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THE INFLUENCE OF STIMULUS CHANGE ON VISUAL DISCRIMINATION LEARNING IN CHILDREN

by

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ABSTRACT

Experiment 1, with grade one children as subjects, investigated the hypothesis that changes in stimulus attributes from trial to trial will facilitate visual discrimination learning by eliciting attention to dimensions associated with change. Following various stimulus change manipulations during acquisition subjects were compared on a difficult size or brightness transfer task. Subjects in a control group received all of their training with the difficult discrimination. Minimal facilitation was observed following change in the relevant dimension, but there was no apparent facilitation due to changes in the irrelevant dimension. There was also some suggestion that an easy discrimination in the relevant dimension per se had some facilitatory effect.

Experiment 2, also with grade one children as subjects compared the transfer performance on a size discrimination of six groups receiving various stimulus arrangements during eight acquisition trials. Different groups received 2, 4 or 8 changes in the stimuli, an easy discrimination or a medium difficulty discrimination. The control group was given a difficult discrimination throughout both acquisition and transfer. Results revealed equivalent facilitation in all three change groups and in the group receiving the easy discrimination. The medium difficulty group performed like the control group at chance level.

Experiment 3, with grade three children as subjects, included three conditions from Experiment 2, the 8-change, the easy discrimination and the control group. Facilitation was observed in the change condition but not in the easy discrimination condition.

The results suggest that a physical difference between stimuli constitutes an important variable in eliciting attention in young children although it appears to have less effect with older subjects. Additional explanations for the results are discussed.

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I. INTRODUCTION

Basic to the ability of higher organisms to modify their behavior through interaction with the environment is the ability to respond to one thing rather than another and to use properties of stimuli as guides to appropriate action. Not surprisingly therefore, a central topic in the field of psychology has long been the study of how organisms discriminate, i.e. respond differentially to stimuli. Related to this is the problem of how organisms come to ignore differences among stimuli and respond to their commonalities.

Three different types of discrimination have been distinguished and studied by psychologists interested in the development of discriminative behavior in children (Reese & Lipsitt, 1970, Ch. 5). This thesis is concerned primarily with one of these types of tasks, dimensional discrimination learning, which has been used extensively as a means of studying the variables affecting choice behavior. This type of discrimination learning has been distinguished by Reese and Lipsitt from perceptual and conceptual discrimination learning. Perceptual discrimination learning refers to the development of the ability to differentiate among two or more highly stimuli (e.g. Gibson & Gibson, 1955). The remaining type, conceptual discrimination learning, refers to the ability to formulate and utilize abstract concepts (e.g. Reese, 1963).

In the typical study under the category of dimensional discrimination learning the child learns to make a consistent response to a stimulus value along one dimension when the stimuli vary in two or more dimensions. The relevant dimension is arbitrarily designated and it is usually assumed that the child is fully capable of perceptually discriminating the stimuli.

This latter assumption, however, may not always be met.

Transfer Along a Continuum - Empirical Findings

One type of task which falls into the dimensional learning category has been named "transfer along a continuum." In this task subjects are initially given training with two widely separated values on a stimulus dimension. The subjects are then either directly presented with two narrowly separated stimuli on the same dimension or are shifted through a number of progressively more difficult discriminations to the final narrowly separated stimulus values. The learning performance of subjects receiving either of these conditions is then compared to a group of subjects which is given an equivalent amount of training with just the difficult stimulus values.

The proposition that a difficult discrimination is more easily established if subjects are first trained on an easy discrimination of the same type, than if all the training is given on the difficult discrimination was formulated in the early literature of both psychology and education. The term "easy" discrimination was used to refer to stimuli widely separated along a stimulus dimension, while the term "difficult" discrimination applied to more similar stimulus values. William James writing in 1890 (James, 1950, pp. 513-515) stated that by gradually contracting the points of a compass placed on the palm of the hand a person is able to discriminate points closer together than is possible without such practice. James noted that the same effect had been described earlier by Volkmann and Fechner for points on the hand, the arm and the fingertips. In her book on educational practice, Montessori (1912) expressed her belief in the utility of training children by means of transfer along a continuum.

She provides a refinement of the commonsense view where she writes:

> stimuli should be presented proceeding from few stimuli strongly contrasting to many stimuli in gradual differentiation always more fine and imperceptible. So, for example, one should present together red and blue, the shortest rod beside the longest, the thinnest beside the thickest, etc., passing from these to the delicately differing tints, and to the discrimination of very slight differences in length and size (Montessori, 1912, p. 184).

These early suggestions of the superiority of the easy-to-difficult training sequence in discrimination learning have gained considerable support from later experimental studies with both animal and human subjects and for a large number of stimulus dimensions.

Pavlov proposed in the area of classical conditioning that:

> the development of a differentiation between two closely allied stimuli may be attempted directly or on the other hand, the same differentiation may be attempted in stages, leading up through the differentiation of more remote stimuli (Pavlov, 1927, pp. 121-122).

Pavlov cites experiments by his student, Gubergritz, which indicate that the second of these two methods results in more rapid differentiation and in the establishment of differentiations not possible when the difficult discrimination is attempted directly. In studies with individual dogs, it was shown that dogs which could not initially differentiate a white object from a neighbouring gray or a circle from a slightly eliptical figure could make these discriminations following prior training with more extreme discriminations of the same type.

Schlosberg and Solomon (1943) found that rats could learn to discriminate without making any errors if the stimuli were progressively changed from a pair of black and while cards to two narrowly separated grays.

Lawrence (1952) demonstrated that in training rats on a difficult brightness discrimination it is more efficient to train them first on an easy discrimination on the same stimulus dimension, than to give all the training on the difficult discrimination. He further showed that learning was more efficient when the animals approached the test discrimination through a series of graduated steps from the easiest to the most difficult. Lawrence was the first to label this effect "transfer along a continuum." Further support of Lawrence's findings has been provided by Sutherland, MacIntosh and MacIntosh (1963) with octupuses on a shape dimension, by North (1959) and Franken (1967) with rats for form and brightness (black-white) dimensions respectively, and by Williams (1968) with pigeons for size.

In human adults the advantage of transfer along a continuum has been demonstrated by Baker and Osgood (1954) with pitch, by Restle (1955) with size, by Trabasso (1963) with angle orientation and by Marsh (1967) with hue. Although Baker and Osgood (1954) found the usual facilitation with a gradual easy-to-difficult shift they did not find facilitation when the test condition was preceded by only the easy discrimination. It is likely, however, that this discrepancy can be attributed to two variations in their procedure (see p. 63). With normal children, the advantage of transfer along a continuum has been reported by Spiker (1959) on a light brightness continuum and by May and MacPherson (1971) on a size dimension. Finally, House and Zeaman (1960) have demonstrated the effect with retarded children using an object-to-pattern transfer task.

Two other types of discrimination training procedures, transposition and errorless learning fading techniques, should be mentioned because of their similarity to transfer along a continuum. In transposition, transfer is typically observed following training by stimuli on the same dimension. Unlike transfer along a continuum, transposition usually is studied with tasks in which the test stimuli differ from each other by the same ratio that separated the training stimuli.

Terrace (1963) discussed what he called "fading" procedures in the establishment of operant discriminations. These procedures are concerned with how and when the negative or non-rewarded stimulus should be introduced so that responses to the negative stimulus, i.e. errors, will be minimized or eliminated. To the extent that these fading procedures are concerned with varying the values of the stimuli presented in a discrimination along a single dimension the fading and transfer along a continuum paradigms are very similar. However, in the transfer along a continuum studies both the positive and negative stimuli usually have been shifted during training, while with Terrace's procedure only the negative stimulus is changed with the positive stimulus retaining a constant value. A number of other studies ostensibly using Terrace's fading procedure deviate further from the transfer along a continuum paradigm (e.g. Moore & Goldiamond, 1964; Touchette, 1968). In these studies a second cue, often referred to as a "prompt", is introduced to facilitate the acquisition of a discrimination and then is gradually faded out over trials. In these studies as opposed to transfer along a continuum a stimulus dimension is varied other than the one on which the final discrimination is to be made.

In experiments not dealing with dimensions the superiority of the easy-to-difficult sequence of training is not always supported. Studies on skills, have shown that for some tasks it is better to teach the more difficult task first to obtain the greatest amount of transfer between tasks (Szafran & Welford, 1950; Gibbs, 1951).

Heim (1954) studied the effect of difficulty of a prior item or test on performance in intelligence testing. She found that the more numerous the harder questions, the higher would be the subject's mean score. Heim argues that people unwittingly adapt their performance according to the degree of difficulty presented. In this analysis, training with easy items could be disadvantageous because it would lower the subject's overall adaptation level resulting in poorer performance than if training were with more difficult items.

In experiments dealing with dimensions, however, the results of transfer along a continuum studies generally confirm the superiority of the easy-to-difficult sequence of training across several dimensions as well as for several categories of organisms.

Transfer Along a Continuum - Theoretical Interpretations

Various explanations have been proposed for the findings demonstrating the advantage of transfer along a continuum.

The usual expectation for transfer between two tasks is that if responses are identical facilitation is obtained, its magnitude increasing with stimulus similarity (Gibson, 1940). Thus, in the transfer along a continuum studies it would be predicted, in contradiction to the findings, that given a fixed amount of training on the original discrimination the greatest transfer will be when the original and transfer discriminations are identical. This prediction is based on classical theories of discrimination (Spence, 1937; Hull, 1939, 1950) which attempt to explain such learning by generalization of excitatory and inhibitory tendencies built up during the original task and which transfer to a second task.

Lawrence (1952, 1955) concluded than only by postulating specialized post hoc gradients of excitation and inhibition designed particularly to explain transfer along a continuum is it possible to account for the transfer along a continuum effect. Two such formulations have been presented by Lawrence (1955) and Logan (1966). Logan on the basis of his postulated gradients was able to account for the usual findings with transfer along a continuum. In addition he was able to predict that greater facilitation would be obtained from the easy discrimination if only the positive and not the negative stimulus was displaced or both the positive and negative stimulus as in Lawrence's (1952) study. However, other transfer along a continuum results with human adults (North, 1959; Trabasso, 1963) do not appear to be interpretable by means of gradients of inhibition and excitation (Riley, 1968, p. 113). The impact of the development of verbal behavior on discrimination learning has been emphasized in numerous articles by Kendler and Kendler (e.g. 1962). By comparing the behavior of human subjects of different ages, as well as relating their results to lower animals, they infer that as a child matures he makes a transition from responding on the basis of a single unit S-R mechanism to a mediational one.

Lawrence (1952) took a different approach in explaining transfer along a continuum. While not dismissing the possibility of the establishment and reinforcement of habit strengths by generalization, Lawrence postulated a second factor which he called "acquired distinctiveness" to account for his results. In two earlier experiments Lawrence (1949, 1950) had demonstrated that a cue utilized in one discrimination is more readily utilized in a second situation requiring a different response. In interpreting his 1952 experiment he merely extended the notion so that a dimension rather than a cue acquired distinctiveness and transferred from the original task. He argued that the animal is able to isolate functionally the relevant stimulus dimension from all other background and irrelevant stimuli because of his earlier experience with an easy discrimination.

"Discrimination set" is another concept which has been utilized to explain why training on an easy discrimination facilitates a difficult one (Barnett & Cantor, 1957; Cantor, 1962). While the notion of acquired distinctiveness is vague the notion of set is yet vaguer. Discrimination set is used to refer to a tendency on the part of the subject to try a particular method of solution or to seek a certain kind of solution because of his experience with similar problems. However, merely to give a name to sequences of responses on the basis of the subject's performance is probably not useful unless the presumed mode of operation is specified. This same criticism can also be applied to other theories utilizing response defined terms such as "error factors" (Harlow, 1959), "hypotheses" (Levine, 1959) or "strategies" (Bowman, 1961).

Another possible approach might involve emotional variables. One could argue that each error is a failure and frustrates the subject (Spiker, 1956). As a result of the buildup of frustration responses produced by the increase in emotionality may interfere with correct performance. In the easy-to-difficult transfer situation the function of the easy problem and the gradual shift to the difficult differentiation would be to minimize the number of errors and thus prevent the buildup of frustration and its resultant debilitating emotional effects.

Transfer along a continuum in recent years has been most frequently interpreted in the context of two-stage theories of discrimination learning which have recently been developed by Lawrence (1963), Zeaman and House (1963), Trabasso and Bower (1968) and others [see Trabasso & Bower (1968) for a more complete list]. Each of the above theories involve different verbal labels, but their assumptions and basic concepts are more or less the same (Hilgard & Bower, 1966; Trabasso & Bower, 1968). Stage one of the postulated two stages refers to a central mediating process in which some property of the stimulus, often a dimension, is "attended to" (Zeaman & House, 1963), "abstracted" (Lashley, 1938, p. 81) or "coded" (Lawrence, 1963). These coding operations are often referred to as "observing responses." Observing responses are themselves not observed by the experimenter but are inferred. Stage two refers to the establishment of an associative bond between the attended-to aspect of the stimulus, stage one, and an instrumental response. Two-stage theories of discrimination of the type just described can be distinguished both from a second type of two-stage theory and from theories which do not differentiate stages. Spence (1936) and Wyckoff (1952) proposed a type of two-stage theory which emphasizes that before learning can occur organisms must orient the stimuli. Orienting or observing responses in this type of theory serve only to expose the ogranism's receptors to the stimuli. Other theories (Spence, 1937; Hull, 1939, 1950) account for the discrimination learning in terms of the relationship between the external stimulus and the overt response without assuming a special mediating stage. These single stage theories and the mediating response theories make differential predictions for a variety of transfer tasks although the two types of theories often make identical predictions about the parameters of original learning.

The Gestalt psychologists (Woodworth & Schlosberg, 1954), Berlyne (1950,

1960) and Zeaman and House (1963) and others have dealt with the variables influencing selective attention. Among these are the number and kinds of dimensions present e.g. color vs. form, two-dimensional vs. three-dimensional, novelty, oddity, reward expectations, redundancy, variability and the type of stimulus presentation e.g. simultaneous vs. successive. The role of past experience in determining the probability of an attribute being observed has been the object of much study. One important influence in the case of human subjects is that resulting from verbal instructions. Schell (1971), for example, trained four and five year old preschool children to identify the relevant concept, either shape, color or number, in a card sorting task and to shift quickly from concept to concept when they were told the task had been changed. Special training included verbal prompts in which subjects were instructed which dimension to attend to and non-verbal prompts in which sample stimulus cards were always present. Schell found that verbal prompts were most effective in facilitating the sorting tasks. She concluded that her instructions were effective in controlling the dimensional attention of four and five year old preschool children. With animals as well as with human subjects, past experience in which a subject is trained to "look for" variations in a particular attribute over a series of problems have been interpreted as having much the same influence as verbal instructions. The transfer operations used to elucidate this influence included object-to-pattern, reversal, over-learning reversal, intradimensional, extradimensional and easy-to-difficult sequences (Zeaman & House, 1963; Sutherland, 1964; Shepp & Turrisi, 1966).

As it is the most relevant to child research further details of the mediating-response model elaborated by Zeaman and House (1963) will be provided. They assume that the stimuli presented to the subject can be represented by a set of _n_ relevant and irrelevant dimensions, each of which can elicit an observing response of determined probability. As a simplification, they assume that at the moment of choice only one of the observing responses is elicited. Whichever observing response occurs exposes the specific cues associated with that dimension. The subject is then able to make an instrumental response of determined probability. Given the correct observing response, reinforcement will always follow approach to the positive cue whereas approach to the negative cue will never be rewarded. If an irrelevant observing response is made, then on the average, cues of the observed dimension will be reinforced on fifty percent of the trials. The next stage in their theory specifies the changes in response probabilities following the various possible combinations of observing response-instrumental response-reinforcement sequences. When an observing response is elicited and followed by a correct instrumental response, direct reinforcement strengthens the observing response and the instrumental response. When an observing response is followed by an incorrect instrumental response, direct extinction weakens that observing response and the instrumental response. All other observing responses are assumed to be weakened by indirect extinction when an observing response is elicited and followed by reinforcement. Similarly when an elicited observing response is followed by nonreinforcement all other observing responses are strengthened by indirect reinforcement. Thus observing responses can be influenced by either direct or indirect effects of reinforcement and extinction, while instrumental responses can only be modified by direct reinforcement and extinction. It should be noted that while instrumental responses are not influenced by the indirect effects of reinforcement any change in the strength of the rewarded cue on a dimension will be accompanied by an equal but complementary change in the nonrewarded cue on that dimension. At the end of training the probability of the relevant instrumental and observing responses will be high, while the probability associated with the irrelevant observing responses and the incorrect instrumental responses will be low. The theory asserts that the probabilities of both the observing and the instrumental responses will transfer to new discrimination learning situations.

Given the above model and some additional assumptions regarding the rates of acquisition and extinction for both observing and instrumental responses computers have been used to obtain theoretical learning curves of discrimination learning for groups of "stat-children." Stat-children are hypothetical children whose performance is calculated by a computer programmed to behave according to the assumptions of the theory. By systematically varying the probability of attending to the relevant dimension, and by varying the assumed number of irrelevant dimensions Zeaman and House (1963) have obtained close approximations of learning curves obtained in actual experiments with children. These observations along with plots of backward learning curves have led Zeaman and House (1963) to suggest that the difficulty in discrimination learning for slow, i.e. retarded children, is not in their learning rate but in their initial probability of attending to the relevant dimension.

Given the above details of attentional theory it is possible to show how Zeaman and House (1963) can account for the transfer along a continuum effect. Shepp and Zeaman (1966) trained retarded children on either a size or brightness discrimination, varying the physical difference between the stimuli. As would be expected, the subjects trained with the greater difference acquired the discrimination significantly faster than those trained with the small physical difference. Examination of the backward learning curves for the different groups revealed that the difference in rate of learning was in the initial flat portion and not in the learning rate shown by the later portions of the graphs. In addition, graphs representing the different functions were produced by the use of stat-children simply by varying the initial probability of attending to the correct dimension. From this data it is reasonable to conclude that the probability of attending to the relevant dimension is related to the physical difference between the positive and negative stimuli on the relevant dimension. With small differences the initial probability should be low and learning should require a large number of trials, whereas with large differences this probability should be high resulting in more rapid acquisition not only for retardates, but for all children.

In the typical transfer along a continuum study the group shifted from easy to difficult should benefit on the difficult problem as a result of the transfer of a strong relevant observing response. For the control group previously receiving just the difficult discriminations the strength of the relevant observing response should be relatively less. That the observing response is dimensional rather than limited to specific cue values has been demonstrated in several studies in which facilitation was obtained even when the cue values used in the original problem were different from those appearing in the transfer task (e.g. House & Zeaman, 1960) or when the rewarded cue value has been reversed (e.g. Spiker, 1959).

It has been argued, however, that the beneficial effect of transfer from easy to difficult may not be entirely due to the physical magnitude of the stimuli. Franken (1967) using rats as subjects, proposed and found evidence for the suggestion that the beneficial effects of prior training on an easy problem may be due in part to the change involved in shifting from one level of difficulty to another. In other words, a change in stimulus attributes from one trial to the next may by itself elicit attention to the dimension which is being changed. Franken's hypothesis was based on a theory of stimulus change proposed by Dember and Earl (1957). These authors state that attending responses are not only elicited by differences in attributes between simultaneously presented stimuli (spatial stimulus change), but also by changing the value of one or more attributes of the stimuli over time (temporal stimulus change) (see also Pillsbury, 1908; Berlyne, 1960).

May and MacPherson (1971) extended the work done by Franken to a size discrimination problem with normal children. The irrelevant stimulus dimension was brightness. Their results showed that children given easy then medium difficulty levels of a size discrimination subsequently performed better on a difficult level than children receiving all their training on the difficult discrimination. Additionally, children given the same easy/medium discriminations in a mixed order, either easy, medium, easy, medium ... or easy, easy, medium, medium ... performed better than the graduated transition group. From these results May and MacPherson concluded that the frequency of stimulus change is a major factor influencing the selection mechanism governing attention.

Formulation of the Problem and Hypotheses

The present study examines the influence of trial to trial variation in specific cue values during eight acquisition trials on a subsequent transfer problem involving a difficult visual discrimination. The following questions are explored using a methodology similar to May and MacPherson (1971).

1. Does stimulus change, i.e. variation in specific cue values over trials, in the relevant dimension facilitate transfer compared to a no change control group (R vs. C)?*

2. Does stimulus change in an irrelevant dimension facilitate transfer compared to a no change control group (a) when the relevant dimension involves an easy discrimination and (b) when the relevant dimension involves a difficult discrimination (I_E vs. C; I_D vs. C)?

3. Does stimulus change in the relevant dimension facilitate performance during transfer more than stimulus change in the irrelevant dimension (a) when the relevant dimension involves an easy discrimination and (b) when the relevant discrimination is difficult (R vs. I_E; R vs. I_D)?

4. Does stimulus change in an irrelevant dimension facilitate transfer more when the relevant dimension is salient during acquisition (I_E vs. I_D)?

It may be found that stimulus change in an irrelevant dimension only facilitates transfer when the relevant stimulus values are salient. Should this be the case the explanation could be in terms of the salience of the relevant dimension rather than stimulus change in the irrelevant

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*For explanation of symbols see procedure page 20 .

dimension. A second experiment would be required to evaluate these alternative possibilities (see page 42).

5. Is there a difference between the acquisition of brightness and size discriminations using the methods employed in this study (B vs. S)?

6. Do the effects of stimulus change interact with the dimension of size and brightness?

On the basis of May and MacPherson's findings it is anticipated that stimulus change associated with the relevant dimension during acquisition will facilitate performance. The relevant stimulus change group included in this experiment is identical to one of the two groups producing optimal facilitation in May and MacPherson's study. Thus it is hypothesized that the group receiving relevant change during acquisition will be superior to the no change control group in their performance on the difficult transfer discrimination ($R > C$).

While it might be expected that increasing the attention value of one of the irrelevant dimensions by introducing stimulus change would interfere with performance compared to a no change control group, Zeaman and House's theory predicts the opposite. They stated that having a single, strong, competing irrelevant observing response theoretically should be facilitating. On this basis it is hypothesized that both the groups receiving stimulus change in an irrelevant dimension during acquisition will be superior to the no change control group during transfer (I_E; $I_D > C$).

In the terms of Zeaman and House's model the relevant change group begins with a high probability of attending to the relevant dimension as a result of the assumed effect of stimulus change. The irrelevant change groups on the other hand, must first extinguish a high probability irrelevant observing response assumed to be elicited by stimulus change in the irrelevant dimension before the relevant observing response can be established. Therefore, it is hypothesized that the group receiving change in the relevant dimension will be superior to the two groups receiving change in an irrelevant dimension ($R > I_E, I_D$).

From the earlier discussion it would seem that performance should be enhanced when the stimulus values in the relevant dimension are more widely separated. Therefore, it is hypothesized that the irrelevant change group with the salient relevant discrimination will be superior in their performance during transfer to the irrelevant change group receiving the difficult discrimination during acquisition ($I_E > I_D$).

It is predicted that brightness will be a more salient dimension and thus result in better performance than size ($B > S$). Further it is hypothesized that there will not be a significant interaction between the change conditions and size and brightness.

II. METHOD - EXPERIMENT 1

Subjects. The subjects were thirty-two girls and thirty-two boys from grade one classes in Calgary Separate School Board Elementary Schools. Their mean age was eighty-four months ranging from seventy-three months to ninety-eight months.

Stimuli. The training stimuli consisted of two ½ in. plywood blocks, one a circle (diameter 2 5/8 in.) and the other an equilateral triangle (2 3/4 in. on each side), both painted the same shade of grey as the apparatus (Munsell 5).

The test stimuli consisted of twenty-eight plywood squares ½ in. thick of six different sizes and six different shades on a black-white continuum. The six size values were 2.1, 2.25, 2.4, 2.6, 2.75 and 2.9 square in. The six brightness values were obtained by painting the stimuli with flat oil paint to correspond approximately to the grey values of Munsell 1, 3, 4, 6, 7 and 9. Twenty-eight of the thirty-six possible combinations of the two variables were used. The design of the experiment did not require the following eight combinations: Munsell 3, sizes 2.25 and 2.75; Munsell 4, sizes 2.4 and 2.6; Munsell 6, sizes 2.4 and 2.6 and Munsell 7, sizes 2.25 and 2.75.

For each dimension the test stimuli were grouped into three sets according to the magnitude of the difference between members of each set on the changing dimension. The Easy Set for size, consisted of the smallest and the largest squares, 2.1 vs. 2.9 square in.; for brightness, the darkest and the lightest, Munsell 1 vs. 9. The Medium Sets consisted of somewhat smaller differences, 2.25 vs. 2.75 square in. and Munsell 3 vs.

7, for size and brightness respectively. The Difficult Sets consisted of the smallest differences, 2.4 vs. 2.6 square in. and Munsell 4 vs. 6 for size and brightness respectively.

Apparatus. The design of the apparatus and the general procedure follows that outlined by May and MacPherson (1971). The stimuli were presented on a circular turntable 24 in. in diameter which was bisected by a screen 12 in. high and 24 in. wide. The turntable and screen were painted grey corresponding to Munsell 5. When presented to the subject any given stimulus pair was located 6 in. from the turntable screen and 7 in. apart center to center. Testing was done in the Department of Psychology's two-room mobile research trailer which was fitted with a small mirror suspended from the ceiling behind the subject to enable the experimenter to observe the children's responses. Marbles were used as token rewards as opposed to small plastic chips used by May and MacPherson. The marbles were placed in 1 in. square metal wells recessed into the turntable and lined with foam rubber to prevent noise cues. Inexpensive trinkets were given as rewards on completion of testing.

Procedure. Each subject was tested individually. He or she was told that a game was to be played and that the aim was to find the marble hidden under one of two objects. The subject was then told that there would be several opportunities to find the marble and that he/she should try to collect as many marbles as possible and that the marbles could be exchanged later for a toy.

Following these instructions each subject was presented with the training triangle and circle and was asked to select one. The marble was not present under either form on the first trial. On all subsequent training trials the marble was placed under the original non-selected form. Training trials continued until the subject had chosen the correct form on three successive trials. Each subject was then presented two squares for forty trials, eight trials on acquisition and thirty-two trials on the transfer task. The placement of a particular pair of stimuli and the marble was carried out with the turntable rotated so that the center screen blocked the child's view of the arrangement. The subject collected marbles found on correct trials and placed them in a plastic dish.

The design of the experiment is presented in Table 1. There were four treatment groups, change relevant (R), change irrelevant-easy (I_E), change irrelevant-difficult (I_D), and a no change control (C). Half of the subjects in each treatment group had size as the relevant dimension with brightness and position irrelevant, while for the remaining half of the subjects brightness was the relevant dimension with size and position irrelevant. Half of the subjects in each of the treatment groups with size relevant were rewarded for selecting the larger square and half for selecting the smaller; for brightness relevant, half were rewarded for selecting the darker square and half for selecting the lighter. Representation from each of the sexes was equated in each condition. Stimulus values on the irrelevant dimensions were counterbalanced according to chance stimulus sequences generated by Fellows (1967).

The treatment groups differed during acquisition in the following way. In the change relevant condition Easy and Medium stimulus sets on the relevant dimension were alternated from trial to trial. On the

TABLE 1

Design of Experiment 1

Treatment	Dimension	Stimulus Value	Sex	
			Male	Female
Relevant (R)	Size	Larger	n = 2	n = 2
		Smaller	n = 2	n = 2
	Brightness	Darker	n = 2	n = 2
		Lighter	n = 2	n = 2
Irrelevant-easy (I_E)	Size	Larger	n = 2	n = 2
		Smaller	n = 2	n = 2
	Brightness	Darker	n = 2	n = 2
		Lighter	n = 2	n = 2
Irrelevant-difficult (I_D)	Size	Larger	n = 2	n = 2
		Smaller	n = 2	n = 2
	Brightness	Darker	n = 2	n = 2
		Lighter	n = 2	n = 2
No change (C)	Size	Larger	n = 2	n = 2
		Smaller	n = 2	n = 2
	Brightness	Darker	n = 2	n = 2
		Lighter	n = 2	n = 2

N = 64

irrelevant dimension only Easy stimulus sets were presented.[1] In the change irrelevant-easy condition Easy and Medium stimulus sets on the irrelevant dimension were alternated from trial to trial. Easy stimulus sets were presented on the relevant dimension. In the change irrelevant-difficult condition Easy and Medium stimulus sets on the irrelevant dimension were alternated from trial to trial. In contrast to the foregoing treatment group, however, Difficult stimulus sets were presented on the relevant dimension. In the no change control condition Difficult stimulus sets were presented on the relevant dimension. Easy stimulus sets were presented on the irrelevant dimension.

During the thirty-two transfer trials Difficult stimulus sets were presented on the relevant dimension. Easy stimulus sets were presented on the irrelevant dimension.

Statistical Tests. The confidence level for all statistical tests to be reported was set at the five percent level.

III. RESULTS - EXPERIMENT 1

Pretest. A 4 (Change) x 2 (Dimension) analysis of variance carried out on the number of trials to criterion on the pretest (Table 2) yielded no significant effects, supporting the intended effects of random assignment of subjects. (One subject's score in group I_D deviated markedly from the other scores. He took 72 trials, 5.11 standard deviations above the overall mean of 13.41 trials, to reach the criterion of three successive correct responses. This subject's performance, however, was not atypical

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[1]When size is the relevant dimension brightness is referred to as the irrelevant dimension and vice versa. Position is an additional irrelevant dimension throughout both acquisition and transfer.

TABLE 2

Summary of Change x Dimension Analysis of Variance on the Number of Trials to Criterion on the Pretest in Experiment 1

SOURCE	DF	MEAN SQUARE	F*
Change Condition (C)	3	114.938	
Dimension (D)	1	30.250	
CD	3	7.542	
Error	56	139.424	

*All F values are insignificant

on the subsequent acquisition and transfer tasks.)

Acquisition (Trials 1 - 8). The mean errors and standard deviation for each treatment group during both acquisition and transfer are given in Table 3. A 4 (Change) x 2 (Dimension) x 2 (Sex) x 2 (Stimulus Value) analysis of variance (Table 4) revealed significant main effects due to Change and Stimulus Value. All other effects were negligible.

Duncan's multiple range test indicated that the I_E ($\bar{X}$ = 2.50) group made significantly fewer errors than the I_D ($\bar{X}$ = 4.13) and C ($\bar{X}$ = 4.06) groups who responded at chance level ($\bar{X}$ = 4.00). The R group ($\bar{X}$ = 3.19) did not differ significantly from any other group.

The Stimulus Value factor in this analysis was obtained by combining subjects rewarded for responding to the smaller and the lighter stimuli as against subjects rewarded for responding to the larger and the darker stimuli. In view of the artificial nature of this variable due to equating values from different dimensions, separate analyses were carried out for size and for brightness.

In the case of size (Table 5) the difference between larger and smaller was not significant. The main effect due to Change was significant. Duncan's multiple range test on the mean error scores for each of the change conditions yielded results identical to those of the overall analysis.

For brightness considered alone (Table 6) Stimulus Value was found to be significant with subjects rewarded for responding to the lighter stimulus ($\bar{X}$ = 2.69) performing significantly better than subjects rewarded for responding to the darker stimulus ($\bar{X}$ = 4.00). The main effect due to Change in this case was not significant although the ordering of means was

TABLE 3

Means and Standard Deviations of Error Scores in Each

Phase of Experiment 1

Stimulus Change Condition		Trials 1-8		Trials 9-40	
		$\bar{X}$	S.D.	$\bar{X}$	S.D.
Relevant-Change (R)	Size	3.38	.86	12.88	5.82
	Brightness	3.00	1.22	11.00	5.02
	Size and Brightness	3.19	1.10	11.94	5.52
Irrelevant-Easy (I_E)	Size	2.38	1.22	8.28	5.83
	Brightness	2.63	.99	5.25	5.24
	Size and Brightness	2.50	1.12	6.75	5.74
Irrelevant-Difficult (I_D)	Size	4.50	1.32	16.13	2.03
	Brightness	3.75	1.30	12.25	4.99
	Size and Brightness	4.13	1.36	14.19	4.27
No Change Control (C)	Size	4.13	1.45	16.38	2.00
	Brightness	4.00	1.66	12.75	5.52
	Size and Brightness	4.06	1.56	14.56	4.57

TABLE 4

Summary of Change X Dimension X Sex X Stimulus Value Analysis of Variance on the Error Scores During Acquisition in Experiment 1

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	3	9.604	5.910*
Dimension (D)	1	1.000	
Sex (S)	1	0.250	
Stimulus Value (V)	1	10.563	6.500*
CD	3	0.708	
CS	3	2.958	
CV	3	2.771	
DS	1	0.563	
DV	1	4.000	
SV	1	4.000	
CDS	3	0.271	
CDV	3	0.208	
CSV	3	2.875	
DSV	1	0.563	
CDSV	3	1.604	
Error	32	1.625	

*$p < .05$

TABLE 5

Summary of Change X Size Value X Sex Analysis of Variance on the Error Scores During Acquisition in Experiment 1

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	3	7.031	4.245*
Size Value (V)	1	0.781	
Sex (S)	1	0.781	
CV	3	1.365	
CS	3	0.865	
VS	1	0.781	
CVS	3	4.365	
Error	16	1.656	

*$p < .05$

TABLE 6

Summary of Change X Brightness Value X Sex Analysis of Variance on the Error Scores During Acquisition in Experiment 1

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	3	3.281	
Brightness Value (V)	1	13.781	8.647*
Sex (S)	1	0.031	
CV	3	1.615	
CS	3	2.365	
VS	1	3.781	
CVS	3	0.115	
Error	16	1.594	

*p <.05

the same as for size.

Transfer (Trials 9 - 40). The mean errors and standard deviation for each treatment group during both acquisition and transfer are given in Table 3. A 4 (Change) x 2 (Dimension) x 2 (Sex) x 2 (Stimulus Value) analysis of variance for the thirty-two transfer trials (Table 7) indicated significant main effects due to Change and Dimension. All other effects were non-significant.

Analysis of the mean error scores for the four change conditions indicated that the I_E group ($\overline{X}$ = 6.75) made fewer errors than the remaining three groups, R ($\overline{X}$ = 11.94), I_D ($\overline{X}$ = 14.19) and C ($\overline{X}$ = 14.56) which did not differ significantly from each other. Chance level of responding was 16.00 errors.

Separate analyses for size and brightness corresponding to those reported for acquisition were carried out. The results for size (Table 8) indicated significant effects due to Change and to the interactions of Change x Stimulus Value and of Change x Stimulus Value x Sex. The results for brightness (Table 9) showed only the main effect due to Change as significant.

For size, Duncan's multiple range test for the mean error scores for the four change groups yielded results identical to the overall analysis. However, when differences were tested with directional t-tests the R change group was shown to have made significantly fewer errors than both the C and I_D groups.

For brightness, the Duncan's multiple range test also confirmed the overall analysis except that in this case the R group did not differ significantly from any of the other three change groups. Tested with a

TABLE 7

Summary of Change X Dimension X Sex X Stimulus Value Analysis of Variance on the Error Scores During Transfer in Experiment 1

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	3	207.141	10.804*
Dimension (D)	1	153.141	7.988*
Sex (S)	1	43.891	
Stimulus Value (V)	1	19.141	
CD	3	3.182	
CS	3	50.099	
CV	3	20.599	
DS	1	0.141	
DV	1	58.141	
SV	1	62.016	
CDS	3	23.516	
CDV	3	44.266	
CSV	3	49.307	
DSV	1	1.891	
CDSV	3	36.516	
Error	32	19.172	

*$p < .05$

TABLE 8

Summary of Change X Size Value X Sex Analysis of Variance on the Error Scores During Transfer in Experiment 1

SOURCE	DF	MEAN SQUARE	F
Change (C)	3	114.865	10.296*
Size Value (V)	1	5.281	
Sex (S)	1	19.531	
CV	3	44.531	3.992*
CS	3	25.115	
VS	1	42.781	
CVS	3	50.698	4.544*
Error	16	11.156	

*$p < .05$

TABLE 9

Summary of Change X Brightness Value X Sex Analysis of Variance on the Error Scores During Transfer in Experiment 1

SOURCE	DF	MEAN SQUARE	F
Change (C)	3	95.458	3.511*
Brightness Value (V)	1	72.000	
Sex (S)	1	24.500	
CV	3	20.333	
CS	3	48.500	
VS	1	21.125	
CVS	3	35.125	
Error	16	27.188	

*$p < .05$

directional t-test, however, the R condition was shown to be superior to the C condition.

Figures 1 and 2 attempt to elucidate the reasons for the two significant interactions in the analysis with size. The graphs seem to indicate that the interaction effect in both cases is largely due to the near perfect performance of the female subjects in the I_E smaller condition. Why this effect should occur is not at all clear, but it does indicate caution in generalizing the results of the present experiment to situations where the present counterbalancing conditions do not apply.

The results indicate that subjects who were given the easier discrimination and performed well also performed better on the subsequent transfer task. On the other hand, subjects who had the difficult acquisition task and performed badly on that also performed poorly on the transfer task. Support for this conclusion is provided by the correlation of .57 between overall acquisition and transfer scores.

May and MacPherson (1971) reported results in terms of the number of subjects reaching a criterion of eight successive correct responses during transfer in addition to their general analysis. In the present experiment, as shown in Table 10, comparison of the number of subjects per group reaching this criterion results in an ordering of the change groups identical to that found with error scores. For the overall comparison and for the size dimension, Fisher's Exact Probability test showed only the I_E and C groups to differ significantly. In the case of brightness none of the comparisons among the group was statistically significant.

Figure 3 shows the performance of the four change groups over

TABLE 10

Number of Subjects in Experiment 1 Reaching Criterion of Eight Successive Correct Responses During Transfer

Condition		Number of Subjects Reaching Criterion
Relevant	Size Relevant	2/8
(R)	Brightness Relevant	3/8
	Total	5/16
Irrelevant-Easy	Size Relevant	4/8
(I_E)	Brightness Relevant	5/8
	Total	9/16
Irrelevant-Difficult	Size Relevant	1/8
(I_D)	Brightness Relevant	3/8
	Total	4/16
No Change Control	Size Relevant	0/8
(C)	Brightness Relevant	2/8
	Total	2/16

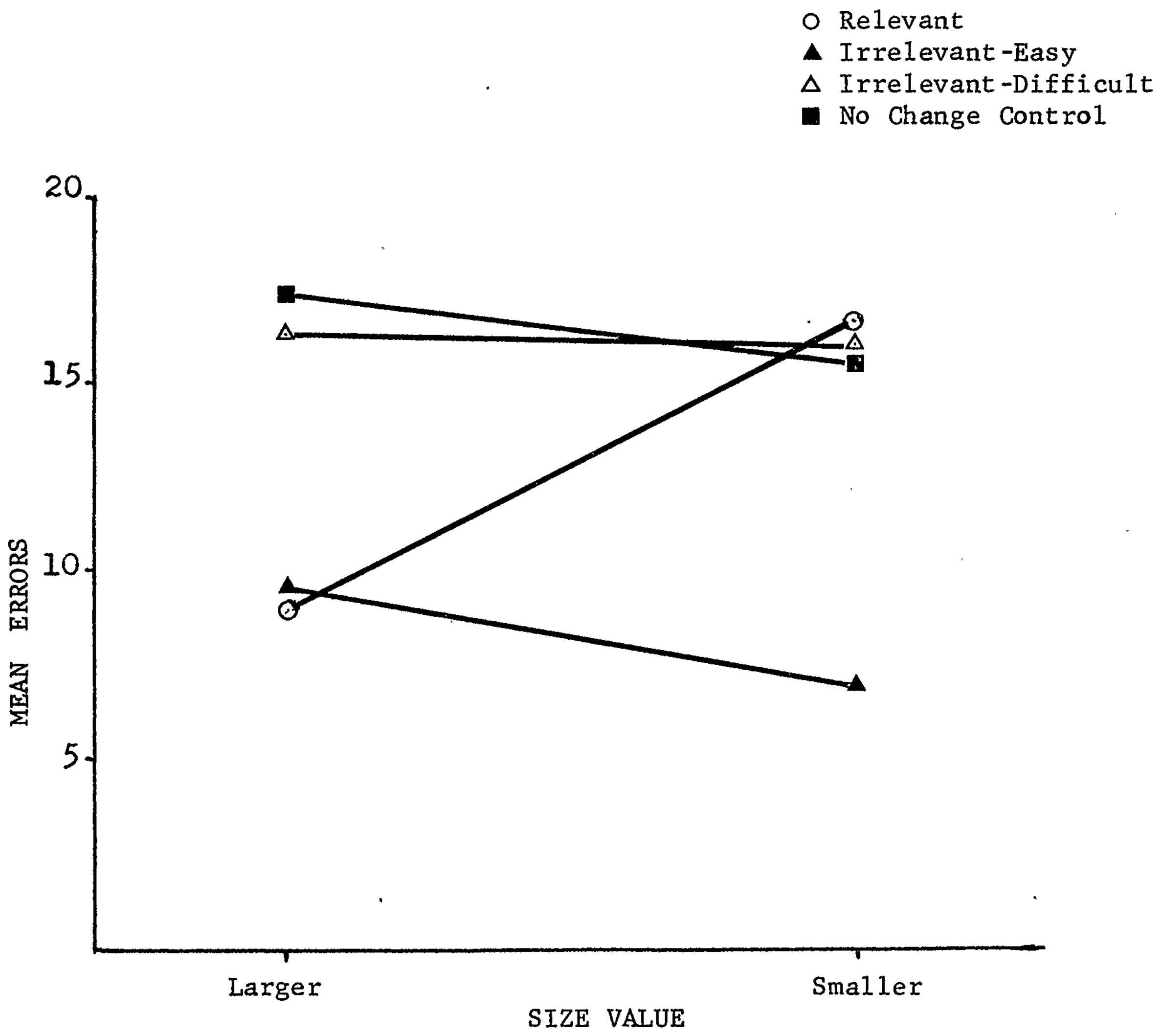

Figure 1: Change x Size Value Interaction in Experiment 1.

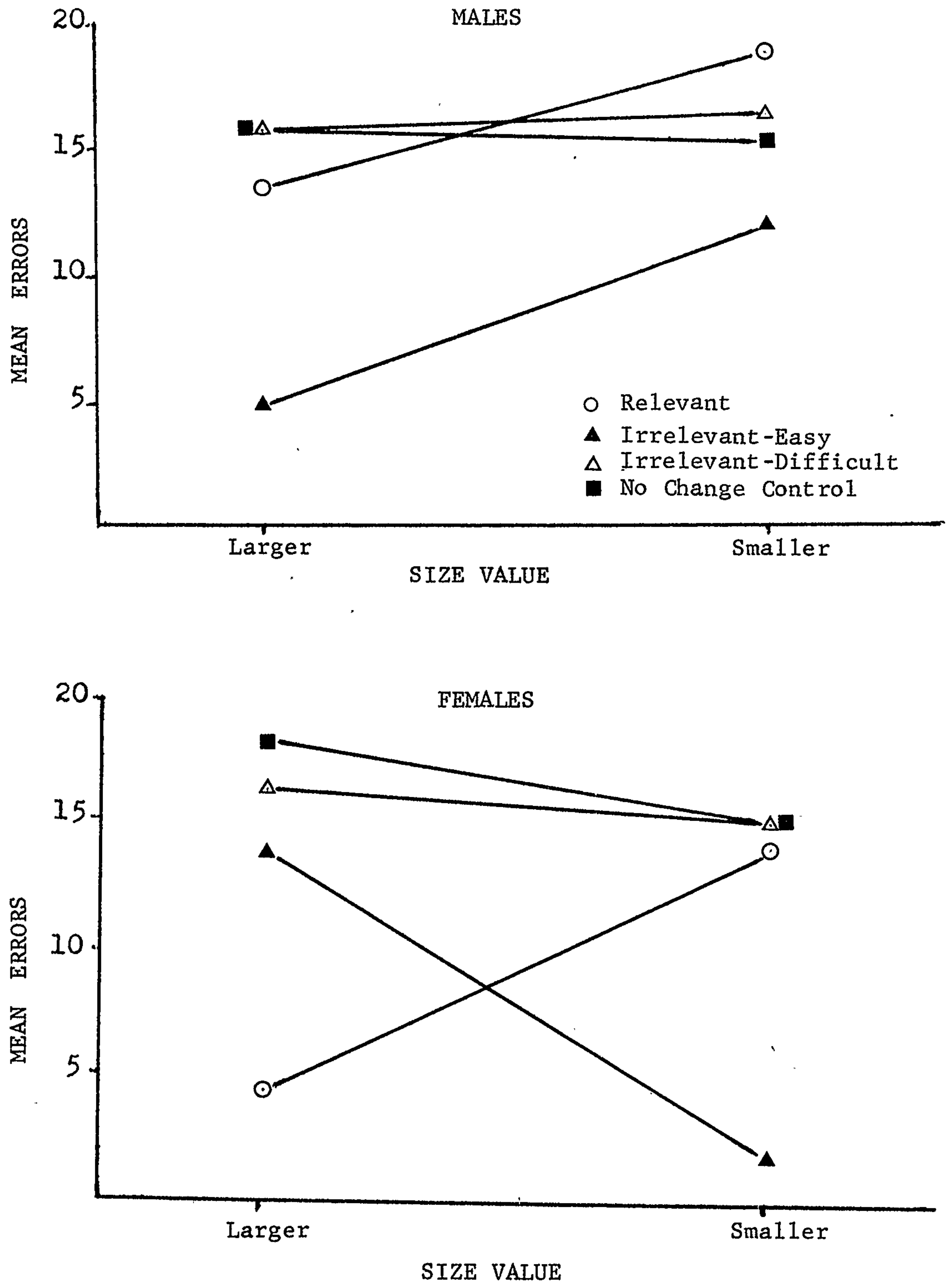

Figure 2: Change x Size Value x Sex Interaction in Experiment 1.

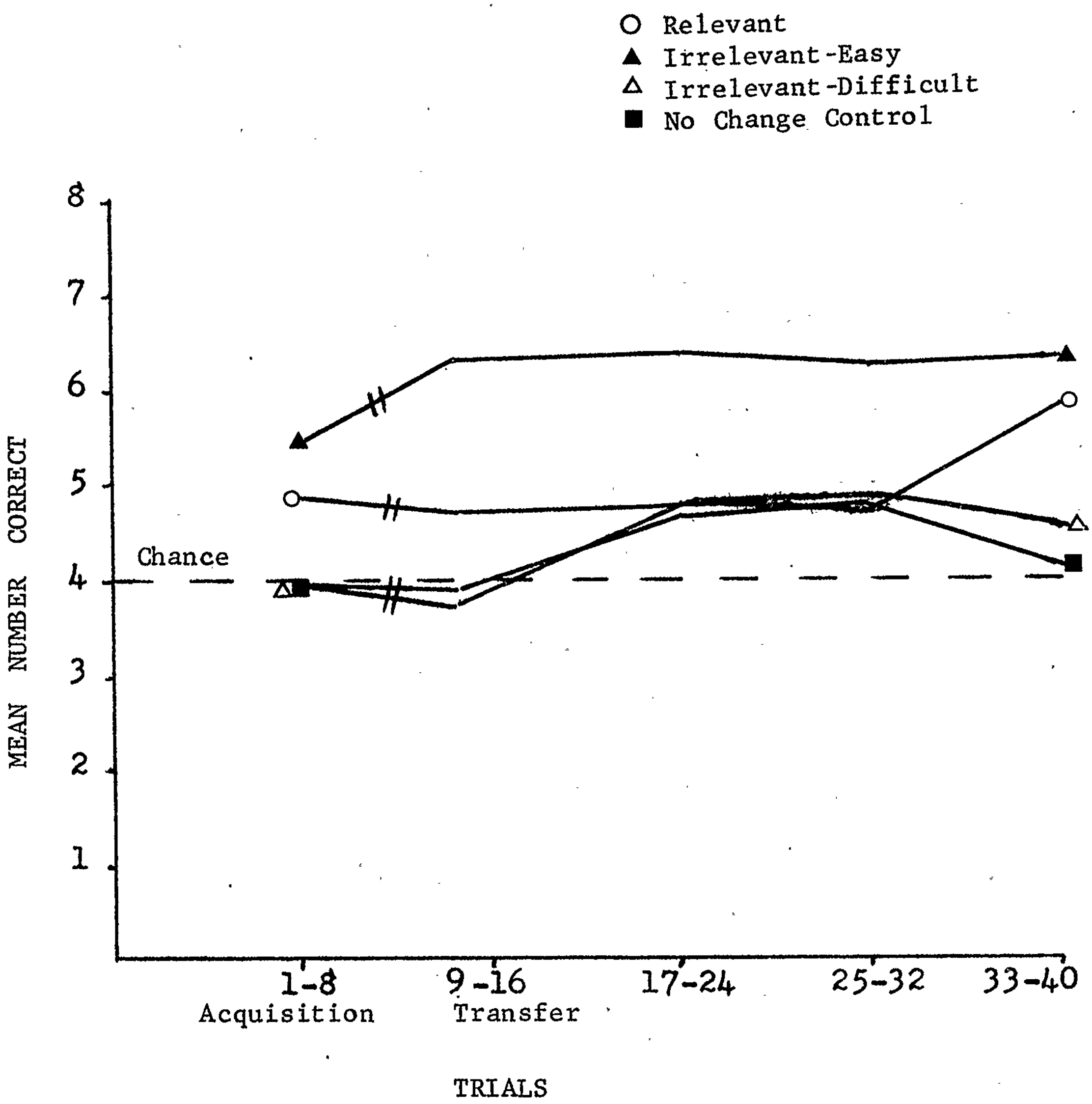

Figure 3: Mean Number of Correct Responses in Blocks of Eight Trials in Experiment 1.

blocks of eight trials during both acquisition and transfer. The graph shows improvement in the R change group to almost the level of I_E during the last block of eight trials, while the I_D and C groups were still responding near chance level. There is no appropriate way to test the significance of these apparent differences as they involve post hoc regrouping of the data which increases the probability of making a type one error to an unknown degree.

VI. DISCUSSION - EXPERIMENT 1

The hypothesis that changes in an irrelevant dimension during acquisition will facilitate performance during transfer is not supported by the results. The basis for this conclusion is a comparison of subjects in the I_D group to subjects in the C and the R groups. Relative to both of these latter groups, however, facilitation was obtained when the relevant dimension involved an easy discrimination and the irrelevant dimension was changing during acquisition (I_E). Due to the failure to observe facilitation when the relevant dimension was difficult it seems that the important variable is whether there is a difficult or easy discrimination in the relevant dimension. The possibility nevertheless remains that the facilitation obtained was due to the combined effect of the easy discrimination on the relevant dimension and change on the irrelevant dimension. A second study to be reported was carried out to test these alternative explanations.

The prediction that irrelevant change would facilitate transfer was based on the assumption that irrelevant observing responses would be extinguished. One possible reason why this hypothesis was not confirmed is that eight trials might be insufficient to allow for such extinction to take place. Future experiments would have to be performed with a greater number of trials in order to test this suggestion. It would be necessary, however, to run fixed trials in order to avoid confounding number of training trials with the change conditions.

A second possible reason for the failure of change in an irrelevant dimension to benefit performance during transfer is that stimulus change as such may have been only minimally effective in eliciting attention to the changing dimension. If, as the results suggest, an easy discrimination is at least as effective in eliciting attention to a dimension as stimulus change, then the control group in the present experiment was inappropriate. As the control group used involved an easy discrimination in the irrelevant dimension the predicted facilitation in the irrelevant change treatment groups would have to be greater than that resulting from the easy discrimination in the control group.

Even in the relevant dimension in the present study the evidence for the attention eliciting value of stimulus change is considerably less striking than that reported by May and MacPherson. Subjects in the relevant change condition (R), when the relevant dimension was size, made a mean of 12.88 errors compared to 16.38 errors in the no change control group. May and MacPherson's corresponding results were $\bar{X}$ = 3.04 for their relevant change condition and $\bar{X}$ = 15.12 for their no change control group. A similar discrepancy between the two studies is also found when the number of subjects per treatment condition reaching the criterion of eight successive correct responses during transfer is compared. May and MacPherson reported that 24/24 of the subjects in their R condition met this criterion, while none of the subjects in their no change control group did so. In the present study the corresponding comparison for size only (see Table 10) showed that 2/8 subjects in the relevant change condition (R) and 0/8 in the no change control (C) met this criterion. Including the findings with brightness from the present experiment 5/16 subjects in the R condition and 2/16 subjects in the C condition satisfied the criterion. The results of the present experiment would suggest that stimulus change in a relevant dimension has some facilitating effect on transfer performance with a difficult discrimination but the magnitude of this influence is much less than that reported by May and MacPherson.

There were three seemingly unimportant differences between the present study and May and MacPherson's and any of these might account for the discrepancies between the two studies. Firstly, May and MacPherson's data represent scores from kindergarten, grade two and grade three children while subjects in the present study were grade one students. Secondly, May and MacPherson observed their subjects' responses through a small hole in the center screen of the apparatus (personal communication), while in the present experiment the responses were observed in a mirror mounted behind the subject. Finally, May and MacPherson used small plastic chips as token reinforcers, while subjects in the present experiment received marbles as token reinforcers.

The predictions that subjects would make fewer errors on the brightness discrimination than on the size discrimination and that stimulus change and/or the easy relevant discrimination would not interact with the effect of dimensions were both confirmed.

In summary the major implications of the first experiment appear to be that:

1. Stimulus change in an irrelevant dimension for eight trials does not influence performance during transfer to a difficult discrimination.

2. An easy discrimination on the relevant dimension appears to produce at least as much facilitation on the transfer task as stimulus change in either the relevant or irrelevant dimensions.

3. Stimulus change in the relevant dimension does not appear to be as potent a variable with subjects in grade one as May and MacPherson's data would suggest.

V. EXPERIMENTS 2 and 3

The purpose of Experiment 2 was to examine the facilitatory effect suggested by Experiment 1 of an easy discrimination in the relevant dimension. In addition, all of the change conditions used by May and MacPherson were included because of the failure to replicate their results in their optimal change condition. Subjects in Experiment 2 were grade one students.

Experiment 3 extended the investigation to grade three subjects because of a possible age effect. Three of the change conditions from Experiment 2 were used.

VI. METHOD - EXPERIMENTS 2 and 3

Subjects. Experiment 2 included twenty-four girls and twenty-four boys from grade one classes under the jurisdiction of the Calgary Separate School Board. The mean age of the subjects was 83 months ranging from 77 to 94 months. Subjects in Experiment 3 were grade 3 children, from one school in the same school system. There were twelve girls and twelve boys with a mean age of 107 months ranging from 100 to 118 months.

Stimuli and Apparatus. Only size appeared as the relevant dimension in Experiments 2 and 3. The twelve stimuli used were of the six size values described in Experiment 1, one of each size painted black (Munsell 1) and one white (Munsell 9). All other details of the stimuli and apparatus were described in Experiment 1.

Procedure. The procedure for the present experiment was identical to that of Experiment 1.

For all subjects in both experiments size was the relevant dimension with brightness and position irrelevant. The Easy set for brightness values appeared on all trials throughout both acquisition and transfer. Half of the subjects in each treatment condition were rewarded for selecting the larger square and half for selecting the smaller. Representation from each of the sexes was equated in each of these latter conditions. Stimulus values in the irrelevant dimensions of brightness and position were counterbalanced according to Fellows (1967).

There were six treatment conditions differing according to the number of stimulus changes during acquisition. One stimulus change is counted whenever the stimulus set for the relevant dimension is different from the stimulus set appearing on the previous trial. In the 8-change condition size alternated from trial to trial between Easy and Medium stimulus sets. (This condition is identical to the "R" condition for size in Experiment 1.) In the 4-change condition the Easy stimulus set appeared on trials 1, 2, 5 and 6 with the Medium set presented on trials 3, 4, 7 and 8. In the 2-change condition the Easy stimulus set appeared for the first four trials followed by four trials of the Medium set. In the 1-E change condition the Easy stimulus set appeared on all eight acquisition trials, while in the 1-M change condition the Medium stimulus set appeared on all eight trials. In the 0-change control group the Difficult stimulus set appeared on all eight trials. (This last condition is identical to the "C" condition for size in Experiment 1.)

As in the first experiment all treatment groups performed an identical task during the thirty-two transfer trials consisting of the Difficult stimulus set on the relevant size dimension and the Easy stimulus set on the irrelevant brightness dimension.

In Experiment 2 all six of the above conditions were included. In Experiment 3 only the 8-change, 1-E change and 0-change were examined.

Statistical Tests. The confidence level for all statistical tests to be reported was set at five percent.

VII. RESULTS OF EXPERIMENT 2

Pretest. A 6 (Change) x 2 (Stimulus Value) x 2 (Sex) analysis of variance carried out on the number of trials to criterion on the pretest (Table 11) yielded no significant differences. Mean number of trials to criterion was 9.37 trials, S.D. = 4.81.

Acquisition (Trials 1-8). The mean errors and standard deviation for each treatment group during both acquisition and transfer are given in Table 12. A 6 (Change) x 2 (Stimulus Value) x 2 (Sex) analysis of variance applied to the error scores from the first eight acquisition trials (Table 13) revealed a significant main effect due to Change. All other effects were negligible.

The mean errors for the change groups during the eight acquisition trials were: 2-change, $\overline{X}$ = 2.25; 1-E change, $\overline{X}$ = 2.38; 4-change, $\overline{X}$ = 2.63; 8-change, $\overline{X}$ = 3.00; 1-M change, $\overline{X}$ = 4.25 and 0-change, $\overline{X}$ = 4.63. Duncan's multiple range test indicated that the 2, 1-E and 4-change groups which did not differ significantly from each other, made fewer errors than the 0-change control group. In addition, the 2 and 1-E change groups made significantly fewer errors than the 1-M change group while the remaining comparisons did not approach significance. Chance level of responding was 4.00 errors.

TABLE 11

Summary of Change X Size Value X Sex Analysis of Variance on Number of Trials to Criterion on the Pretest in Experiment 2

SOURCE	DF	MEAN SQUARE	F*
Change Condition (C)	5	14.883	
Size Value (V)	1	12.000	
Sex (S)	1	27.000	
CV	5	14.200	
CS	5	44.010	
VS	1	60.750	
CVS	5	25.650	
Error	24	22.333	

*All F values are insignificant

TABLE 12

Means and Standard Deviations of Error Scores in Each Phase of Experiments 2 and 3

Experiment 2

Stimulus Change Condition (Relevant Dimension Size)	Trials 1 - 8		Trials 9 - 40	
	$\bar{X}$	SD	$\bar{X}$	SD
8 - change	3.00	1.66	11.88	4.86
4 - change	2.63	2.12	8.63	8.01
2 - change	2.25	1.56	9.50	7.40
1-E change	2.38	1.22	9.00	8.31
1-M change	4.25	1.39	16.50	1.32
0 - change	4.63	1.22	17.88	1.76

Experiment 3

Stimulus Change Condition (Relevant Dimension Size)	Trials 1 - 8		Trials 9 - 40	
	$\bar{X}$	SD	$\bar{X}$	SD
8 - change	3.00	1.87	9.88	6.73
1-E change	2.63	1.11	14.13	5.97
0 - change	3.75	1.48	15.38	2.45

TABLE 13

Summary of Change X Size Value X Sex Analysis of Variance on the Error Scores During Acquisition in Experiment 2

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	5	8.137	2.982*
Size Value (V)	1	1.688	
Sex (S)	1	3.521	
CV	5	3.837	
CS	5	3.471	
VS	1	0.188	
CVS	5	1.837	
Error	24	2.729	

*$p < .05$

Transfer (Trials 9-40). The mean errors and standard deviation for each treatment group during both acquisition and transfer are given in Table 12. A 6 (Change) x 2 (Stimulus Value) x 2 (Sex) analysis of variance carried out on the error scores for the thirty-two transfer trials (Table 14) showed a main effect due to Change. All other effects were non-significant.

Duncan's multiple range test indicated that the 4, $\overline{X}$ = 8.63; 1-E, $\overline{X}$ = 9.00; 2, $\overline{X}$ = 9.50 and 8, $\overline{X}$ = 11.88 groups did not differ significantly from each other. All of these groups, however, made significantly fewer errors than the 1-M, $\overline{X}$ = 16.50 and 0, $\overline{X}$ = 17.88 groups which did not differ significantly from each other. Chance level of responding was 16.00 errors.

As in Experiment 1 the correlation between subjects' acquisition and transfer scores was significant, r = +.59.

The number of subjects reaching May and MacPherson's criterion of eight successive correct responses during transfer are given in Table 15. Fisher's Exact Probability test revealed that significantly more subjects reached criterion in the 4 and 1-E change group than in the 0 and 1-M groups.

Figure 4 shows the performance of the six change groups over blocks of eight trials during both acquisition and transfer. As in Experiment 1 the 8-change group appears to show considerable improvement during the last block of eight trials.

VIII. RESULTS - EXPERIMENT 3

Pretest. Analysis of variance on the number of trials to criterion on the pretest (Table 16) again yielded no significant differences. Mean trials to criterion were 9.63, S.D. = 6.55.

TABLE 14

Summary of Change X Size Value X Sex Analysis of Variance on the Error Scores During Transfer in Experiment 2

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	5	129.771	2.959*
Size Value (V)	1	150.521	
Sex (S)	1	99.188	
CV	5	28.671	
CS	5	38.837	
VS	1	0.521	
CVS	5	18.271	
Error	24	43.854	

*$p < .05$

TABLE 15

Number of Subjects in Experiments 2 and 3 Reaching Criterion on Eight Successive Correct Responses During Transfer

Experiment 2

Condition	Number of Subjects Reaching Criterion
8 - change	2/8
4 - change	5/8
2 - change	3/8
1 -E change	4/8
1 -M change	0/8
0 - change	0/8

Experiment 3

Condition	Number of Subjects Reaching Criterion
8 - change	5/8
1 -E change	2/8
0 - change	0/8

TABLE 16

Summary Change X Size Value X Sex Analysis of Variance on Number of Trials to Criterion on Pretest in Experiment 3

SOURCE	DF	MEAN SQUARE	F*
Change Condition (C)	2	9.042	
Size Value (V)	1	2.667	
Sex (S)	1	10.667	
CV	2	19.042	
CS	2	34.042	
VS	1	24.000	
CVS	2	9.375	
Error	12	66.416	

*All F values are insignificant

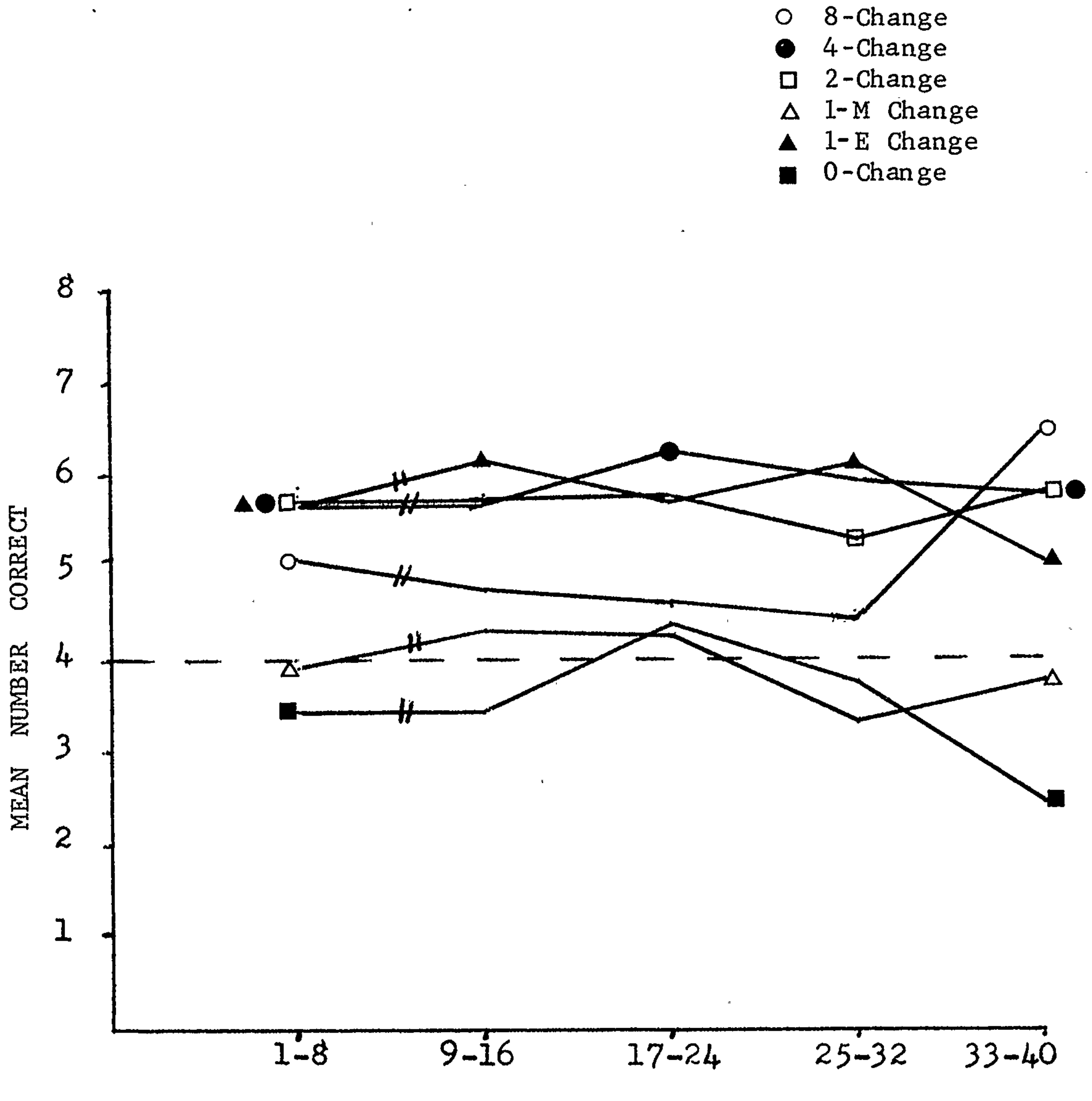

Figure 4: Mean Number of Correct Responses in Blocks of Eight Trials in Experiment 2.

Acquisition. The mean errors and standard deviation for each treatment group are given in Table 12. A 3 (Change) x 2 (Stimulus Value) x 2 (Sex) analysis of variance applied to the error scores for the eight acquisition trials (Table 17) did not reveal any significant effects.

Transfer (Trials 9-40). The mean errors and standard deviation for each treatment group are given in Table 12. A 3 (Change) x 2 (Stimulus Value) x 2 (Sex) analysis of variance for the thirty-two transfer trials (Table 18) revealed main effects due to both Change and Stimulus Value. The Change x Stimulus Value x Sex interaction was also significant.

Duncan's multiple range test applied to the means for the three change groups revealed that the 8-change group, $\overline{X} = 9.88$, made significantly fewer errors than either the 1-E, $\overline{X} = 14.13$ or 0, $\overline{X} = 15.38$ change groups which did not differ significantly from each other.

The significant effect due to Stimulus Value indicated that overall, subjects made more errors when the rewarded stimulus value was larger than when the rewarded stimulus value was smaller.

A plot of the significant Change x Stimulus Value x Sex interaction is given in Figure 5. The interaction appears to be attributable to the large number of errors made by the males in the 1-E smaller condition. In contrast the girls in the same change condition made zero errors in the smaller condition. A post hoc explanation for this result is better to be avoided because of the inconsistent findings with this particular interaction in the present three experiments. This interaction was significant for size during transfer in Experiment 1. It was not significant, however, for brightness in Experiment 1 or for size in Experiment 2.

TABLE 17

Summary of Change X Size Value X Sex Analysis of Variance on Error Scores During Acquisition in Experiment 3

SOURCE	DF	MEAN SQUARE	F*
Change Condition (C)	2	2.542	
Stimulus Value (V)	1	0.375	
Sex (S)	1	7.042	
CV	2	0.875	
CS	2	0.542	
VS	1	1.042	
CVS	2	2.042	
Error	12	2.625	

*All F values are insignificant

TABLE 18

Summary of Change X Size Value X Sex Analysis of Variance on Error Scores During Transfer in Experiment 3

SOURCE	DF	MEAN SQUARE	F
Change Condition (C)	2	66.500	3.902*
Stimulus Value (V)	1	117.042	6.868*
Sex (S)	1	0.375	
CV	2	12.667	
CS	2	50.000	
VS	1	12.042	
CVS	2	118.166	6.934*
Error	12	17.042	

*$p < .05$

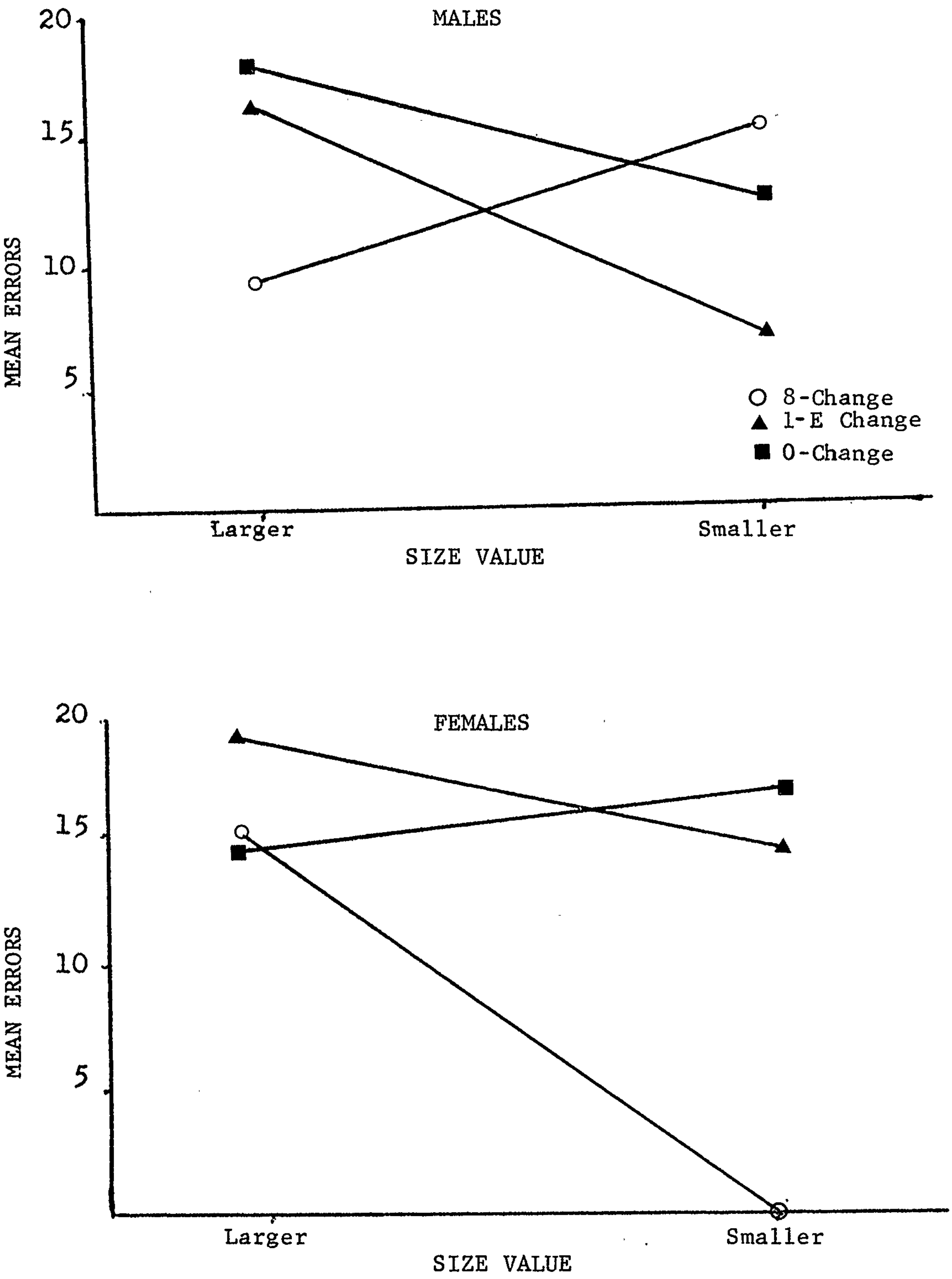

Figure 5: Change x Size Value x Sex Interaction in Experiment 3.

The correlation of the subjects' acquisition and transfer scores in Experiment 3 was +.47.

The number of subjects meeting the criterion of eight successive correct responses during transfer are given in Table 15. Fisher's Exact Probability test showed that significantly more subjects reached this criterion in the 8-change group than in either the 1-E or 0-change groups.

Figure 6 shows the performance of the three change groups over blocks of eight trials during both acquisition and transfer. Again the 8-change group appears to be improving during the last block of eight trials.

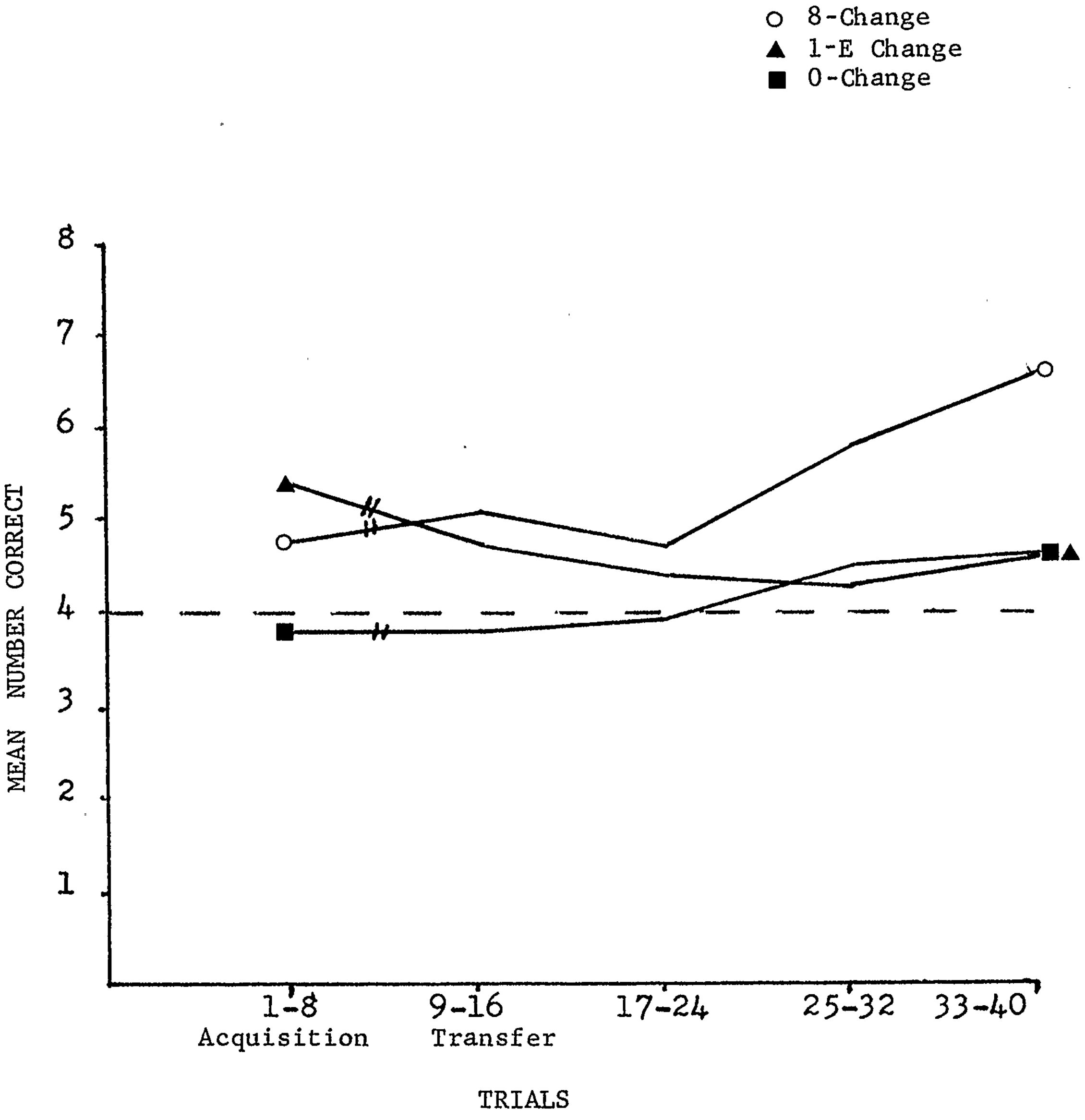

Figure 6: Mean Number of Correct Responses in Blocks of Eight Trials in Experiment 3.

IX. DISCUSSION - EXPERIMENTS 2 and 3

The results of Experiment 2 support the suggestion from Experiment 1 that for children in Grade 1 an Easy discrimination during acquisition facititates performance on a difficult transfer task. Thus, it appears that facilitation in the Irrelevant-Easy condition of Experiment 1 can be attributed to the easy discrimination in the relevant dimension during acquisition and not to stimulus change in the irrelevant dimension. The results of Experiment 3, however, indicate that the easy discrimination which facilitated transfer performance for children in Grade 1 did not facilitate transfer performance for children in Grade 3. One possible interpretation of this difference between the performance of the younger and the older children is that for the older children given the easy initial discrimination the solution to the task was too easy. It may also be, that when transferred to the difficult transfer discrimination, older subjects interpreted the change in stimuli to indicate that the correct solution to the task had been changed. Stevenson (1970) reviews a number of studies, with children of ages comparable to those of subjects in the present experiments, which support the suggestion that older subjects are often unable to accept the fact that a problem is as simple as the one they are actually presented. Appealing to a concept of adaptation level similar to that proposed by Heim (1954) previously discussed, Stevenson concludes that whenever children's expectations about the level of difficulty of a problem are discrepant from the actual level of difficulty, poorer performance may result.

A limitation on this tentative explanation for the failure of the easy discrimination to facilitate performance for older children results from the significant three-way interaction in Experiment 3. As illustrated in Figure 3 the easy discrimination did facilitate transfer performance for males rewarded for responding to the smaller stimulus. As noted earlier, however, this interaction effect was not reliable in the present experiments and probably does not warrant interpretation at present.

In contrast to the beneficial effects on performance of presenting the Easy stimulus set to the younger children no facilitation was obtained following eight trials of training with the Medium stimulus set. Subjects in this condition responded in the same manner as subjects receiving the difficult discrimination through out both acquisition and transfer, the two groups responding at about chance level. This finding would indicate that the physical magnitude of the difference between the two stimuli in a set was a critical variable in eliciting attention to the relevant dimension for younger children.

The results show that for children in Grade 1, all three stimulus change conditions replicated from May and MacPherson's study facilitated subsequent transfer performance. In addition, the 8-change condition also facilitated performance on the difficult transfer discrimination when tested with children in Grade 3. With children in Grade 1, however, there was no evidence that the important aspect of these conditions was temporal change in problem difficulty, since the three change groups representing varying amounts of problem difficulty did not result in differential performance during transfer to the difficult discrimination. During acquisition, however, the data indicate that the 8-change group representing the greatest amount of temporal change did not perform as well as the 2 or 4-change change groups. This finding does conform to a result reported by May and MacPherson that children in kindergarten perform better during acquisition with 2 or 4 rather than 8 changes. Possibly, as May and MacPherson suggest, the effectiveness of a particular amount of change may be tied to the age of the subjects. Another possibility is that with younger children the easy discrimination may have accounted for all of the facilitation demonstrated during transfer, even the stimulus change conditions. The faster learning during acquisition in the 1-E, 2 and 4 change groups might indicate that having at least two easy discriminations is superior to presenting the easy discriminations on every other trial.

X. GENERAL DISCUSSION

The present experiments emphasize the importance of the magnitude of differences between simultaneously presented stimuli as a critical variable in eliciting the attention of younger children. The results from both Experiments 1 and 2 showed that subjects made fewer errors in learning a visual discrimination when stimuli were more widely separated on a stimulus dimension. In addition, younger children having an initial easy discrimination performed better when transferred to a more difficult discrimination on the same dimension. This finding confirms other transfer along a continuum experiments in which following an easy discrimination the difficult discrimination was presented directly (e.g. Lawrence, 1952; Spiker, 1959; Williams, 1968). Further, the results of Experiment 2 demonstrated that performance remained at chance level during both acquisition and transfer when subjects were given a medium difficulty size discrimination only slightly more difficult than the easy discrimination.

The issue of whether it is better to jump abruptly to the final difficult discrimination after training with an easy discrimination or to approach the final discrimination through a series of graduated steps is equivocal both in terms of the experimental findings and theoretical analyses. Present results from Experiment 2 revealed equivalent facilitation in the abrupt, 1-E change, condition and in the gradual, 2-change, condition. This finding supports results reported by Marsh (1967) who compared these two methods of training on a hue discrimination task with college students as subjects. He found equivalent facilitation for both abrupt and gradual training. On the other hand, all of the early writers who advocated training by means of transfer along a continuum adhered to the gradual method (Montessori, 1912; Pavlov, 1932; James, 1950). Lawrence (1952) provided experimental support for this position in a study in which he compared the two methods in teaching rats various discriminations. He found that while both the abrupt and the gradual methods of training were superior to giving all of the training on the difficult discrimination, the gradual method resulted in more efficient learning. Further, Baker and Osgood (1954) compared the two methods in training pitch discriminations in human adults and found no facilitation in the abrupt condition but did find facilitation in the gradual condition. These latter results may be due to the fact that unlike other studies Baker and Osgood used a same-different response and did not provide reinforcement (informative feedback) during the test period with the difficult discrimination.

Attention theories predict that both the gradual and abrupt methods of training should facilitate transfer performance by means of the acquisition and transfer of attending responses. These theories, however, do not predict the relative superiority of either method. The present result would indicate that once a relevant observing response is established, stimulus values presented all along the dimension are revealed and thus it is not necessarily advantageous to shift a discrimination gradually along a dimension.

When dealing with younger children the results of this study are clearly at variance with those of May and MacPherson (1971). Using kindergarten, grade two and grade three subjects these authors found that increasing numbers of stimulus changes lead to increased facilitation of transfer performance with a difficult discrimination. Three change conditions in Experiment 2, replicated from May and MacPherson, did show facilitation compared to the control group. However, these conditions representing different numbers of stimulus changes did not differ from one another during transfer. In addition the results of both Experiments 1 and 2 indicate that stimulus change had far less effect in these experiments both in terms of error scores and the number of subjects reaching criterion than did the corresponding conditions in May and MacPherson's study.

Possibly the stimulus change groups did not differ in their transfer performance with younger children in the present study because, as the results of Experiment 2 indicate, the medium difficulty size discrimination was too subtle for most of the subjects to notice. Thus, the facilitation observed due apparently to stimulus change may have been due entirely to the easy discrimination appearing on half of the acquisition trials in each change group. There seems to be no plausible reason, however, why the medium difficulty discrimination should have been effective in May and MacPherson's study and not in the present study.

Some support for the facilitatory effect of stimulus change reported by May and MacPherson (1971) is provided by the results of Experiment 3. Here, with older children the 8-change condition did facilitate transfer performance, whereas an easy discrimination alone did not. Both this finding and the discrepancy with the results from younger children can be reconciled if one assumes that as children become older subtle dimensional differences between stimuli become more salient. As was argued in the discussion of Experiment 3, the easy discrimination may have been ineffective for older children as it was "too obvious", and therefore made the discrimination much easier than children expected. Stimulus change may have been effective for older children because both the easy and the medium difficulty discriminations were salient. This interpretation of the results would suggest that both differences between simultaneously presented stimuli and changes in the amount of the difference from trial to trial are important variables in eliciting the attention of children. Further, the effectiveness of stimulus change may be dependent on the absolute physical differences involved in the change. Both of these variables were shown to interact with age.

One important finding in the present study concerns the absence of improvement by many subjects during the acquisition period. This might lead to a conclusion that no learning took place and therefore there is no possibility of transfer. On the other hand, something akin to latent learning seems to have taken place in many subjects among the experimental groups who, although not exceeding the control group's performance during acquisition, did show superior performance during transfer. These subjects demonstrate positive transfer. The positive transfer, following Zeaman and House, would be attributed to the acquisition and transfer of attending responses.

It cannot be assumed, however, that subjects performing at chance level during both acquisition and transfer have learnt nothing. They may have learned that their optimal strategy was to guess. Although subjects were instructed at the beginning of training that it was possible to obtain a reward on every trial, some children may have concluded that reinforcement was not associated with any specific cue. Subjects who did not choose the correct cue from the beginning of training might have discovered that they would be reinforced half of the time by selecting at random. On every trial each subject was presented with two stimuli varying in three dimensions but only one of the six resulting cues was reinforced consistently. Further, subjects may have developed additional hypotheses not based on the stimulus dimensions varied by the experimenter. The present experimental results do not provide definitive experimental support for the "learning to guess" strategy. Such a strategy if confirmed, would require a reconsideration of two stage theories of attention (e.g. Zeaman & House, 1963). These theories assume that the subject modifies his observing and instrumental responses until the correct discrimination is acquired. It may be that the subject "decides" to guess, that this response is reinforced, and that alternative observing-instrumental responses are no longer being modified.

XI. REFERENCES

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