discussion

While the chief purpose of this study was to advance the understanding of flexibility as it was defined previously, there are some interesting implications for the Zeaman and House (1963) discrimination learning theory as well.

Flexibility

This experiment was undertaken as a phenomenon-oriented empirical investigation with incidental theoretical implications. Mankinen and Heal (1965) had found that retardated individuals trained to approach a nonpreferred dimension acquired flexibility in solving discrimination problems with either a preferred or a nonpreferred dimension relevant.

How was this acquired flexibility to be characterized? Was it generalizable, or was it specific to the training conditions in which it had been acquired? This experiment attempted to answer these questions.

The results of this study were consistent with those of previous experiments demonstrating that dimension preference, prior to flexibility training, is a significant individual differences variable affecting the relative difficulty of discrimination problems. Although different combinations of dimensions were used, the results of training corresponded closely to those found by Mankinen and Heal (1965). Subjects trained with a preferred dimension relevant learned all problems in the training series easily but failed to acquire flexibility. Subjects who had a nonpreferred dimension relevant learned the initial problems of the training series with great difficulty but showed significant improvement over successive problems. Furthermore, they acquired the predicted flexibility as reflected in transfer. Flexibility manifested in transfer to the same dimensions was attenuated by the failure of one subject in the train-nonpreferred-transfer-nonpreferred (same) condition to learn. However, flexibility was particularly evident in transfer to novel dimensions. The acquired flexibility appears to be a generalizable phenomenon. Flexibility learned in two-choice simultaneous discrimination problems was subsequently functional in a matching-to-sample task. Perhaps the most important finding was that flexibility was independent of the dimensions with which it was acquired: it generalized to novel nonpreferred dimensions.

These findings may have implications for our understanding of developmental changes in discrimination learning performance. The flexibility-trained retarded subjects performed like 4- to 7-year-old children on the initial training problems, i.e., dimension preference had a significant effect on the difficulty of discrimination learning (e.g., Smiley & Weir, 1966; Trabasso et al., 1969; Wolff, 1966). Following flexibility training, however, the retarded subjects performed like more mature children and adults, i.e., dimension preference had little effect on discrimination learning difficulty (e.g., Odom & Mumbauer, 1971). The change from performance characteristic of the young to that characteristic of the more mature suggests that variation in discrimination learning performance is not a necessary correlate of ontological development. It is, at least for the retarded, a correlate of experience. Experience may be the primary controlling factor in nonretarded children as well. Experience with all the dimensions involved in a subsequent learning task (Tighe, 1965), especially with a nonpreferred dimension (Caron, 1969) appears to result in more mature performance in young children. Similarly, experience in general discrimination problem solving also results in more mature discrimination learning performance characteristics (Saravo & Gollin, 1968; Saravo & Kolodny, 1969). The performance of train-preferred subjects in this study indicated that problem-solving experience is of itself insufficient to generate discrimination learning performance characteristic of mature humans: the train-preferred subjects had great difficulty learning the transfer task with a nonpreferred dimension. Apparently the acquisition of mature discrimination performance characteristics requires that the subjects respond selectively to nonpreferred dimensions.

Caron (1969) attempted to explain developmental changes in discrimination learning in terms of dimension preferences. He suggested that discrimination learning performance of mature humans is unaffected by dimension preference, because most dimensions, for them, have acquired equivalent asymptotic attention values. In this experiment neither the flexibility-trained subjects nor the controls had had differential experience with the novel dimensions; yet flexibility-trained subjects were superior in transfer. The successful transfer of flexibility to novel dimensions precludes equivalence of experience with dimensions (Caron, 1969) as the sole explanation of developmental changes in discrimination learning. Whatever the explanation, the flexibility observed in the present experiment and its predecessors in the series (Mankinen, 1968; Mankinen & Heal, 1965; Mankinen & Lucker, 1966) appears worthy of further systematic investigation. Discrimination problem solving certainly involves greater complexities than current theories of discrimination have been willing to treat. The following is a detailed examination of the implications of this study for one such theory, that of Zeaman and House (1963), which has inspired considerable research with the mentally retarded.

Theoretical Implications

Zeaman and House (1963) proposed two models of the discrimination learning process in the mentally retarded: a multiple-look model and a single-look model. The multiple-look model applies when several dimensions are relevant or partially relevant; hence, it does not apply to this experiment. The single-look model does apply. According to this model, the subject makes a dimensional observing response which exposes attributes along the single dimension observed. The subject learns on any one trial only about those attributes that he has observed. The single-look model allows for changes in the probability of an observing response in four ways: through (a) direct acquisition operators, and (b) direct extinction operators, both functioning with regard to the observed dimension, through which an observing response either increases or decreases as a direct function of reinforcement or nonreinforcement, respectively; and through (c) indirect acquisition operators, and (d) indirect extinction operators, both functioning with regard to all unobserved dimensions. Nonreinforcement of an observing response produces indirect acquisition of observing responses to all unobserved dimensions in proportion to their respective strengths. Similarly, reinforcement of a relevant observing response produces indirect extinction of observing responses to all unobserved dimensions in proportion to their respective strengths. Unobserved dimensions have usually been considered to be available for response in the discrimination task. When the subject attains criterion on the relevant dimension, the irrelevant dimension(s) is, by definition, unobserved.

The training data from this experiment were in agreement with Zeaman and House's (1963) attention hypothesis that mentally retarded individuals suffer from a low initial probability of observing certain relevant dimensions rather than from a deficient ability to learn which of two observed attributes is correct. When a preferred dimension was relevant, the subjects solved the problems immediately. When a nonpreferred dimension was relevant, however, the subjects solved their initial problem with great difficulty. Backward learning curves, while not reported, were in substantial agreement with those published by Zeaman and House (1963) indicating that dimension preferences affected the observing response to the dimension and not the instrumental response to cues on the dimension. The inferred probability of an observing response to the nonpreferred dimension, in accord with the model, increased over problems as a function of consistent reinforcement of responses to the nonpreferred dimension. According to the assumption of indirect extinction, then, there should also have been a concurrent decrease in the probability of observing the irrelevant dimension(s). Examination of the transfer data permits an evaluation of this assumption.

The results of the analyses of transfer involving the same dimensions that were used in training tended to support the Zeaman and House theory. When transfer involved the nonpreferred dimension, the error data revealed a significant difference favoring superior performance of train-nonpreferred subjects over that of train-preferred subjects. This difference was not significant for the trial data. When transfer involved a preferred dimension, the trial data revealed a significant difference favoring superior performance of the train-preferred subjects. This difference was not significant for the error data. Moreover, trial-by-trial inspection of the transfer data revealed that 6 of the 10 train-nonpreferred subjects responded to their nonpreferred dimension during the initial trials of the transfer task. These findings support the model's assumption that as attention to the relevant dimension increases, attention to the irrelevant dimension decreases. This pattern of results--superiority of transfer-nonpreferred subjects after nonpreferred training and superiority of transfer-preferred subjects after preferred training--may be reinterpreted in a more traditional manner. The train-preferred-transfer-preferred and the train-nonpreferred-transfer-nonpreferred conditions were, operationally, intradimensional shifts. The train-preferred-transfer-nonpreferred and the train-nonpreferred-transfer-preferred were extradimensional shifts. In the analyses reported in Table 7 the A X C interaction is identical to the main effect for a comparison between intradimensional and extra-dimensional shifts. The C main effect and the A main effect are identical to the main effect for Relevant Dimension in transfer and the Shift X Relevant Dimension interaction. On reinterpretation the intradimensional shift was significantly easier than the extradimensional shift and did not interact with dimension preference. The results, as reinterpreted, were precisely what the model predicts, given criterion learning prior to shift.

Considered independently of transfer involving novel dimensions, the results of transfer involving the training dimensions appear to be entirely consistent with Zeaman and House's (1963) discrimination theory. However, this conclusion is not supported by the results involving novel dimensions. The first anomaly regards the train-preferred-transfer-nonpreferred subjects who had the same dimension relevant in transfer, i.e., those subjects whose relevant dimension in transfer had been a previously irrelevant dimension with a low probability of being observed. On the transfer task these subjects were superior to their counterparts who had a novel dimension relevant in transfer, a dimension with which they had had no pretransfer experience (F-errors = 4.24, 1/32 df, $p < .05$; F-trials = 4.49, 1/32 df, $p < .05$). This result suggests that not only had train-preferred-transfer-nonpreferred (same dimensions) subjects maintained a high probability of observing the relevant pretransfer dimension, but they had also increased in probability of observing the irrelevant nonpreferred dimension in direct violation of the assumption of indirect extinction of observing responses to the irrelevant dimension. Indeed, direct extinction of the previously irrelevant nonpreferred dimension would assure that the familiar dimension would be, if anything, less likely to be observed than a novel nonpreferred dimension.

The following discussion of the results of transfer to novel dimensions requires two qualifications. First, interpretation must be tempered by acknowledgment of possible dimensional generalization from spatial configuration to angular orientation, e.g., the functional dimension for subjects trained with the nominally defined spatial-configuration dimension relevant might have involved aspects of angular orientation and, thus, could transfer directly to angular orientation, if relevant, in the transfer task. Secondly, subsequent discussion depends on the validity of defining novel transfer dimensions as theoretically equivalent to dimensions that were unobserved during training, but available for response. Neither of the novel dimensions had been available for response during training. The position taken here is that, according to the theory, there is no difference between an available dimension and an unavailable dimension. This argument is predicted on the theory's assertion that the subject observes attributes on one dimension at a time. Thus, during acquisition of a problem, the subject comes to observe only the relevant dimension. Since he cannot also be observing the available irrelevant dimension, it makes no difference whether that dimension is available for response or not. Furthermore, since every reinforced observing response to the relevant dimension is accompanied by indirect extinction of observing responses to the irrelevant dimension, which is not observed on those trials, then indirect extinction is assumed to apply with equal logic to unavailable dimensions.

Granting the theoretical equivalence of unavailable dimensions with respect to the operation of indirect extinction permits further evaluation of the assumption of indirect extinction. Consider the case of transfer to a novel nonpreferred dimension which, by definition, was unavailable during training. The theory would predict indirect extinction of attention to this dimension during training. Furthermore, training with a preferred or nonpreferred dimension relevant should have no differential effects on acquisition of the novel nonpreferred dimension when it is relevant in transfer. The finding that train-nonpreferred subjects were superior to train-preferred subjects on the novel, nonpreferred dimension in the transfer task, therefore, contradicts the assumption of indirect extinction.

In the case of train-nonpreferred-transfer-nonpreferred (novel dimensions) subjects, it appears that some kind of indirect acquisition of the formerly unavailable dimension occurred. A critical test of this assertion requires comparison of the transfer performance of these subjects with untrained subjects who were not included in the present experiment. However, their performance in transfer did not differ significantly from perfect, errorless performance (F-trials = 3.18, 1/32 df, $p > .10$). In all relevant studies cited earlier performance on an untrained nonpreferred dimension was found to be inferior to performance on an untrained preferred dimension. It is reasonable to conclude, therefore, that training on a nonpreferred dimension resulted in an increment in attention to a previously unavailable nonpreferred dimension. Train-nonpreferred subjects received frequent nonreinforcement of their often-observed preferred dimension, because it was irrelevant during training. Nonreinforcement of observing responses meets the theoretical criterion for indirect acquisition of unavailable, unobserved dimensions. Similarly, train-preferred subjects received frequent reinforcement of their preferred dimension, because it was relevant during training. Reinforcement of observing responses meets the theoretical criterion for indirect extinction of unavailable, unobserved dimensions. Indirect extinction would apply equally to the relevant and irrelevant dimensions in novel transfer for train-preferred subjects. Similarly, indirect acquisition would apply equally to the relevant and irrelevant dimension in novel transfer for train-nonpreferred subjects. Thus, the theory seems able to account for the significant superiority of the train-nonpreferred subjects over the train-preferred subjects when transfer involved a novel nonpreferred dimension. However, the same pattern of performance should have obtained for train-preferred and train-nonpreferred subjects when transfer involved a novel preferred dimension. That is, when transferred to a novel preferred dimension the performance of train-preferred subjects should have been inferior to that of train-nonpreferred subjects. In fact, train-preferred subjects did not differ from errorless performance (F-trials = .09, 1/32 df, $p > .50$), indicating no indirect extinction.

Comparisons of training and transfer conditions involving the same dimensions appeared to be consistent with Zeaman and House's (1963) theory of discrimination learning as well as consistent with previous research supporting the theory. By introducing novel dimensions, the present experiment represented a departure from traditional paradigms used to test the theory. The results provided evidence making questionable the validity of the theory's assumption that indirect extinction of unobserved dimensions occurs concurrently with reinforcement of relevant observing responses. The assumption that indirect acquisition of unobserved dimensions occurs only as a function of nonreinforcement of observing responses may also be of questionable validity.

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APPENDIXES

APPENDIX A

REVIEW OF RESEARCH

Review of Research: The Relationship of Dimension Preference to Discrimination Learning

The processes of discriminating among stimulu and of abstracting invariants (dimensions) among various attributes of stimuli are two fundamental abilities necessary for learning and survival. These processes often act in concert. Stimuli to be discriminated almost invariably feature complexes of attributes from several dimensions. In discriminating among stimuli, an individual frequently learns to isolate or abstract certain of the dimensions and to respond selectively to stimulus attributes that vary on those dimensions. Furthermore, an individual appears predisposed to attend to (respond selectively to) specific dimensions as his first--occasionally only--basis of discrimination or comparison, to the exclusion of other equally functional dimensions. This predisposition, operationalized, is a person's dimension preference.

Dimension preference has been operationalized in a number of paradigms, such as the two-choice simultaneous discrimination (Heal, Bransky, & Mankinen, 1966), the matching-to-sample task (Mitler & Harris, 1969), and the oddity learning task (Brown, 1970a). In each of these paradigms the individual is shown two or more stimuli, each differing from the others in terms of the simultaneous presence of attributes from several dimensions. Each dimension preference task is ambiguous, because there is more than one possible "solution." Each of these solutions is a systematic trial-to-trial response pattern that is associated with trial-to-trial stimulus variations on one and only one of the dimensions of the stimuli. If the subject uses one response pattern with an arbitrarily defined degree of consistency he is said to have manifested a preference for that dimension.

Although an individual may manifest dimension preferences among highly abstract dimensions such as functional and relational conceptual dimensions, this review is focused on issues surrounding dimension preferences among visual-perceptual dimensions, e.g., color and form, with special awareness of the relationship between dimension preferences and cognitive maturity. Issues of concern include: (a) the effects of stimulus variations on dimension preference; (b) dimension preference as a correlate of chronological age; and (c) the relation between dimension preference and unidimensional discrimination learning, multidimensional discrimination learning, and transfer shifts.

The Effects of Stimulus Variations on Dimension Preference

Varying the relative discriminability of attributes within dimensions can affect the proportions of individuals preferring one dimension to another. Campione (1969), for example, minimized the discriminability of form attributes relative to size attributes and found that all of his Ss manifested size preferences. Alternatively, one could adjust the relative discriminability of attributes within dimensions so that half of a sample would prefer one dimension, and half would prefer the other. Quite obviously, manifest dimension preferences are modified by the relative discriminability of attributes among the dimensions being compared.

A distinction must be made between manifest dimension preference, as operationally defined, and dimension preference as a hypothetical construct. While dimension preference as a construct is considered stable across situations, stimulus variations do affect behavior. For example, Heal (1967, 1968) found that a given retardate might manifestly prefer color with one set of stimuli and form with another set. However, despite these variations in absolute manifest preferences, the preferences of his retardates relative to one another was stable. Heal (1967) concluded that, for any pair of dimensions, individuals lie along a continuum of preference for one or the other, and that the distance between any given pair of individuals was invariant over the stimulus values lying on those dimensions. The studies cited throughout this review indicate that there may in fact be stable differences in dimension preferences among individuals. However, there is evidence that stimulus variations have a more complex effect on the manifestation of dimension preferences than Heal proposed. For instance, it may be that color and form preferrers are differentially affected by the use of stereometric *vis-a-vis* planometric stimuli, or by a change in the discriminability of attributes of one dimension, but not the other.

Stereometric versus planometric stimuli. An apparent paradox has resulted when stereometric and planometric stimuli have been used in the assessment of dimension preference. Relative to planometric stimuli, stereometric stimuli have been associated with both more color choices and more form choices. Brian and Goodenough (1929) investigated the relative preferences for color and form among children ranging in age from 1-2 to 14-0 years. From age three to six most of the children were color preferrers. Within the three- to six-year group stereometric and planometric stimuli were used to determine preferences for color and form. Among mostly color-preferring children more color choices were obtained with stereometric stimuli than with planometric stimuli. Other studies, in which most of the children were form preferrers, found more form choices with stereometric stimuli than with planometric stimuli (Gaines, 1964; Huang, 1945; Suchman, 1966a). Since the learning of discrimination problems is easier with stereometric stimuli than with planometric stimuli, other conditions being equal (House & Zeaman, 1960), it seems reasonable to assume that stereometric stimuli are more discriminable than planometric stimuli. The apparent paradox, then, may be resolved by the interpretation that to increase the discriminability of cues is to increase the salience of the preferred dimension at the expense of the nonpreferred dimension.

Variations in form and color discriminability. While there is a more or less monotonic relationship between discriminability of attributes on a dimension and manifest preference for that dimension, recent data force qualification of this simple interpretation. Corah (1966) compared the number of color and form choices made by kindergarten children in an ambiguous matching-to-sample task under three levels of form discriminability. Most of the Ss preferred form. He found that the more easily discriminable forms were associated with more form choices. In the least discriminable form condition, even though the stimuli differed on saturated colors, a large and significant number of Ss were dropped from the experiment either for adopting a positional response bias or for lack of "consistency" (not clearly defined). This attrition suggests that many form-preferring children found it difficult to adopt an alternative color response when the forms were difficult to discriminate. Similarly, Kagan and Lemkin (1961) found that when form was eliminated from a color-form-size problem, 20% of the form preferrers were unable to adopt one of the alternative solutions. An additional finding of Corah's (1966) was that making colors more discriminable increased the number of color responses regardless of the relative discriminability of the forms. In preschoolers, about evenly matched for form and color preference, Huang (1945) also found that the number of form choices increased with increasing discriminability of form attributes and that the number of color responses increased with increasing discriminability of colors. These three studies provide fairly consistent evidence that the two dimensions act together to determine the number of choices made to either dimension. In criticism it should be noted that Corah's (1966) stimuli were so biased that almost all Ss could meet a stringent criterion of form preference. Huang's (1945) stimuli permitted sufficient variability of preference, but comparisons did not permit assessment of differential effects of stimulus variations on color and form preferrers.

Two studies investigated stimulus variations among color and form preferrers separately. Harris, Schaller, and Mitler (1970) compared color and form choices under three form conditions: geometric stimuli, silhouettes of animal figures, and "scrambled" animal figures. Young color preferrers (4-1 to 6-4) made more color choices to the realistic figures than to the geometric forms. Scrambled figures, the least meaningful, were also associated with increased color choices. Furthermore, similar effects were observed for form preferrers. This study was concerned with meaningfulness of stimuli, rather than discriminability; hence, the findings are not clearly interpretable within the framework of this review. Suchman and Trabasso (1966) found that increasing the saturation of colors led to more color choices among preschool color preferrers, but paradoxically led to more form choices among form preferrers.

In summary, extreme bias in discriminability of one stimulus dimension can lead to unanimous manifest preference for that dimension over another. More moderate stimulus variations permit greater heterogeneity of manifest preference. Under such moderate conditions the studies comparing stereometric versus planometric stimuli and Suchman and Trabasso's (1966) study suggest a dynamic relationship between preference and stimulus variations--increasing the discriminability of color within certain limits may increase responding to a preferred color dimension or to a preferred form dimension. It appears that the relationship between preference and discriminability is not straightforward. An important question for further research is whether individuals maintain the same rank-ordering on the hypothetical dimension preference continuum, in spite of the complexities introduced as stimulus variations.

Dimension Preference as a Correlate of Age

Of the studies investigating or reflecting dimension preferences at several age levels in Western culture, several have noted a preference for form among young children between two and three years of age (Brian & Goodenough, 1929; Trabasso, Stave, & Eichberg, 1969, Experiment 2). These and others have demonstrated a preference for color in preschool children above three years and a preference for form in school-age children (Corah, 1964; Kofsky & Osler, 1967, Experiment I; Suchman & Trabasso, 1966). Most studies, however, have found that more than 50% of normal children at both preschool and school-age levels prefer form (Colby & Robertson, 1942; Corah, 1966; Doehring, 1960; Harris et al., 1970; Kagan & Lemkin, 1961; Mitler & Harris, 1969; Odom & Mumbauer, 1971; Reichard, Schneider, & Rapaport, 1944; Trabasso et al., 1969, Experiment 1). Furthermore, most studies have shown an increasing preference for form with increasing age.

While there is agreement that the frequency of form choices increases with age, investigators have reported widely varying proportions of color and form preferrers at any given age level. Perhaps these differences among studies reflect the influences of variations in stimulus discriminability discussed in the previous section. On the other hand, they might reflect differences in childrens' relative experiences with different stimulus materials from one decade to another (Corah, 1966), or perhaps experientially confounded social class differences between samples (Trabasso et al., 1969). Extensive experimentally imposed experience color or form discriminations has been associated with shifts in preferences towards color or form in both color- and form-preferring children from 4.6 to 7.6 years of age (Gaines, 1970). Such shifts, although statistically significant, were not remarkable, indicating that preferences are reasonably stable, in spite of experience, over a five-week interval.

The commonly demonstrated increasing incidence of form preference as a function of increasing age is not universal. Greenfield, Reich, & Olver (1966) found a continuously increasing preference for color as a function of age in certain African cultures not being schooled in Western traditions. Similar findings have been reported by Serpell (1969a, 1969b) and Suchman (1966b). It is probable, then, that the incidence of preferences reflects cultural demands, or more specifically, the ability of children to adapt to cultural demands. Thus, in Western culture, which emphasizes such form discriminations as learning of the alphabet, color preference beyond preschool might indicate inferior learning ability or lack of conceptual maturity (Suchman & Trabasso, 1966). This conjecture is supported by positive correlations reported between IQ and form preference (Corah, Jones, & Miller, 1966) and a disproportionately high percentage of color preferrers among the mentally retarded as indicated by initial sorting in concept sorting tasks (Halpin, 1958; Silverstein & Mohan, 1962) and by performance on the Color Pyramids Test (Schaie, 1958).

Discrimination Learning as a Correlate of Dimension Preference

If dimension preferences do reflect developmental levels of perceptual and/or cognitive maturity, form preferrers should be superior to color preferrers in unidimensional discrimination ability. In multidimensional discriminations, if dimension preference controls initial attention, a problem with a preferred dimension relevant should be easier than one with a nonpreferred dimension relevant. Furthermore, to the extent that dimension preferences reflect cognitive maturity, interactions may be expected between dimension preference and the relevant dimensions of a multidimensional discrimination and discrimination shift.

Unidimensional discrimination ability. There appear to be no investigations of possible relationships between discrimination ability in a strictly psychophysical sense and dimension preferences. Several studies, however, have compared form and color preferrers' unidimensional discrimination ability with small, invariant differences between stimuli. Gaines (1964) compared normal-IQ deaf and hearing children matched on age (8 to 11 years) and other important demographic and organismic variables. She found that deaf children, 55 percent of whom preferred color, discriminated colors differing by 5 percent in saturation more accurately than did hearing children, only 23 percent of whom preferred color. On the otherhand the hearing children preferred form and discriminated asymmetric forms differing in internal angle by 4 degrees more accurately than did deaf children. Suchman (1966a) also found that deaf children (CA 7-6 to 12-3) preferred color and discriminated 5 percent saturation differences more accurately than hearing children. Hearing children preferred form and discriminated 4 degree internal angle differences more accurately than deaf children. She found a nonsignificant trend for form preferrers to be generally superior to color preferrers on both color and form discriminative accuracy.

In an experiment involving unimpaired children (CA = 56.94 months) Corah et al. (1966, Experiment 1) found no differences between form and color preferrers' abilities in an oddity discrimination involving colors or forms of quantitatively unspecified stimulus differences. In a second experiment, involving older children (CA = 67 months) and a greater range of stimulus differences, Corah et al. (1966, Experiment 2) found that form preferrers discriminated colors better than color preferrers! There were no differences between color and form preferrers' abilities to discriminate forms.

These studies suggest that form preferrers hold an overall advantage in discrimination ability. Drawing conclusions from the limited data available at this time, however, seems unwarranted.

Multidimensional discrimination learning as a correlate of dimension preference. The preceding section reviewed discrimination studies having a single dimension that varied under the experimenter's control. This section considers studies in which Ss were required to learn a multidimensional discrimination problem with the solution based on either a preferred or a nonpreferred dimension. Some studies used a single problem, while others tested for transfer effects from an initial problem to a second problem. The acquisition of a single problem is, of course, equivalent to acquisition of a pretransfer problem in discrimination shift studies.

The studies reviewed found universally that a single or pretransfer discrimination problem was learned more easily when a preferred dimension was relevant to solution than when a nonpreferred dimension was relevant. This was found to be true in the two-choice simultaneous discrimination learning paradigm for the following combinations of dimensions and populations: with color and form dimensions among nonretarded children (Crane & Ross, 1967; Dahlem & McLaughlin, 1969; James, O'Brien, & Brinley, 1969; Odom & Mumbauer, 1971; Smiley & Weir, 1966; Trabasso et al., 1969) and among retardates (Heal, George, & Bransky, 1970; Mankinen &

Heal, 1965); with size and brightness dimensions among young nonretarded children (Caron, 1969; Wolff, 1966); with brightness and numerousity dimensions (Heal et al., 1966) and form and size dimensions among the retarded (Campione, 1969). Similar results were obtained by Brown (1970a, 1970b) among young nonretardates in oddity learning tasks involving color and form and by Wilcock and Venables (1968) among both retardates and nonretardates in a matching-to-sample task involving color and form. There can be no doubt that dimension preferences are universal subject characteristics expressed with respect to a number of perceptual stimulus dimensions and within a variety of learning paradigms.

Discrimination shifts and dimension preferences. A number of the above-mentioned studies were also concerned with the effects of dimension preference on discrimination shifts, which involve the acquisition of two successive problems. Performance in the second problem is used to assess transfer effects from the first. Discrimination shifts may be classified, on the basis of changes in stimulus attributes, as reversal and non-reversal shifts or an intradimensional (ID) and extradimensional (ED) shifts. Reversal and nonreversal shifts involve no changes in attributes from the relevant and irrelevant dimensions, respectively, of the pre-transfer problem to the shift problem. Although complex variations are possible, ID and ED shifts commonly involve substitution of new attributes in the shift problem for those of the relevant and irrelevant dimensions, respectively, of the pretransfer problem. Discrimination shift problems may also be classified into two general paradigms: predetermined shifts and optional shifts. In the predetermined shift paradigm the experimenter arbitrarily designates which dimensions will be relevant and irrelevant in the transfer problem. For the purpose of this review several indices of the effects of dimension preference are of interest: (a) the relative difficulty of the pretransfer problem when a preferred or a nonpreferred dimension is relevant, which was reviewed in the previous section; (b) the relative difficulty of the shift problem when a preferred or a nonpreferred dimension is relevant; and (c) the effects of pretransfer training with a preferred or a nonpreferred dimension on the learning of a preferred or nonpreferred dimension in the shift problem. In the optional shift paradigm all of the shift dimensions may be "relevant," and the S can get maximum reward for the solution based systematically on any of them. His solution is taken as the index of the effects of dimension preference and of pretransfer training. Although a large body of literature has evolved exploring the effects of various parameters on discrimination transfer phenomena, this review is confined to interrelationships between dimension preferences and transfer.

Several studies have explored the relationship between dimension preference and transfer among nonretarded children. Two used the predetermined shift paradigm. Caron (1969) administered a two-choice simultaneous discrimination involving size and brightness dimensions to nursery school children. In the pretransfer problem, solution was easier with a preferred dimension relevant than with a nonpreferred dimension relevant. Appropriate subgroups were required to make either a reversal or a nonreversal shift in the transfer problem. From a first problem with a preferred dimension relevant, a reversal shift to the preferred dimension was easier than a nonreversal shift to the nonpreferred dimension. However, from a first problem with a nonpreferred dimension relevant, a nonreversal shift back to the preferred dimension was no easier than a reversal shift to the nonpreferred dimension. These results suggest that training on the nonpreferred dimension in the first problem had a marked effect on the relative difficulty of responding to a preferred or nonpreferred dimension in the transfer shift. In support of this point, a third group, "presensitized" to its nonpreferred dimension and then trained with the nonpreferred dimension relevant, did not differ from the group trained with a preferred dimension relevant. Thus, for nursery school children experience with a nonpreferred dimension appears to reduce the difference in difficulty between a preferred and nonpreferred size- or brightness-relevant problem.

Brown (1970b) administered an oddity problem to preselected form-preferring kindergarten and second-grade children. In pretransfer a preferred form-relevant problem was easier than a nonpreferred color relevant problem. In the subsequent transfer problem an ID shift was easier than an ED shift, regardless of whether a preferred or a nonpreferred dimension was relevant. Since they did more poorly on the pretransfer problem when a nonpreferred dimension was relevant, one interpretation may be that form preferrers are easily able to overcome the effect of preferences as reflected in the oddity shift; hence, ID and ED shifts would be of equivalent difficulty. Unfortunately, color-preferring children were not included, making impossible any comparisons between children of differing dimension preferences.

Several studies have employed the optional shift paradigm among nonretarded children. Brown (1970a) administered an oddity optional shift to both color-preferring and form-preferring first- and second-grade children. A pretransfer problem was easier with a preferred dimension relevant than with a nonpreferred, and color preferrers were inferior to form preferrers even when a preferred dimension was relevant. An almost-significant interaction suggested that there was less difference between learning color and form for form preferers than for color preferrers providing additional evidence that form preferrers are able to shift attention easily from a preferred to a nonpreferred dimension. In the transfer task form preferrers were more likely than color preferrers to respond to their preferred dimension regardless of their training condition. Color preferrers, who were trained on a nonpreferred dimension, became markedly inconsistent, responding systematically to neither their preferred nor their nonpreferred dimension.

In a two-choice simultaneous discrimination using the optional shift paradigm, form-preferring kindergarten children learned a pretransfer problem more easily when a preferred dimension was relevant than when a nonpreferred dimension was relevant (James et al., 1969). However, there were no differences in the relative frequencies of reversal and nonreversal shifts. Whether trained on a preferred form dimension or on a nonpreferred color dimension, about half of each group made reversal shifts. That more form preferrers failed to elect a reversal shift on their preferred dimension is surprising. Perhaps the stimuli used to assess preferences were so biased as to fail to differentiate children with color preference "tendencies." Fewer than 15% of the subjects were color preferrers, which was half the incidence of color preference conservatively estimated in this age group by other investigators, e.g., 30% color preferrers in the age range of 4-1 to 5-9 years (Harris et al., 1970), 28% color preferrers in preschoolers (Trabasso et al., 1969, Experiment 1). Dahlem and McLaughlin (1969) found that 97% of form-preferring first-grade children made reversal shifts following training with a preferred dimension relevant, while about half of the form preferrers trained with a nonpreferred dimension made reversal shifts.

Smiley and Weir (1966) found that color- and form-preferring kindergarten children learned a pretransfer problem more easily when a preferred dimension was relevant than when a nonpreferred dimension was relevant, and that they were more likely to make a shift, whether reversal or nonreversal, to a preferred dimension than to a nonpreferred dimension. Of those trained on a preferred dimension 83% made reversal shifts. Of those trained on a nonpreferred dimension 44% made reversal shifts. Unfortunately performance characteristics of color and form preferrers were not distinguished by the investigators as they were in the next two experiments reported by Trabasso et al. (1969). In both experiments color- and form-preferring preschool children learned a pretransfer problem with either a preferred or a nonpreferred dimension relevant to solution, followed by an optional shift. In both experiments the pretransfer problem was learned more easily if a preferred dimension was relevant. Moreover, color preferrers tended to be inferior to form preferrers even when a preferred dimension was relevant. In the first experiment, involving experimentally sophisticated middle class children, reversal shifts were more frequent to a preferred attribute regardless of whether it was color or form. In the second experiment, involving naive lower class children, those who preferred color were more likely to make nonreversal shifts, while those who preferred form were more likely to make reversal shifts. The selection of reversal shifts has been accepted as an index of maturity in concept formation (e.g., Kendler & Kendler, 1962). By this criterion, as well as superior performance in acquisition of the pretransfer problem, form preferrers would seem to be more mature in their conceptual development than color preferrers.

Several studies have investigated dimension preferences and discrimination shifts among the retarded. Heal et al. (1966) and Campione (1969) found that a shift to a preferred dimension was easier than a shift to a nonpreferred dimension for young-adult retardates. A reversal shift was easier than a nonreversal shift following preferred relevant training, but not following nonpreferred relevant training. Using a matching-to-sample task, Wilcock and Venables (1968) found that a nonreversal shift to a nonpreferred dimension was more difficult for 17-year-old retardates than a nonreversal shift to a preferred dimension. The nonreversal shift to the nonpreferred dimension was also more difficult for the retardates than for 5-year-old nonretardates.

Two studies used the two-choice simultaneous discrimination and optional shift paradigm with retardates. Mankinen and Heal (1965) gave to naive retardates a series of five sets of optional shift problems with either a preferred or a nonpreferred dimension consistently relevant during all pretransfer problems. For Ss trained with a preferred dimension relevant, pretransfer performance was at ceiling, and virtually all Ss elected reversal shifts across the five transfer problems. For Ss trained with a nonpreferred dimension relevant pretransfer performance on the initial problems was inferior, and only 37% elected a reversal shift in the first problem. By the fifth problem, pretransfer performance was at ceiling, and all Ss elected reversal shifts. In a follow-up study with these Ss (Mankinen and Lucker, 1966), the train-preferred Ss and the train-nonpreferred Ss were split factorially into subgroups: half of each original training group was tested on a two-choice simultaneous discrimination problem with the preferred dimension relevant, and half with the nonpreferred dimension relevant. The train-nonpreferred-test-preferred Ss, train-nonpreferred-test nonpreferred Ss, and train-preferred-test-preferred Ss did not differ from one another and were all significantly superior to the train-preferred-test-nonpreferred Ss. These two studies indicated that, prior to training, the retardates functioned, with respect to their dimension preferences, like young nonretarded children, i.e., dimension preferences had a significant effect on their discrimination learning. Following training, however, they functioned like young nonretarded adults, i.e., dimension preferences had little effect on their discrimination learning (Odom & Mumbauer, 1971).

Finally, Heal et al. (1970) trained experimentally sophisticated color- and form-preferring retardates on a color relevant problem. Subgroups were then given one of four optional shifts with 2 X 2 combinations of the same or new color or form stimuli. Color preferrers made reversal shifts from color to color. Except when novel form cues were introduced, form preferrers also made reversal shifts from color to color. This pattern of results suggests that experienced color- and form-preferring retardates may be similar to experienced color- and form-preferring nonretardates, i.e., under the typical experimental conditions (no cues replaced) they tend to maintain their response to the relevant dimension of the pretransfer task whether preferred or nonpreferred.

In summary, among naive nonretarded children as well as naive retarded adolescents and adults, dimension preference is an important determinant of performance in both single discrimination and discrimination transfer problems. A single or pretransfer problem is universally more easily learned when a preferred dimension is relevant. In transfer problems a reversal shift to a preferred dimension is easier or more likely than to a nonpreferred dimension. However, whether a nonreversal shift to a preferred dimension is easier or more likely than to nonpreferred dimension in nonretarded children may depend in part on the specific dimension preferences of the subjects. Young nonretarded form preferrers appear to be more mature than color preferrers, since they learn a pretransfer problem more easily than color preferrers even when a preferred dimension is relevant, and they are more likely to make a reversal shift than a nonreversal shift in transfer.

Among nonretarded children, the studies cited dealt primarily with experimentally naive children, ranging from preschool to approximately the third grade. There is evidence that, in addition to dimension preference, experience is an important factor in the discrimination learning efficiency of children. For example, Saravo and Gollin (1968) and Saravo and Kolodny (1969) have shown that reversal shifts are easier for children experienced in discrimination problem solving. Furthermore, nonreinforced "nonproblem-solving" experience with both dimensions to be used in a subsequent discrimination shift (Tighe, 1965; Tighe & Tighe, 1970), particularly with a nonpreferred dimension (Caron, 1969), facilitates reversal shift performance in preschool children. However, if findings from adult retardates (Mankinen & Heal, 1965) may be generalized to nonretardated preschool children, problem-solving experience alone is insufficient to facilitate reversal shifts. Problem-solving experience, and probably nonreinforced dimensional experience, requires systematic responding (attention) to a nonpreferred dimension in order for 'general' reversal shifting tendencies to develop. Caron (1969) suggested that the reason older children and adults appear to be unaffected by manifest dimension preferences, as was found by Odom and Mumbauer (1971), is that extensive experience with most common stimulus dimensions assures that preferences will be asymptotic and therefore equivalent. Thus, the effects of dimension preference may well be an age-dependent phenomenon among nonretarded children in the sense that experience is somewhat age-dependent.

Finally, untrained adult retardates appear to function with respect to their dimension preferences like preschool and early school-aged naive nonretarded children. However, with appropriate training they appear to function in a manner comparable to mature nonretardates, i.e., they seem able to attend to and respond both to preferred and nonpreferred dimensions with equal facility; moreover, they elect reversal shifts to a nonpreferred dimension as well as on a preferred dimension.

APPENDIX B

STIMULUS MATERIALS

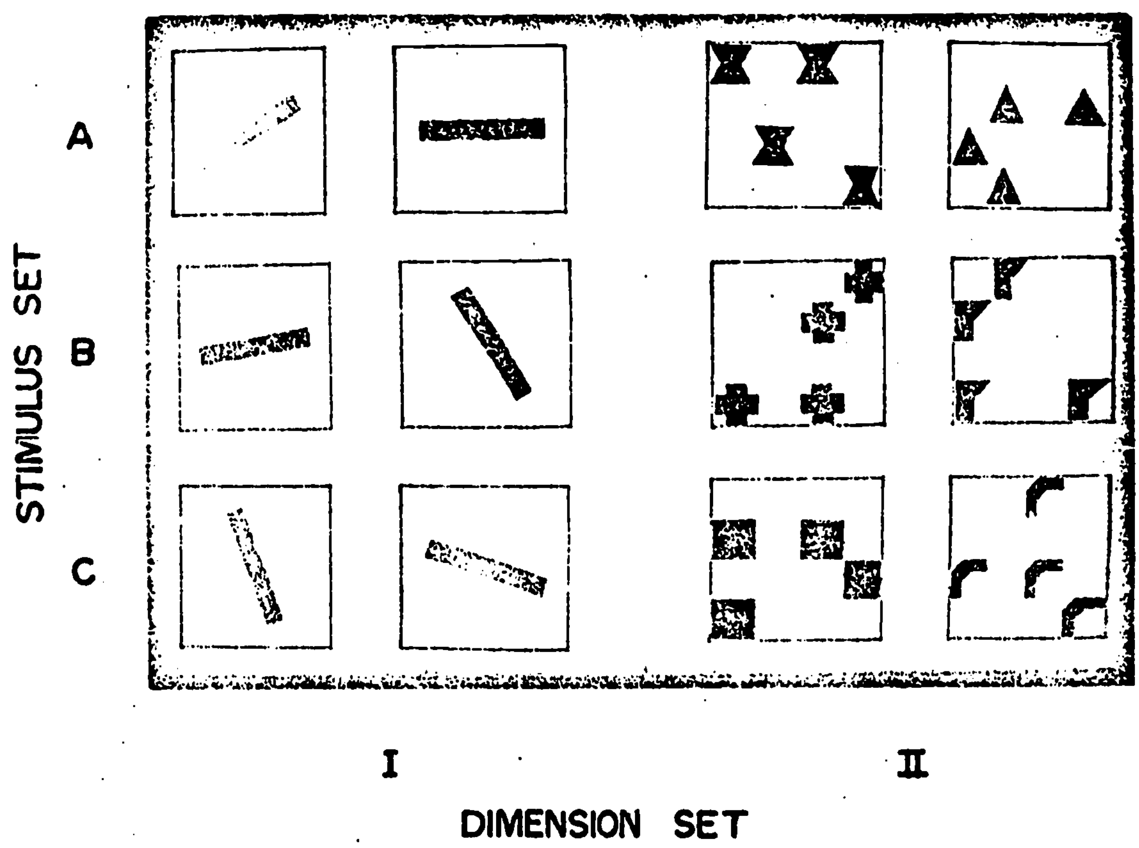

Figure 3. Stimulus sets for dimension preference problems.

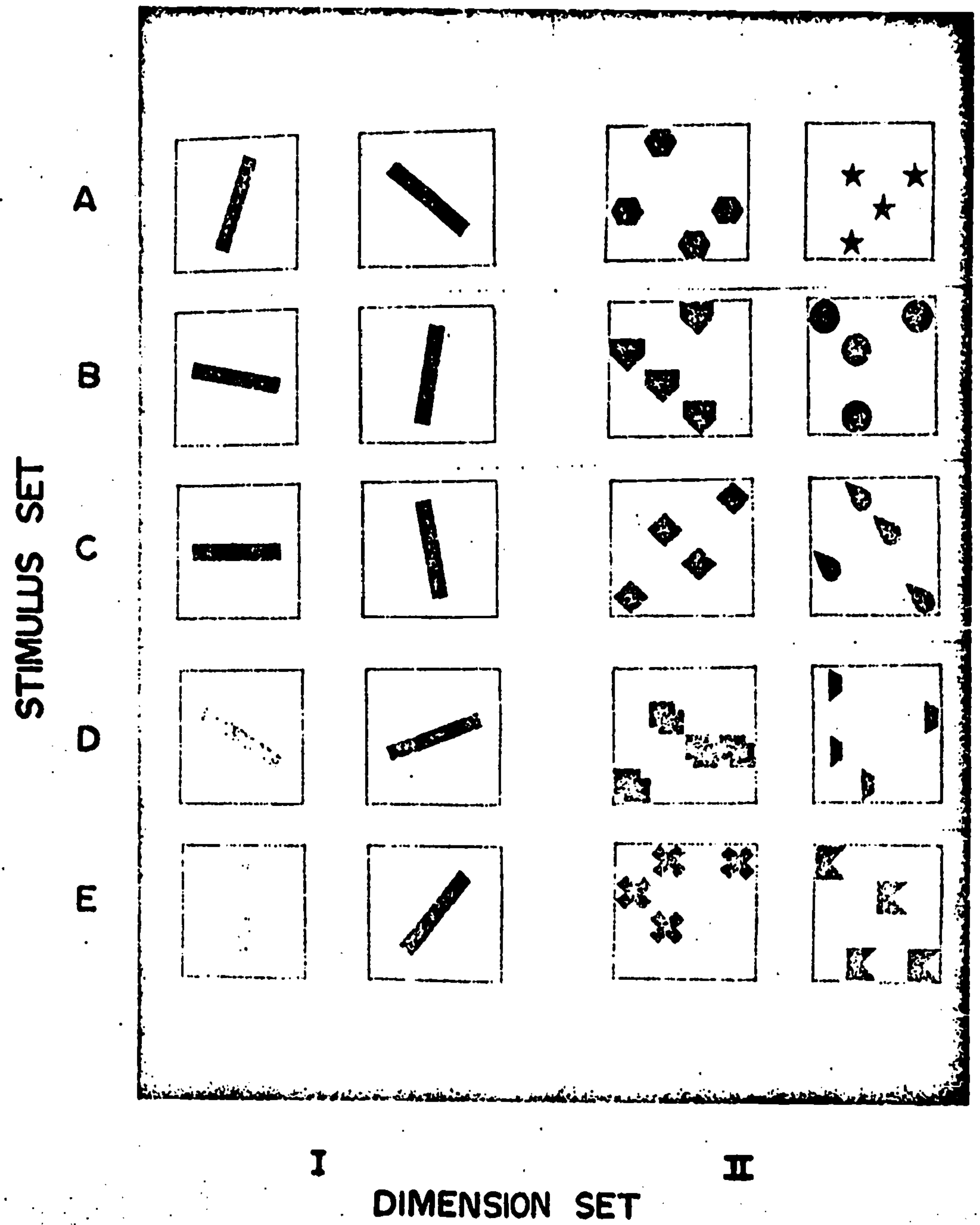

Figure 4. Stimulus sets for training problems.

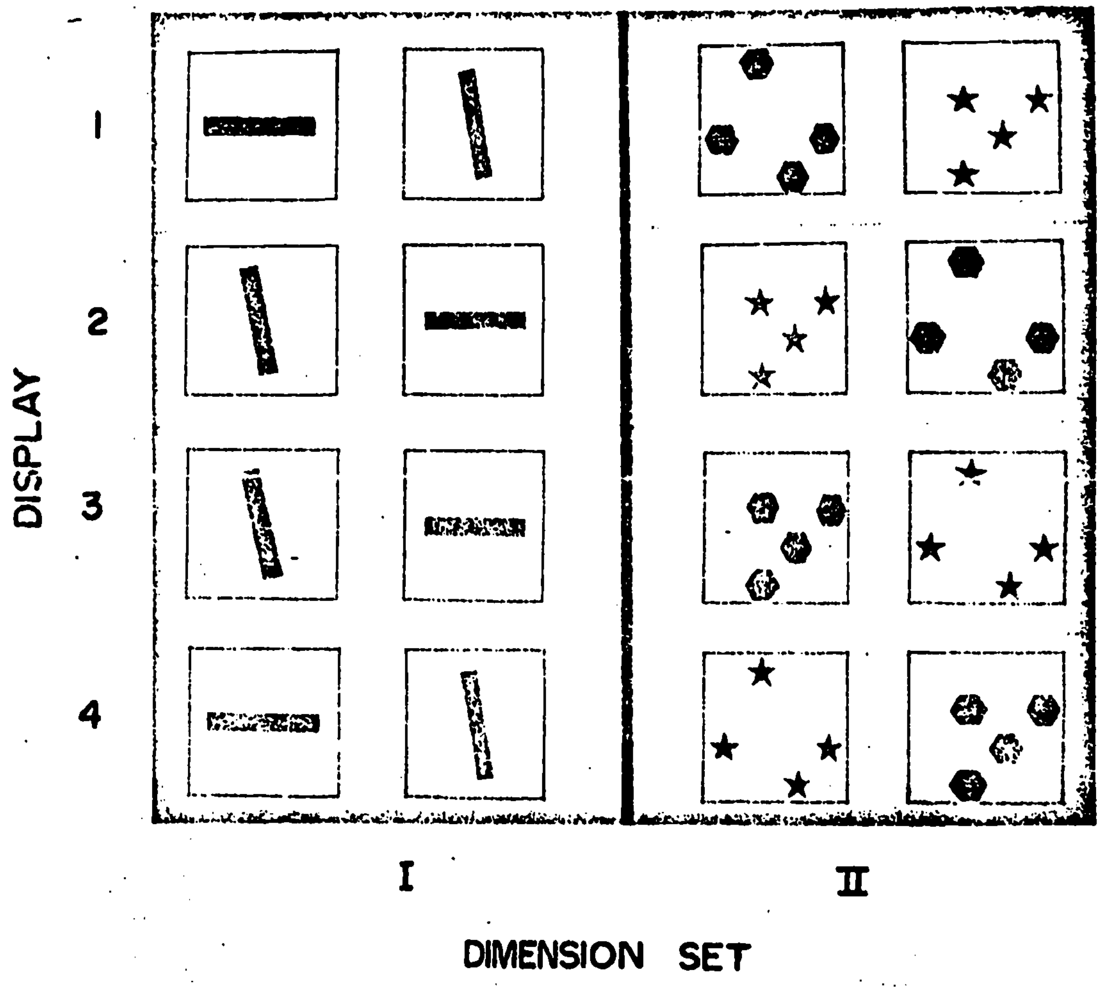

Figure 5. The four possible stimulus displays in a training problem.

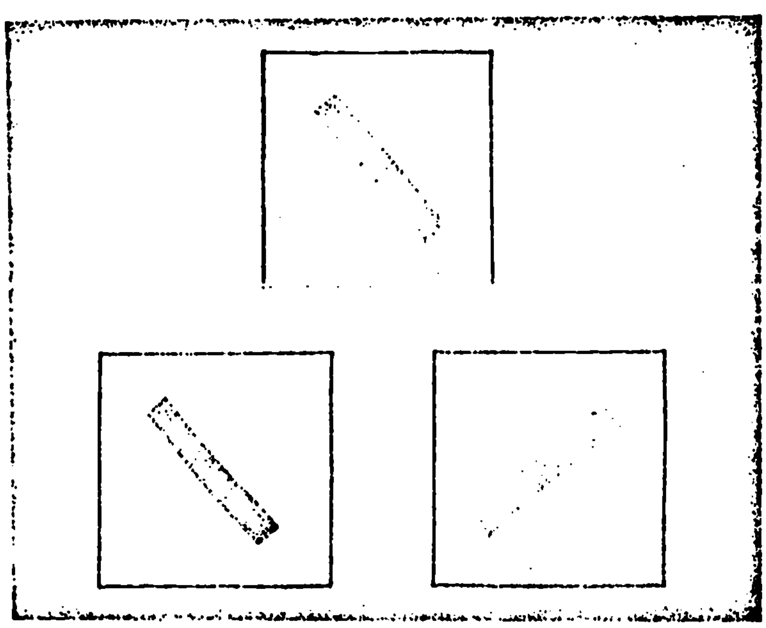

Figure 6. Example stimulus display from the matching-to-sample transfer problem.

APPENDIX C

SUPPLEMENTARY ANALYSES

Table 8

Analysis of Variance Summary Table: Transformed Errors on Training Problems as a Function of Relevant Training Dimension and Dimension Set

Source	*df*	Mean Square	*F*
Between Subjects	39		
Training(A)	1	93.35	76.69*
Dimension Set (B)	1	1.37	1.13
A x B	1	1.85	1.52
Error (between)	36	1.22	
Within Subjects	160		
Problems (C)	4	12.36	11.70*
A x C	4	11.68	11.06*
B x C	4	0.49	0.47
A x B x C	4	1.40	1.33
Error (within)	144	1.06	
Total	199		

* $p < .001$.

Table 9

Analysis of Covariance (IQ) Summary Table: Transformed Errors on Training Problems as a Function of Relevant Training Dimension and Dimension Set

Source	df	Mean Square	F
Between Subjects	38		
Training (A)	1	94.52	83.40*
Dimension Set (B)	1	1.85	1.63
A x B	1	1.66	1.47
Error (between)	35	1.13	
Within Subjects	160		
Problems	4	12.39	11.74*
A x C	4	11.59	10.98*
B x C	4	0.42	0.40
A x B x C	4	1.45	1.37
Error (within)	144	1.06	
Total	198		

* $p < .001$.

Table 10

Analysis of Variance Summary Table: Transformed Trials on Training Problems as a Function of Relevant Training Dimension and Dimension Set

Source	df	Mean Square	F
Between Subjects	39		
Training (A)	1	225.84	72.91*
Dimension Set (B)	1	1.44	0.46
A x B	1	5.70	1.84
Error (between)	36	3.10	
Within Subjects	160		
Problems (C)	4	34.47	12.87*
A x C	4	28.13	10.51*
B x C	4	1.68	0.63
A x B x C	4	3.48	1.30
Error (within)	144	2.68	
Total	199		

* $p < .001$.

Table 11

Analysis of Covariance (IQ) Summary Table: Transformed Trials on Training Problems as a Function of Relevant Training Dimension and Dimension Set

Source	df	Mean Square	F
Between Subjects	38		
Training (A)	1	228.48	78.00*
Dimension Set (B)	1	2.19	0.75
A x B	1	5.23	1.79
Error (between)	35	2.93	
Within Subjects	160		
Problems (C)	4	34.44	12.87*
A x C	4	28.05	10.48*
B x C	4	1.53	0.57
A x B x C	4	3.52	1.31
Error (within)	144	2.68	
Total	198		

* $p < .001$.

Table 12

Analyses of Covariance (IQ) Summary Table: Transformed Errors and Trials on the Transfer Task

Source	df	Errors		Trials	
		Mean Square	F	Mean Square	F
Regression	1	3.89	1.35	7.15	1.26
Training (A)	1	10.52	3.67	12.41	2.19
Dimension Set (B)	1	0.94	0.33	0.99	0.18
Transfer (C)	1	39.62	13.81**	85.57	15.11**
A x B	1	8.41	2.93	20.04	3.54
A x C	1	43.20	15.05**	89.97	15.89**
B x C	1	11.29	3.93	27.45	4.85*
A x B x C	1	0.00	0.00	0.05	0.01
Error (between)	31	2.87		5.66	
Total	39				

* $p < .05$.

** $p < .001$.

APPENDIX D

RAW DATA

Table 13

Raw Data

ID	Group	CA	IQ	Dimension Preference		Errors						Trials					
						Training Problems					Transfer	Training Problems					Transfer
				Set I	Set II	1	2	3	4	5	Problem	1	2	3	4	5	Problem
1		17	50	A	F	0	7	0	5	0	1	0	23	0	10	0	4
2		20	52	C	F	0	1	0	0	1	0	1	2	1	1	2	0
3	$A_1B_1C_1$	20	58	C	F	1	0	0	0	0	0	4	1	1	0	1	0
4		19	62	C	F	0	0	0	1	0	0	0	0	0	2	1	0
5		13	65	C	F	0	0	0	0	0	0	1	1	0	1	0	0
6		16	54	C	F	0	0	0	1	0	49	1	1	0	1	1	100
7		15	60	C	F	0	0	0	0	1	1	0	0	0	0	2	4
8	$A_1B_1C_2$	20	51	C	F	1	1	0	16	0	8	4	8	0	55	0	16
9		14	61	C	F	0	0	0	0	0	41	1	0	0	0	1	65
10		20	66	A	F	0	7	0	0	4	1	1	15	0	1	12	4
11		16	50	C	F	6	1	0	0	0	0	23	2	1	0	0	0
12		16	52	C	F	0	0	0	1	0	0	0	0	1	2	0	0
13	$A_1B_2C_1$	11	57	C	F	0	3	2	0	0	0	1	4	5	0	0	0
14		20	64	A	F	0	0	0	0	0	2	1	0	0	0	0	5
15		16	72	C	F	0	0	1	0	0	0	0	1	2	1	0	0

Table 13 (continued)

ID	Group	CA	IQ	Dimension Preference		Errors						Trials					
						Training Problems					Transfer	Training Problems					Transfer
				Set I	Set II	1	2	3	4	5	Problem	1	2	3	4	5	Problem
16		15	74	C	F	0	0	0	0	0	38	0	0	1	0	1	100
17		12	62	C	F	0	0	0	0	0	56	0	0	0	0	0	100
18	$A_1B_2C_2$	13	55	C	F	2	0	0	0	1	53	3	1	0	1	2	100
19		16	60	C	F	0	0	0	2	0	2	0	1	1	5	0	5
20		20	51	C	F	1	1	5	12	0	53	4	2	14	19	0	100
21		18	53	C	F	25	0	0	21	0	49	56	1	0	56	0	100
22		16	54	A	F	25	10	0	0	0	1	56	22	0	1	0	4
23	$A_2B_1C_1$	13	57	C	F	18	21	1	20	0	8	56	56	4	56	0	32
24		9	63	C	F	19	0	0	0	0	1	56	0	1	1	1	2
25		21	66	A	F	1	0	0	1	0	1	4	0	0	4	1	4
26		11	51	C	F	29	1	0	25	0	3	56	2	0	56	0	14
27		14	54	C	F	12	0	27	0	0	8	29	0	56	0	0	20
28	$A_2B_1C_2$	15	58	C	F	18	19	9	1	0	2	34	56	12	2	1	6
29		13	62	C	F	18	2	0	0	0	0	56	7	0	1	0	0
30		9	70	C	F	21	6	0	0	23	0	38	15	1	0	56	0

Table 13 (continued)

ID	Group	CA	IQ	Dimension Preference		Errors						Trials					
						Training Problems					Transfer	Training Problems					Transfer
				Set I	Set II	1	2	3	4	5	Problem	1	2	3	4	5	Problem
31		19	52	C	F	14	6	4	7	1	0	23	14	13	10	3	0
32		17	53	A	F	19	7	4	1	0	1	56	19	13	4	0	4
33	$A_2B_2C_1$	24	55	C	F	18	25	0	9	7	0	56	56	0	15	17	0
34		18	77	A	F	23	12	4	0	0	1	56	26	12	1	1	4
35		19	73	C	F	17	2	3	1	0	0	41	5	4	2	0	0
36		18	50	A	F	2	4	1	2	6	2	6	6	2	7	12	5
37		25	58	C	F	26	11	3	8	5	17	56	29	10	20	10	41
38	$A_2B_2C_2$	14	63	C	F	25	22	0	0	1	1	56	56	1	0	4	4
39		18	55	C	F	15	3	10	2	0	1	34	7	14	4	0	4
40		18	61	C	F	4	24	3	26	8	4	12	46	6	56	16	8

Note.—Under the heading for groups, A_1 and A_2 designate training with a preferred or nonpreferred dimension relevant, respectively; B_1 and B_2 designate transfer involving the same or novel dimensions, respectively; and C_1 and C_2 designate a preferred or a nonpreferred dimension relevant in transfer, respectively. Under the heading for dimension preference, A stands for angular orientation, C for color, and F for form.

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