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INCENTIVE EFFECTS UPON ATTENTION IN CHILDREN'S DISCRIMINATION LEARNING. INTERIM REPORT.

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REPORT NUMBER CRP-2512   PUB DATE   1 JAN 67
REPORT NUMBER BR-5-0331
CONTRACT OEC-SAE-5-10-217
EDRS PRICE   MF-$0.09   HC-$1.44   36P.

DESCRIPTORS- LEARNING MOTIVATION, *MOTIVATION TECHNIQUES, *EDUCATIONAL STRATEGIES, LEARNING PROCESSES, LOW MOTIVATION, STIMULUS DEVICES, *AROUSAL PATTERNS, *STIMULUS BEHAVIOR, *DISCRIMINANT ANALYSIS, ATTENTION CONTROL, GRADE 2, GRADE 4, GRADE 5, GRADE 6, MODELS, STORRS, CONNECTICUT

THE EXPERIMENTAL DESIGN OF THIS PROJECT WAS DEVELOPED TO TEST THE INFLUENCE OF INCENTIVE VALUES IN TWO-CHOICE, SIMULTANEOUS DISCRIMINATION LEARNING WITHIN THE FRAMEWORK OF AN ATTENTION THEORY (ZEAMAN AND HOUSE, 1963). FOLLOWING A 40-TRIAL TRAINING PROCEDURE IN WHICH HIGH AND LOW INCENTIVE VALUES WERE USED TO INFLUENCE STIMULUS DIMENSION PREFERENCES, 276 CHILDREN IN GRADES 2, 4, 5, AND 6 WERE TESTED ON AN 80-TRIAL, TWO-CHOICE DISCRIMINATION LEARNING TEST. THE ZEAMAN-HOUSE ATTENTION THEORY MODEL WAS USED WITH APPROPRIATE CONDITIONS FOR TESTING TO CONFIRM THE HYPOTHESIS THAT THE PROBABILITY OF OBSERVING A RELEVANT DIMENSION IN DISCRIMINATION LEARNING IS INCREASED MORE BY A HIGH INCENTIVE THAN BY A LOW INCENTIVE. THE HYPOTHESIS WAS CONFIRMED FOR MALES IN THE SECOND GRADE. EQUIVOCAL SUPPORT WAS FOUND FOR GIRLS AND FOR OLDER CHILDREN UNDER VARYING EXPERIMENTAL CONDITIONS. RESULTS SUGGESTED THAT DIFFERENTIAL INCENTIVE VALUES INFUENCE HOW QUICKLY LEARNING STARTS, RATHER THAN THE RATE OF LEARNING. (GD)

CRP 2512
(5-0331)

INTERIM REPORT

Project #2512
Bureau #5-0331-2-12-1, Contract SAE OE-5-10-017

Date: January 1, 1967
Sam L. Witryol, Project Director

Incentive Effects upon Attention in Children's

Discrimination Learning

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Abstract

Following a 40-trial training procedure in which high and low incentive values presumably influenced stimulus dimension preferences, 276 children in grades 2, 4, 5, and 6 were tested on an 80-trial, two-choice discrimination learning test. Differential, incentive associated, dimension preferences from training were hypothesized to facilitate or impair test performance by altering observing responses to the relevant dimension in which the correct stimulus cue was found. After exploring boundary conditions of instructions, incentive type, definition of samples as learners or nonlearners, and mode of stimulus presentation in training, the hypothesis was clearly confirmed for males in the second grade. Equivocal support was found for girls and for older children under varying experimental conditions. The effect was more apparent for boys at all age levels where experimental conditions were comparable. Results, taken together with backward learning curves, strongly suggest that differential incentive values influence the point at which learning starts, rather than slope or asymptote. The application of attention theory was commended to investigators who have been puzzled in the past from findings of acquisition differences as a function of different reinforcement values.

Incentive Effects upon Attention in Children's Discrimination Learning[1]

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This experiment was designed to test the influence of differential incentive values in two-choice simultaneous discrimination learning within the framework of an attention theory (Zeaman & House, 1963). Research using subjects at various phylogenetic levels has confirmed Spence's (1956) theory concerning the incentive motivational construct K added to drive D and interacting with habit H to account for reaction potential. Since Spence's system explicitly stated that motivation does not operate directly on the associative or habit factor H, most of the differential incentive studies have been concerned with "performance" measures characterized by Pubols (1960) as time dependent, rather than with "learning" or time independent variables such as errors or trials to criterion in acquisition. High versus low reinforcement values have most often been tested on measures reflecting energy output, maintenance of behavior, perseveration, preference, asymptotic level etc., but only relatively infrequently on acquisition in instrumental conditioning. Probably the only programmatic research with children successfully testing acquisition as a function of reward values has been published by Terrell and his associates (Terrell, 1959; Terrell, Durkin, & Wiesley, 1959; Terrell & Kennedy, 1957). There also exists a relatively recent substantial domain in the animal literature where acquisition differences have been related to incentive strength (Allison, 1964; Clayton, 1964, Cross & Boyer, 1964; Fowler, Blond, & Dember, 1959; Furchgott & Salzberg, 1959; Hill, Cotton, & Clayton, 1962; Ison, 1964; Lawson, Cross, & Tambe, 1959; Pubols, 1961; Wike & Farrow, 1962). While speculating about the significance of parametric acquisition results, researchers seem to have been very careful not to invoke a direct motivational influence of K upon associative learning H. This restraint is salutary since acquisition measures strongly suggest, but do not necessarily always reflect, the operations of H directly. Ware and Terrell (1961), employing delay of reward to which Spence attributed ambiguous incentive status, ingeniously attempted to distinguish associative from motivational responses with equivocal success. More recently Mitchell, Perkins, and Perkins (1965) invoked Wyckoff's attention theory to explain differential reinforcement influences upon acquisition in an animal learning experiment.

Early in the present research program from which this experiment derived, we discovered that children could make reliable preference judgments on commonly employed laboratory rewards via the method of paired comparisons (Tyrrell, Witryol, & Silverg, 1963; Witryol & Alonzo, 1962; Witryol & Fischer, 1960; Witryol & Ormsby, 1961) and that these preferences were generally compatible with results obtained on a five-choice discrimination learning task (Witryol, Tyrrell, & Lowden, 1964; Witryol, Tyrrell, & Lowden, 1965). The latter procedure yielded measures, however, from which it was impossible to separate the joint effects of learning and incentive preferences. These measures, termed discrimination preference choice behavior, were found to be related to paired comparison incentive preference choices by Siegel, Forman, and Williams (1966) working with mental retardates and different incentives; their results independently replicated our own, and extended the possibilities for more direct influence on instrumental learning. Our research experience, together with findings from Terrell et al., the animal literature, and Siegel's laboratory, indicated that the incentive might influence habit in some way, but neither theory nor research was entirely compatible with such an hypothesis.

In a number of exploratory investigations, we tested the notion that the point at which learning starts might be a function of differential incentive values. In experimenting with a two-situation, two-choice discrimination task, we assumed that Ss would solve the situation cued with the high incentive earlier than the second situation with the low incentive cue; both two-choice situations (form discriminations) were randomly interspersed over a common trial sequence with subjects as their own controls. The hypothesis failed confirmation, but in a terminal preference test, Ss strongly favored the stimulus conditioned to the high reinforcement over the low one. Within the single stimulus dimension (form) employed, it appeared that once reinforcement threshold was crossed, children solved problems for the information value of the reward even though differential incentive preference obviously obtained. Under these circumstances (a reinforcement is a reinforcement is a reinforcement) faster learning could not occur however large the added incentive increment.

These considerations led us to invoke a formal attention theory and to arrange the necessary conditions of an experiment for the appropriate test. Zeaman and House (1963) have developed an attention theory to account for differences in discrimination learning ability when more than one stimulus dimension is present. Their two-link learning model includes (a) a presolution phase during which S must discover the correct dimension, and (b) an acquisition phase when S makes appropriate instrumental responses to the relevant cue in the correctly observed dimension. Observing responses in the first link are inferred from chance performance and the point at which learning starts in the second link. Ss characteristically perform near chance levels until they identify the proper dimension, at which point acquisition accelerates sharply to asymptote. Backward learning curves clearly depict the phenomena, showing parallel slopes and asymptotes and different starting points under various experimental treatments.

Attention theory suggests that the higher the initial probability of observing the relevant stimulus dimension, the greater will be the speed of acquisition in discrimination learning. It would follow, then, that any alteration of this initial probability (P_o) would be reflected in acquisition speed. We hypothesized that the initial P_o for a particular stimulus dimension would be altered by association with incentives of varying magnitudes, and that the greater the magnitude of an incentive associated with a particular stimulus dimension, the greater will be the initial probability of observing that dimension as a basis for making a choice in discrimination learning. Thus, if the initial P_o for a relevant stimulus dimension has been enhanced by association with a valued incentive, learning will be facilitated. Conversely, if an irrelevant stimulus dimension has been enhanced, learning will be retarded.

The test of such an hypothesis demands careful experimental arrangements, given equivocal research on acquisition as a function of incentive magnitude and the admonitions deriving from research and theory. Spence's (1956) theory states that incentive value is determined by number of trials, and Kimble (1961, p. 374) concluded from a delay study by Logan:

"...the differential performance must have resulted from an incentive mechanism derived from a classical conditioning of responses during the delay to stimuli associated with the right and left sides of the apparatus. This suggests the intriguing possibility that, with trials equated, in instrumental conditioning discriminations may be established through the classical conditioning mechanisms involved in the development of incentive motivation or secondary reinforcement. The implications of this idea are largely unexplored."

Pretraining, then, with incentives of high and low magnitude demands careful control of the number of trials upon which <u>S</u> is reinforced.

A second desideratum advocated by Meyer (1951) is that Ss experience the range of rewards studied. When Ss are employed as their own controls, this arrangement is easily instrumented, whereas the use of independent groups provides experience only with the single reinforcement. Under the latter circumstance, incentive differences in instrumental conditioning have less often been obtained (Pubols, 1960). A third related consideration is the selection of rewards easily discriminable since incentive differences probably control a relatively small proportion of learning variance after crossing reinforcement threshold. Indeed, it seems highly possible that low rewards of near-threshold status, as compared to clearly supra-threshold reinforcements, constitute the essential differentiation in controlling acquisition behavior. Finally, multidimensionality in training and test tasks seems most relevant since the correct cue in a simple dimension is easily identifiable to the human S with almost any reinforcement. These four factors were critical to our experimental design in the training and test conditions.

While numerous exploratory researches suggested a general optimal strategy, the specifics became clear only upon further investigation. For this reason this study will be reported in two parts: (a) Preliminary Investigations and (b) Main Experiment. The hypothesis concerning the differential influence of high and low incentive magnitudes upon children's discrimination learning was tested in grades 2, 4, 5, and 6. Various boundary conditions were explored at the older age levels, before the optimal requirements in the main experiment were determined for grade 2. Results from the preliminary investigations will be reviewed more generally, but the main experiment will be reported in detail.

Method in Preliminary Investigations

Design

The experimental design included a: (a) 40-trial training session on a two-choice discrmination learning task, during which two form and two color stimulus dimensions were differentially reinforced (high and low), and (b) two-choice simultaneous discrimination test in which either the form or color dimensions in compounds was relevant to task solution, while the other was variable and irrelevant. Except for counterbalancing of dimensions, the training experience of all Ss was identical with respect to number of trials, rewards, and reward types received. During training half of the Ss in each age-sex group received a high incentive associated with form and a low reward for color, while the opposite associations obtained for the other half. Further subdivision of Ss was arranged for the test task so that half were assigned to a condition in which the stimulus dimension previously associated with the high incentive was relevant; the remaining half were tested on the dimension previously associated with a low dimension. A final assignment was made to counterbalance stimulus preferences for the correct cue. All assignments, including an equal division to two male E's (the junior authors) were made by a random procedure within the limiting restrictions of definition of experimental samples.

The basic experimental comparisons were defined in the test conditions where prior incentive training was evaluated by a discrimination task with a neutral reinforcement. For example, if S during training has received a high incentive for form choices and low, for color, and if the correct cue lies within form on test, there should be a higher initial probability for observing form which should more easily lead to the identification of the correct cue within this dimension. On the other hand, if his opposite number with the same training experience is subsequently tested on a color cue, his observing probability for form should also be higher, but now this dimension is variable and irrelevant. He must overcome his initial tendency to observe form in order to facilitate learning in the reinforced color dimension. Identical training, then, was hypothesized to facilitate in the former case and to impair learning in the latter under appropriate test conditions.

Subjects

Ss were 24 boys and 24 girls at each of grades 2, 4, and 6; and 16 children from each sex in grade 5. The 128 Ss in the preliminary investigations and the 48 Ss in the main experiment were drawn from a university community population biased toward upper middle social status reflected in the IQ (Otis Quick-Scoring Mental Ability, 1954) distributions in Table 1.

Insert Table 1

Condition assignment to high and low incentive in the table is based on test trials, since training was identical for each S within age-sex groups.

Apparatus

A portable modification of the Wisconsin General Test Apparatus was employed for the (a) training task and the (b) two-choice discrimination learning test. E, separated from S by a one-way screen, activated an electronic control unit for displaying stimuli and dispensing rewards. Each of two 6" x 5" response panels, on a horizontal plane and tilted 60° away from S at the base of the one-way screen facing him, contained a digital display device which presented a circular stimulus figure, 15/16" in diameter, from a library of 8 color, form, and color-form stimuli.[2] When S pushed one of the two response panels containing a "correct" stimulus, a reward was automatically dispensed at the base of the panel; thus, the loci of stimulus, response, and reward were in close temporal and physical proximity during training. During test trials a light, centered just above and between the response panels, signalled the reinforcement.

Procedure

Training

S was instructed to push one of the two panels with its embedded stimulus "picture" on 40 training trials. Half of the training trials (20) consisted of two color stimulus choices, while the other half (20) consisted of two form choices. Color choices on a given trial might consist of two identical colors or two different ones from red and blue; form choices were similarly arranged from circle and diamond (white figures against a black background). Color and form choices were presented in random order over the 40 training trials with the restriction that each color or form arrangement appeared an equal number of times (e.g., red-red , red-blue, blue-red, blue-blue) for the following pairs:

C_1	C_1	F_1	F_1
C_2	C_2	F_2	F_2
C_1	C_2	F_1	F_2
C_2	C_1	F_2	F_1

S was told, "...No matter which picture you push, you will get something...." Whenever S pushed a color panel, regardless of position or hue, a high reward (penny) was dispensed; whenever S responded to a form panel, a low reward (bean or paper clip; see Table 1) was dispensed. It should be reiterated that his choice on a given trial was always made within a given dimension, color or form, and always rewarded, high or low, but without the opportunity to explore the nonselected stimulus of a choice pair. Half of the Ss in each age-sex group were trained with the high reward to color and the low reward to form; the remaining half obtained high reward for form and low reward for color in order to counterbalance dimension preferences. The essence of this training procedure was to condition dimension preferences, form and color, by high and low reward associations.

Test

On test trials each stimulus pair consisted of a color-form compound with cues different from those available in training. Color cues were orange and green (red and blue in training), while form cues were triangle and square (circle and diamond in training). Green triangle was always paired with orange square, while green square and orange triangle always appeared together. This yielded two possible pairs of stimulus compounds to be used on a given trial:

1. $C_1F_1 - C_2F_2$	Green triangle	Orange square
2. $C_1F_2 - C_2F_1$	Green square	Orange triangle

Each pair of compounds appeared randomly over trials with the restriction that both pairs were presented an equal number of times over each successive block of 20 trials. Position of each compound was also varied randomly with the same restriction. S was required to make a response which would lead to a light signal for reinforcement of the correct cue on this discrimination learning test. Since the stimuli now differed both in form and color (as contrasted to form or color in training), this condition served to test stimulus dimension disposition as a function of prior incentive association value.

The correct cue within a dimension was reinforced in such a manner that half the Ss received a light signal within that dimension previously associated with high reward (penny) in training, while the other half were similarly reinforced for the cue within the trained dimension of low reinforcement (bean or paper clip). An intradimensional shift was required of the former group; an extradimensional shift, for the latter, assuming differential incentive efficacy in training. Positive cues and incentive associated dimensions were counterbalanced to minimize stimulus preference value, so that half the Ss were tested on color relevant, form variable and irrelevant; the other half, form relevant, color variable and irrelevant in each age-sex group. This two choice discrimination test condition required a learning criterion of 9 correct trials within a block of 10, up to a limit of 80 trials. Test was immediately consequent to training, and the total experimental time averaged 35 minutes.

Experimental Modifications

In exploring various boundary conditions to determine the optimal experimental approach, several modified treatments were tried, as described below. In general, these alterations proceeded from higher to lower grade levels.

Instructions

Instructions for training were:

"We are going to try something with this machine (E indicates apparatus). I will show you two pictures like this (E illuminates apertures with two forms), or like this (E illuminates two colors, and then demonstrates all color and form pairs to appear on task). I want you to look at each picture and then push either one of them, like this (E pushes one panel and stimuli lights go off). No matter which pictures you push, you will get something. One of the things you get you'll like very much, the other thing you may not care for. You may keep whatever you get and put it into this bag by your chair. Be sure that you look at both pictures before you push one. Do you have any questions? Fine! I am going behind the machine, now, where you won't be able to see me. We'll start as soon as I turn the pictures on."

Instructions on the test task for sixth grade males, and for grades 4 and 5 were:

"Now we are going to try something else. I will show you two pictures like this (E illuminates both apertures, each with a color-form compound, e.g., orange square on the right; green triangle on the left). I want you to look at both pictures and then push one of them. If you push the correct picture this light will go on (E flashes centered light reinforcement); if you push the wrong picture the light will not go on. The object is to make the light go on every time. Any questions? Fine! We'll start as soon as I turn the pictures on."

Experimental experience suggested the desirability of more orienting (see Table 1) instructions on test, and the following sentences were inserted before "...the object is to..." for grade 6 females and all second grade Ss: "Remember to look carefully at the pictures because there is something about the pictures themselves which will tell you what makes the light go on."

Incentives.

Prior research in the program indicated that pennies and paper clips yielded relatively polar high and low incentive values, and these were used in grades 4 and 5, and for sixth grade females. Prior to training, paired comparison preference rankings were obtained on sixth grade males for penny, bubble gum, charm, paper clip, and nothing, and on sixth grade females and all second grade Ss, for penny, bubble gum, charm, paper clip, and bean. Since bean yielded smaller incentive values, it was employed as a low incentive for girls in the sixth grade and for all second grade Ss (see Table 1).

Successive stimulus presentation

While exploring various boundary conditions, successive stimulus presentation on training, to minimize position strategies, was tried with the fifth grade.

Learners and nonlearners

Learners were defined as Ss attaining a block criterion of 9 out of 10 correct choices within the 80-trial test task, but analyses were based upon a 9 of 10 running criterion just antecedent to block criterion. This turned out to be a more sensitive measure, especially under conditions where learning was very rapid. Sample requirements included nonlearners and learners in grades 4 and 6, and learners only in grades 2 and 5.

Results and Discussion from Preliminary Investigations

Results will be summarized here for grades 4, 5, and 6 with special attention to statistically significant findings and trends suggested by the experimental modifications, which led to the refinements for the main investigation in grade 2. Since the distributions were characteristically positively skewed in most treatment groups, Mann-Whitney U tests were computed for total errors, errors on trials 2 to 10, and trials to criterion, along with chi square analyses on the fourth test trial. The random arrangement of the stimulus compounds in the test task led to a critical choice situation for the subject on the fourth trial where he first clearly committed himself to form or color; this choice, together with errors on trials 2 to 10 presumably reflected early dimension dispositions. There were no "correct" choices in training, and latency measures did not turn out to be discriminating.

The rationale for the fourth trial analyses can be inferred from the sequence of the first four trials on test:

1. Orange triangle - green square
2. Orange triangle - green square
3. Green square - orange triangle
4. Orange square - green triangle

Whichever cue (orange, green, triangle, or square) happened to be assigned as a correct choice for a given subject was confounded in the compounds for the first three trials. For example, if an S chose triangle consistently, orange always was part of the compound; similarly green appeared with square. On the fourth trial, however, orange appeared with square, and green with triangle. This fortuitous arrangement from the random sequence provided a clear test of S's dimension and cue committment on the fourth trial.

In the three higher age samples, only grade 4 yielded statistically significant results congruent with the major hypothesis; males at this grade level performed better in the high incentive test condition than in the low condition on total errors and trials to criterion scores. In the high condition, error and trial means and standard deviations were 10.0 and 12.7, 26.7 and 23.4 respectively; in the low condition, 24.3 and 17.5, 53.0 and 31.4. One-tail U probabilities for the incentive condition comparisons were .035 and .05 for errors and trials, respectively, and males tended to perform better than females under the high incentive condition. The two-tail U probabilities for sex differences in the high condition were .10 and .11 for errors and trials to criterion, respectively. Fourth trial and early trial analyses were not differentiating.

The most general boundaries were explored in grade 4 (see Table 1), i.e., relatively unstructured instructions, inclusion of nonlearners, and paper clip as the low incentive. It is noteworthy that early dimension preference, reflected in trials 2 to 10 and fourth trial analyses, failed significance. This was attributed in part to the inclusion of nonlearners who adopted all kinds of strategies consequent from the training condition which might reinforce any approach, e.g. position, since rewards followed all responses. There was only one nonlearner in the male high incentive group, but six in the low group; female nonlearners numbered six and four for high and low incentives, respectively. Considering failure of significance from early trial analyses, it seemed likely that significance in total scores for males was a function of the distribution of nonlearners to relevant conditions. Such an approach, however, seemed to obscure the identification of early observing tendencies to the relevant dimension.

This interpretation seemed to be confirmed, employing the same proceudre for sixth grade males; incentive condition effects were not reliable, although mean error and trial scores were in the hypothesized direction. As a consequence, test instructions were modified for better task orientation with the sixth grade females, and bean was substituted for penny in training so as to provide greater incentive differentiation. While there was the hypothesized high-low trend for females, no reliable incentive differences were obtained; but their scores under each incentive condition were significantly lower than the males', and the number of nonlearners were reduced. The girls were superior to boys on both conditions combined, with a two-tail U probability of .003 on errors and trials to criterion, clearly reflecting the facilitating effects of instructions and incentives, altered for the female population. Analyses of trials 2 to 10 and of the fourth trial also indicated female superiority under these conditions which reversed the sex differences favoring males in all the other samples.

Two further boundary conditions merited exploration with a smaller sample in grade 5 (see Table 1). Single stimulus presentation in training, to reduce position strategies, and the inclusion of learners only on test, to detect dimension preferences early in learning, were employed with the same incentives (penny and paper clip) and the same instructions (relatively less oriented) as in grade 4 where reliable differences had been discovered. No reliable incentive condition effects were obtained, but the tendency for male superiority on errors and trials to criterion in the high incentive group (two-tail U probabilities <.08) appeared, as in grade 4. Successive presentation in training was abandoned, because the advantage of reducing position strategies was negated by the subjects' relative lack of regard for such training as discrimination choice behavior. On the other hand, it seemed reasonable to define future samples to include learners only, instituted at grade 5, since backward learning curves, as will be seen in the main experiment, best define when learning starts. Nonlearners increase the multiplicity of test strategies from the training experience and obviously do not demonstrate a learning origin.

The preliminary investigations served to suggest:

(a) An incentive effect in grade 4.

(b) The desirability of detecting early dimension preferences in a population of learners only.

(c) Sensitivity of the test condition to oriented instructions.

(d) Maximization of incentive differentiation by using a bean as the low reward in training.

(e) Efficacy of two-choice simultaneous, as contrasted with successive presentation in training.

(f) Stronger male than female response to incentive training.

These trends determined the final parameters to be investigated in the Main Experiment.

Method in Main Experiment

Ss were 24 boys and 24 girls in grade 2, half of each sex being assigned to high and low incentive test conditions as indicated in Table 1. Apparatus and procedures were in general the same as in the preliminary investigations with the following refinements. Pennies and beans were the high and low incentiv.s in the simultaneous, two-choice discrimination training task. The relatively orienting instructions were administered on the discrimination learning test, and the experimental populations included learners only. Ss and two male E's were randomly assigned to each condition with the restriction of equal representation as previously.

Results from Main Experiment

Means, standard deviations, and probability values are shown in Table 2

Insert Table 2

for grade 2 incentive test total error, total trial, and trial 2 to 10 measures; exact probability estimates were calculated from Mann-Whitney one-tail U tests. Also presented in the bottom rows of the table are chi square probability values based upon the number of subjects in each incentive condition who passed or failed the critical fourth trial where a clear dimensional choice (color or form) first appeared in the test series.

The high incentive dimension was superior to the low incentive dimension in test trials for males on all measures at probability levels ranging from .025 to .035. Although identical comparisons for females failed statistical significance, similar trends obtained on all but the fourth trial analyses so that when sexes were combined, probability values ranged from .042 to .068, excluding the nonsignificant chi square, of course. Interestingly, when second grade results were combined with all the other samples, a significant chi square value (6.72; N = 88) at the .01 level favoring the high condition on the critical fourth trial was obtained for boys, despite the alterations in procedure for age-sex samples; the same analysis for females failed significance.

Figures 1, 2, and 3 graphically demonstrate the incentive effect for

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Insert Figures 1, 2, and 3

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boys on test measures of trials to criterion, total errors, and errors, trials 2 to 10. Overall, the distributions are markedly skewed with modal performance reflecting fast learning in all samples. The male populations in all comparisons, however, show truncated distributions in the high incentive condition relative to the others, i.e., they lack extremely poor scores, but the other samples are characterized by long tails, reflecting more slow learners. Close inspection of the tails also shows fewer female cases in the high, than in the low, condition.

Backward learning curves in Figure 4 most clearly represent the attention

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Insert Figure 4

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phenomenon hypothesized as a function of differential incentive values. Zeaman and House (1963) have contended that forward learning curves typically mask individual differences in slope and asymptote, so that averaging frequently may lead to spurious generalizations. In adapting Hayes' (1953) backward learning curve to reflect the shape of the learning function more typical of the individuals comprising an experimental group, they have repeatedly demonstrated the utility of this technique in connection with their two-link learning theory. Figure 4 shows early learning in the present experiment for both experimental treatments, but the low incentive gorups are displaced in the direction of poorer performance with respect to when learning started. The congruence of slope and asymptote are in accord with the Zeaman-House attention theory.

Backward learning curves serve to reflect the shape of the learning function typical of individuals comprising a group by putting each S, in effect, at the same terminal point on the abscissa for his group, namely, the median for the last five trials in this study. The scores for all such individuals are then averaged to determine per cent correct responses for location of terminal group points on the ordinate. Moving these average scores back in blocks of five trials yielded the curves in Figure 1. A minor artifact introduced by the definition of learning criterion as a running criterion of 9 out of 10 correct trials, just antecedent to a 9 of 10 block criterion, resulted in a chance level of 40% when backward curves were plotted in blocks of five trials.

Discussion

The major hypothesis that the probability of observing a relevant dimension in discrimination learning is relatively more enhanced by a high incentive than a low incentive was confirmed in the main experiment, particularly for the male sample. The magnitude of the effect was small within the present experimental context because the test task was relatively easy for most of the learners when instructions were altered; this modification was necessary to minimize position tendencies from the training experience. Since S was rewarded for any response in training, it was possible for him to invoke many implicit strategies, among which might be diminished attention to cues and dimensions. This troublesome feature, apparent from poor learning on test in the preliminary experiments, was solved by test orienting instructions toward color-form dimensions, with the subsequent loss of test variance as the task became easier. Similar considerations and consequences were involved in the decision to exclude nonlearners in the definition of our final experimental samples. Nonlearners employing unusual strategies seem to confound the analysis of form-color dimension salience associated with differential incentive values. The sum of these experimental adjustments provided a cogent design to test a theoretical framework which might explain previously puzzling, reinforcement associated, "acquisition" differences.

Persistent sex differences favoring males under comparable conditions in all samples, while not always reliable, were striking. The significant chi square value obtained for all samples combined, reflecting male superiority on the critical fourth trial where a clear commitment to dimensional salience was first required, was also noteworthy. The sex differences are difficult to explain, but past research (Witryol, Tyrrell, & Lowden, 1965) suggested boys like pennies (the high incentive) somewhat better than girls. One might further speculate that the male Es generated task irrelevant drive in female Ss through cross-sex E-S interactions, thus diminishing the relevance of physical incentives. When conditions were approximately comparable, learning seemed better with age for both sexes and the differential incentive effect diminished or disappeared. This developmental trend should be interpreted with caution because of modifications in experimental procedures, which, at the same time, did not change the direction of sex differences.

Of paramount significance is the demonstration that differential incentive values can be associated with stimulus dimensions in discrimination training so as to result in positive and negative transfer in the test phase. The backward learning curves in the main experiment show that a high incentive can direct attention to a relevant dimension, implied by Tolman's (1959) theory, and that the point at which acquisition starts follows the identification of the proper dimension, as in the Zeaman-House (1963) two-link learning model. The curves are remarkably parallel and asymptotically congruent in the second link where instrumental conditioning takes place.

Some provocative possibilities emerge. From animal research, Cross and Boyer (1964) reported that acquisition differences as a function of differential reward values were rarely but persistently discovered on complex learning tasks. If complexity in these instances stemmed from the inclusion of more than one dimension, our findings may be replicable in the past animal learning experiments by the simple expedient of drawing backward learning cur- curves. Forward learning curves mask the first link of the attention model with the second link in instrumental conditioning. Acquisition differences from the animal domain, showing different slopes in forward curves, cannot theoretically be ascribed to H differences in rate, but they might follow from the point at which H starts in the parallel backward curves of attention theory.

An alternative theory might invoke the association of incentive with stimulus in discrimination learning to enhance cue distinctiveness, relevance, and preference (Shepp, 1962, 1963, 1964; Siegel & Forman, 1966). Estes (1966) has recently proposed a paired associate explanation of stimulus-incentive relationships together with a scanning model to account for reward expectation in discrimination learning. His research with verbal discrimination learning and a companion article by Meyer, LoPopolo, and Singh (1966) on visual discrimination learning in monkeys tended to support the model. Estes, however, like Logan (1965), has examined decision constructs consequent from reward magnitudes, with cue distinctiveness as a necessary antecedent.

Research and theory on cue distinctiveness and transfer would account for our findings if one substituted the word "dimension" for stimulus "cue." This entails the conception of a color or form dimension as a stimulus cue, subject to the laws of discrimination learning. Such a designation is arbitrary and contrary to convention. Attention theory handles the central process assumed in dimensions better, while accounting for instrumental conditioning in the second link, namely, the peripheral learning process. Suchman and Trabasso (1966) found that preferred dimensions, color or form, by young children facilitated or impaired learning in a card sorting task. Dimension preferences were manipulated in our own experiment via incentive associations with the same result. Under these and comparable circumstances, investigators might do well to examine their data by means of backward learning curves when incentive conditions seem to yield different acquisition rates.

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Footnotes

[1]The research reported herein was supported through the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare. The support and encouragement of the teachers and administrative officials in the Mansfield, Conn. school system is gratefully acknowledged.

[2]Training and test stimuli pictures can be obtained from the authors upon request.

Table 1

A Comparison of IQ Characteristics by Grade, Sex, and Experimental Condition

Grade	Sex	Condition					
		High Incentive			Low Incentive		
		M	SD	N	M	SD	N
	Male	114.5	8.8	12	113.8	6.8	12
2[a,b,c]	Female	115.9	5.6	12	116.1	6.0	12
	All	114.8	7.2	24	114.9	6.4	24
	Male	118.8	6.6	12	114.1	10.0	12
4	Female	118.4	13.0	12	119.0	11.5	12
	All	118.6	10.1	24	116.5	10.8	24
	Male	118.1	12.3	8	118.1	15.3	8
5[a,d]	Female	117.2	16.2	8	116.1	11.7	8
	All	117.7	13.9	16	117.1	13.2	16
	Male	110.8	13.5	12	106.1	12.0	12
6	Female[b,c]	111.2	9.0	12	115.2	8.9	12
	All	111.0	11.2	24	110.7	11.4	24

[a]Learners only

[b]Orienting instructions

[c]Penny and bean rewards in training

[d]Successive stimulus presentation in training

Table 2

Analysis of Discrimination Test Measures, Grade 2

Test Measures	Incentive Conditions					
	High	Low	High	Low	High	Low
	Males		Females		Combined sexes	
N	12	12	12	12	24	24
Errors						
M	1.4	4.0	3.5	5.1	2.5	4.6
SD	1.0	4.2	5.0	6.5	3.7	5.4
U	39		64		214	
p	.035		N.S.		.068	
Trials						
M	10.8	15.1	14.2	17.6	12.5	16.3
SD	1.1	7.4	8.9	10.8	6.4	9.2
U	37		61		204	
p	.025		N.S.		.042	
Trial 2-10 errors						
M	0.9	2.8	1.8	2.5	1.3	2.6
SD	0.9	2.8	1.4	2.4	1.3	2.5
U	39		61		206	
p	.035		N.S.		.046	
N,4th trial						
Pass	10	4	5	6	15	10
Fail	2	8	7	6	9	14
χ^2	4.29		.00		1.34	
p	.025		N.S.		N.S.	

Note. - One-tail probability values were estimated from Mann Whitney U tests for errors, trials to criterion, and trials 2-10; χ^2 values for 4th trial analyses were also one-tail tests.

Fig. 1. Distributions of total trials to criterion by incentive conditions and sex, grade 2.

Fig. 2. Distributions of total errors by incentive conditions and sex, grade 2.

Fig. 3. Distributions of errors, trials 2 to 10, by incentive conditions and sex, grade 2.

Fig. 4. Backward learning curves by incentive conditions and sex, grade 2.

Figure 1

Training: Sample randomization sequence for first 10 of 40 training trials.

TRAINING

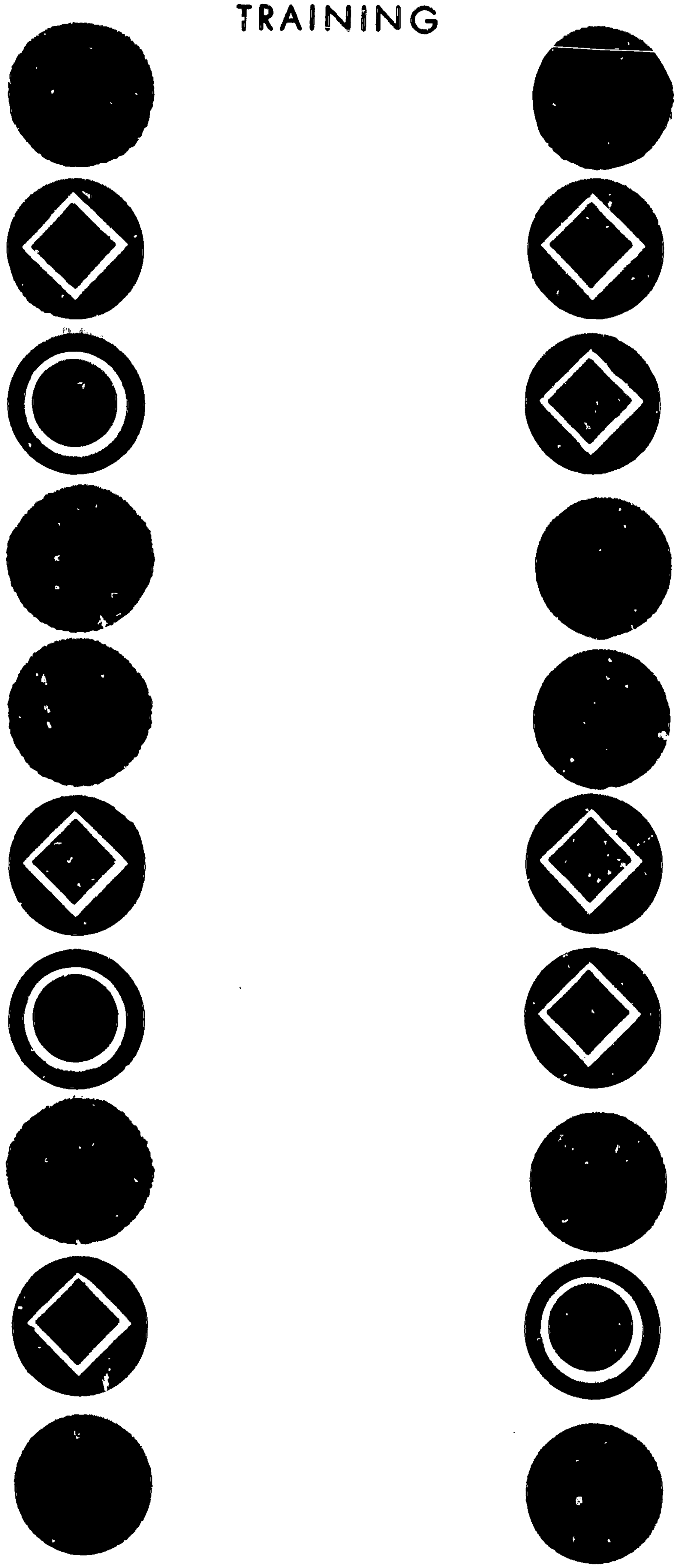

Figure 2

Test: Sample randomization sequence for first 10 of n trials to criterion (9 of 10 correct trials). Note critical choice for correct dimension on fourth pair.

TEST