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POST-DISCRIMINATION GENERALIZATION IN HUMAN SUBJECTS OF TWO DIFFERENT AGES

by

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I

INTRODUCTION

The primary purpose of the present study is to investigate the effects of S+, S- differences in discrimination training on post-discrimination generalization (PDG) in human subjects of two different ages. More specifically, the effect of the degree separation between line oriented stimuli on line orientation PDG is investigated with children ranging in age from 3-1/2--4-1/2 years and college adults. In addition, there are three related purposes: the first is to investigate the effects of S+, S- differences on discrimination acquisition; the second is to determine the relations between PDG and choice behavior; and the third is to determine the effects of the sequential occurrence of the generalization test stimuli on the relationship between S+, S- differences and PDG.

Definition of Terms

Stimulus Dimension: variations in one property of a physically defined stimulus, S1, S2, S3,... (e.g., variations in the orientation of a line, 30°, 60°, 90°, etc.).

Stimulus Distance: the separation between any two stimuli (S1-S2, S1-S5) on the same stimulus dimension (e.g., the stimulus distance between 90° and 120° is 30°; that between 90° and 150° is 60°; etc.).

S+, S- Distance: the stimulus distance between a reinforced response to one stimulus and a non-reinforced response to a different stimulus.

Stimulus Generalization (SG): SG is defined by the results of a two phase operation. In the first phase, S is trained to respond to a specified stimulus (e.g., S5). In the second phase, S is presented with stimuli which lie on a stimulus dimension related to the training stimulus (e.g., S1, S3,...S9). SG is said to have occurred if S responds to the second phase stimuli.

Stimulus Generalization Gradient (SGG): the occurrence of response variation in SG on a stimulus continuum.

Post-Discrimination Generalization (PDG): PDG is defined by the results of a two phase operation. In the first phase, S is trained to respond differentially either to two stimuli which lie on different stimulus dimensions (S+, S_D-) or to two stimuli which lie on the same stimulus dimension (S+, S-). In the second phase, S is presented with stimuli which lie on the S+ stimulus dimension. PDG is said to have occurred if S responds to the second phase stimuli.[1, 2]

Post-Discrimination Generalization Gradient (PDGG): the occurrence of response variation in PDG on a stimulus continuum.

Generalization

Hull-Spence Theory: Post-Discrimination Generalization. The theories of Hull (1939, 1943, 1950) and Spence (1936, 1937) continue to provide the most detailed analysis of stimulus generalization phenomena. Of primary concern to the present investigation are Hull-Spence predictions of

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[1] This definition as well as the definition of SG refers to generalization of responding (or excitation) which is of primary relevance to the present paper. Generalization of excitation may be contrasted with generalization of non-responding (or extinction). This latter phenomenon has also been defined as a two phase operation (Honig, Boneau, Burstein, & Pennypacker, 1963). In the first phase, S is trained to respond differentially to two different stimuli (S+, S_D-). In the second phase, S is presented with stimuli which lie on the S_D- stimulus dimension. Generalization of extinction is said to have occurred if there is non-responding to the second phase stimuli.

[2] The major distinction to be emphasized between the definitions of SG and PDG is that in the definition of PDG the training operations explicitly involve differential reinforcement.

PDG as a function of S+, S_D- and S+, S- distance training.

Hull and Spence postulate that when S+, S- distance is small, SGG's of excitation and inhibition, which are being established to S+ and S- respectively during discrimination training, combine to produce PDG. For Hull, a small S+, S- distance yields a PDGG with the following properties: (1) a peak height at S+ and (2) a bilateral asymmetrical form in which (a) response drops sharply from S+, approximately linearly, to zero at S-, (b) response is zero to stimuli on that side of S- farthest from S+, and (c) more gradual response decrement occurs from S+ to stimuli on that side of S+ farthest from S-; the amount of decrement is directly related to S+--test stimulus distance, and the form of this relationship is concave upward.

Spence's analysis of the PDG under the small S+, S- distance condition is essentially the same as Hull's. However, as a result of different assumptions regarding the form of the SGG's of excitation and inhibition (see next paragraph), Spence's theoretical PDGG has the unique characteristic of a "peak shift;" that is, (1) a peak height at a value different from S+ and on that side of S+ farthest from S-

(e.g., if S+ = 90° and S- = 120°, then S will respond maximally to a 60° test stimulus rather than to the 90° training stimulus), and (2) the amount of shift is inversely related to S+, S- distance.

When the S+, S- distance is large or when S- lies on a different stimulus dimension (S+, S_D-), the SGG's of excitation and inhibition do not overlap and interact. The resulting PDGG has the same properties as an SGG of excitation. For both Hull and Spence (a) the peak height is at S+, (b) response decrement occurs to stimuli which lie on either side or bilateral to S+, (c) the amount of decrement is directly related to and solely a function of the distance between these stimuli and S+, and (d) the form of this relationship is concave upward (Hull) or convex upward (Spence), extending from the extremes of the stimulus dimension to S+.

PDG Research. In general, Spence's predictions regarding the PDGG which results from a small S+, S- training distance has been supported. That is, the peak of the PDGG has been observed to be at a value different from S+ and on that side of S+ farthest from S-. The "peak shift" has been found in studies with pigeons and color discrimination (Hanson, 1959; Honig, 1962; Honig, Thomas α Guttman, 1959;

Thomas, 1962; Thomas, Ost α Thomas, 1960); with adult humans and vertical-spatial discrimination (LaBerge, 1961); and with both adult humans and rats and auditory intensity discrimination (Cross α Lane, 1962; Pierrel α Sherman, 1962). In addition, Hull's predictions regarding the PDGG which results from S+, S_D- training has been supported. That is, the PDGG has been observed to be concave upward with a peak at S+. This gradient form has been found in studies with pigeons and auditory discrimination (Jenkins α Harrison, 1960) and with pigeons and line orientation discrimination (Hōnig, Boneau, Burstein α Pennypacker, 1963).

The present investigation may be considered an extension of the above studies. Within the context of Hull-Spence theory, the primary purpose is to compare line orientation PDG under the S+, S_D- condition to line orientation PDG under two S+, S- distance conditions.

Discrimination Acquisition

Hull-Spence Theory. Hull and Spence predict an inverse relation between S+, S- distance and amount of training necessary to attain a discrimination criterion. Their prediction is based on the following assumptions: (1) SGG's of excitation and inhibition develop during discrimination acquisition, (2) the gradients interact and generate response competition when S+, S- distance is small, resulting in relatively slow acquisition, and (3) the interaction effect is minimized and discrimination learning facilitated as S+, S- distance is increased or if S- lies on a dimension different from that of S+.

Distance Discrimination Research. The Hull-Spence formulation has received experimental support from studies with pigeons and color discrimination (Hanson, 1959; Thomas, 1962), rats and auditory intensity discrimination (Pierrel & Sherman, 1962), adult humans and vertical-spatial discrimination (LaBerge, 1961), and fourth grade children and color discrimination (Lipsitt, 1961).

There is some evidence which would suggest that the rate of formation of orientation discriminations may not be predictable from a specification of the degree physical separation between S+ and S- (Mackintosh & Sutherland, 1963; Rudel α Teuber, 1963; Sutherland, 1957, 1963). That is, a vertical-oblique discrimination ($\overset{S+}{|}$ $\overset{S-}{\backslash}$) has been found to be less difficult than an oblique-mirror image discrimination ($\overset{S+}{/}$ $\overset{S-}{\backslash}$).

The present investigation will provide additional information on the relationship between S+, S- distance and line orientation discrimination acquisition, since different orientation distance discriminations precede PDG testing.

PDG and Choice Behavior

Spence Theory. According to Spence, the form of the PDG determines behavior in a choice situation. That is, the height of the PDG at any point on the stimulus dimension determines the probability of reponse to each stimulus in a set of stimuli presented simultaneously.

Research. There has been only one direct test of Spence's hypothesis (Honig, 1958, 1962). Honig tested SG and PDG by presenting pigeons with single stimulus (SS) presentations (ie. S1, S2, etc., generalization) and double stimulus (DS) presentations (S1 + S2, S2 + S3, etc., choice). The predictions generated by Spence's model were generally supported.

For example, when S was trained to respond to a 550 mμ stimulus, the SGG showed greater responding to 550 mμ than to 540 mμ and correspondingly greater responding to 550 mμ in the 540 mμ--550 mμ pair.

The SS and DS aspects of Honig's testing procedure are utilized in the present investigation. The purpose is to provide information regarding the generality of Spence's hypothesis.

Test Order Effects

Generalization has been conceived of as a process which is solely determined by the training conditions (Hull-Spence). It has also been thought of as being determined by the relationship between training and testing (Razran, 1949; Mednick α Freedman, 1960).

Pilot research established that when S+ was a vertical line and S- the absence of the line (S+, S_D-), a test order in which oblique stimuli occurred initially produced a PDGG which was different from the one found when horizontal stimuli occurred initially. Subsequent research suggested, however, that when S+ was a vertical line and S- an oblique line, PDG did not interact with order.

Test order is included in the design of the present experiment. The purpose is to determine its relationship to PDG under the S+, S_D- and S+, S- distance conditions.

Age Effects

Developmental psychology has been conceived of as a within species comparative psychology (Gollin, 1964). One of the concerns of human comparative investigation has been to test the generality of formal explanation. This has been accomplished by varying a specified subject dimension (e.g., age) and determining the extent to which each of the different groups conforms to theoretical predictions. Another concern of developmental investigation has been the identification and specification of organismic properties which differ over age and which produce different performance outcomes under the same experimental conditions.

The present investigation is concerned with the following questions: (1) Will both children and adults exhibit PDG patterns which correspond to Hull-Spence predictions? and (2) If child-adult PDG differences are found, will the generalization patterns suggest inferences about the mediational properties of the different age groups?

In the present study, the performance of children ranging in age from 3-1/2--4-1/2 years and college adults is compared. These age groups were selected for two reasons: (1) Hull has stated that when a generalization gradient which does not conform to theory is obtained with human Ss, secondary or abstract classifications based on speech responses and involving the dimension under investigation may be mediating performance. Similarly, Spence's theoretical formulations are limited to the case of the non-mediated or primary stimulus dimension. For these reasons human research involving tests of Hull-Spence theory have sometimes employed young children ranging in age from 3-5 years (Kendler α Kendler, 1962; Johnson α Zara, 1960). The assumption has been that these Ss are like infrahuman Ss in that they are less likely to have learned abstract classifications involving the experimental stimulus dimension. (2) Pilot research suggested that while no age-related differences would be found on S+, S_D- discrimination acquisition, differences would be found in PDG. Thus, these age groups seem particularly suited to an investigation of the theoretical and developmental questions of interest.

General Experimental Design

In order to investigate the problems outlined above, a two phase research design was devised. In the first phase, two parameters of discrimination learning are varied: physical distance between S+ and S- (30°, 60°, and $>60^{\circ}$ or S+, S_D-) and the values utilized as S+ (90°, vertical; and 120°, oblique) across distance conditions. The purpose of the latter condition is to assess the generality of results obtained in the distance conditions. These values have been used in previous research with infrahuman Ss (Honig, Boneau, Burstein α Pennypacker, 1963) and human Ss (Rudel α Teuber, 1963) and thus allow for cross-experimental comparisons. Since there are three levels of distance, two S+ conditions, and two age groups, the first phase of the research consists of a 3 x 2 x 2 factorial design for independent groups. In the second phase, SS and DS generalization tests are given to all of the first phase groups. Half of the Ss within each of the discrimination groups are presented with one test order (oblique first) while the other half are given a different test order (horizontal first).

II

METHOD: EXPERIMENT 1

Subjects. Ninety-two children in attendance at nursery schools in Queens, New York, ranging in age from 3-1/2--4-1/2 years, and one hundred twenty-two introductory psychology students at Queens College, New York served as Ss.

Apparatus. The apparatus consisted of a flat black three-sided masonite display box, 14 inches wide x 12 inches high x 10 inches deep.

Cut into the face of the apparatus were two circular windows in horizontal alignment. The diameter of the windows was 2.75 inches and the spatial separation between the center of the two windows was 6.25 inches. Behind each of the windows was a rectangular card holder.

The stimuli (lines of variable orientation) were constructed by placing 1/16 inch wide black tape strips on rectangular white cards. When these cards were placed in the holders from the back of the apparatus, a black diameter on a white disc could be observed from the front of the display box. In addition, a black masonite board, 14 inches wide x 10 inches high, was utilized: (1) it was hinged on the front of the apparatus during inter-trial intervals, and (2) it was placed over one window during single stimulus presentations.

Procedure. All Ss were seated in front of the apparatus and given the following instructions:

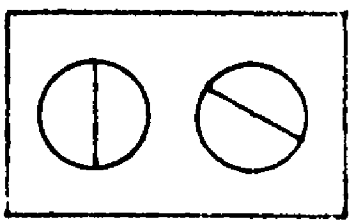
> I am going to show you some pictures. Some of these pictures have been given a name. They are called 'vec.' Sometimes I'll show you two pictures and sometimes I'll show you only one picture. If you see two pictures and you think that they both have the name 'vec', say 'yes' and point to them one at a time. If you think that only one of them has the name 'vec,' say 'yes' and point to the one you think it is. If you think none of the pictures has the name 'vec,' say 'no.' If you see only one picture and you think that it has the name 'vec,' say 'yes' and point to it; if you don't think it has the name 'vec,' say 'no.' I will tell you whether you are right or you are wrong.

There were six discrimination conditions for each of the two age groups (Figure 1): For group I (90-W), S+ was a 90° (vertical) black line on a white circular background and S- was the white background alone; for group II (90-150), S+ and S- were respectively 90° and 150°; and for group III (90-120), S+ and S- were respectively 90° and 120°. For groups IV (120-W), V (120-90), and VI (120-60), S+ was 120° and S- was, respectively, W, 90°, and 60°.

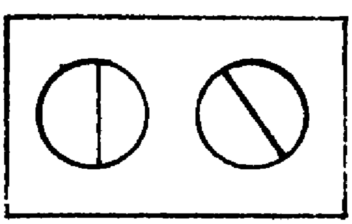
Fig. 1 Stimuli used in each of the six discrimination conditions.

$S+ = 90^{\circ}$

(90-W)

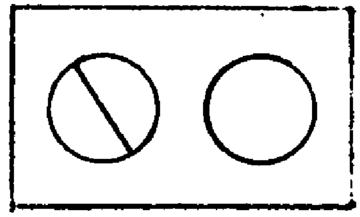


(90-150)

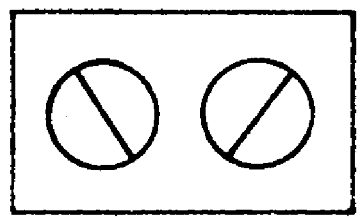


(90-120)

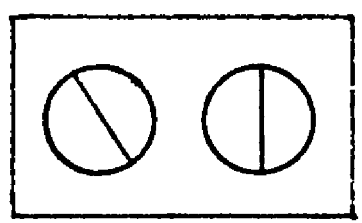
$S+ = 120^{\circ}$



(120-W)



(120-60)



(120-90)

Within blocks of eight trials there were single stimulus (SS) and double stimulus (DS) presentations of S+ and S-. The ordinal position of SS and DS trials was randomly assigned. On SS trials S+ or S- appeared alone in one of the two windows (the black masonite board, M, masked the window not containing a stimulus) or in both the left and right windows (S+, S+ or S-, S-). On DS trials S+ and S- appeared in both windows (left-right position counterbalanced). The eight trials within each block may be represented as follows (M refers to masked window): S+,M; M,S+; S+,S+; S-,M; M,S-; S-,S-; S+, S-; S-,S+. This mixed training procedure effectively equated the training condition with the test condition which consisted of both SS and DS presentations of different line oriented stimuli.

Criterion was errorless performance on an entire block of eight training trials. If criterion was not reached after six blocks (48 trials), training was discontinued and S was eliminated from the generalization test phase of the experiment. Eighteen children (90-150, n=1; 90-120, n=1; 120-90, n=3; 120-60, n=13) and two adults (120-60) failed to learn. Four children (90-120, n=1; 120-90, n=2; 120-60, n=1) refused to remain for testing. Thus, seventy children and one hundred twenty adults were available for testing. There were ten adults in each of twelve discrimination-order subgroups (six discriminations, two orders) and seven children in each of ten discrimination-order subgroups (five discriminations, two orders; children were not available for testing in the 120-60 condition).

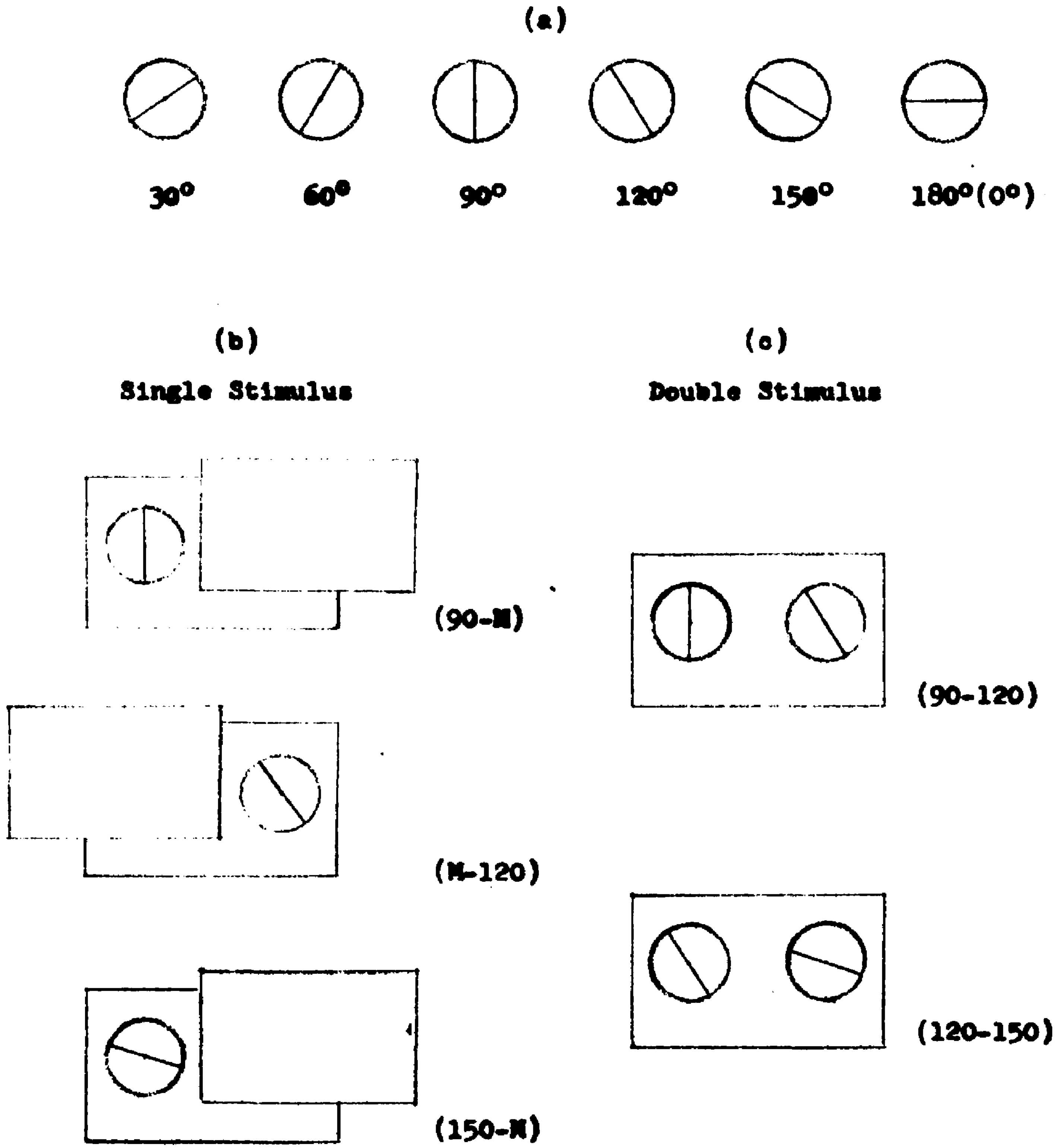
Immediately after criterion had been attained, S was told that he was now going to be shown a "few more pictures," and that he should continue as before. The training instructions were then repeated with the exception that S was now informed that he would not be told whether he was right or wrong. The exact instructions were as follows:

> Now I am going to show you a few more pictures. We will continue as before. That is, sometimes I will show you two pictures and sometimes I'll show you only one picture. If you see two pictures and you think that they both have the name 'vec,' say 'yes' and point to them one at a time. If you think that only one of them has the name 'vec,' say 'yes' and point to the one you think it is. If you think none of them has the name 'vec,' say 'no.' If you see only one picture and you think it has the name 'vec,' say 'yes' and point to it; if you don't think it has the name 'vec,' say 'no.'
>
> This time, however, I am not going to tell you whether or not you have guessed correctly. That is, you will have to guess as to which pictures have the name 'vec,' but you will have no way of knowing from me whether or not you have guessed correctly.

Generalization testing was then begun. There were six generalization test stimuli presented over a total of eighteen trials [30°, 60°, 90° (vertical), 120°, 150°, and 180° (horizontal)]. Figure 2a shows the test stimuli. Two generalization test orders which differed with respect to the initial test trials were used. Table 1 shows the test orders. In order 1 (O1) the first three test trials contained the 60° (oblique) stimulus, while in order 2 (O2) they contained the 180° (horizontal) stimulus. On all other trials (except 10, 11 and 12) and in all other respects the two test orders were exactly the same.

Each test order contained both single stimulus (SS) and double stimulus (DS) presentations. Figure 2b shows examples of SS presentations and Figure 2c shows examples of DS presentations. On SS presentations the black masonite board masked the window not containing a stimulus. Each single test stimulus appeared twice, once in each window. Thus, the position of the test stimuli was counterbalanced within Ss. The DS presentations consisted of pairs of stimuli adjacent to each other on the line orientation dimension (i.e., 180°-30°, 30°-60°, 60°-90°, 90°-120°, 120°-150°, 150°-180°). In this condition each test stimulus appeared twice, once in each window and once in each pair.

Fig. 2 (a) Generalization test stimuli.
(b) Examples of SS presentations.
(c) Examples of DS presentations.


(a)
30°
60°
90°
120°
150°
180°(0°)
(b)
Single Stimulus
(90-M)
(M-120)
(150-M)
(c)
Double Stimulus
(90-120)
(120-150)

Each *S* received only one spatial arrangement of the DS pairs, either left-right or right-left. For example, a left-right *S* received 30^{o}-60^{o}, 60^{o}-90^{o}, etc., while his right-left counterpart received 60^{o}-30^{o}, 90^{o}-60^{o}, etc. Thus, the position of individual test stimuli in the DS series was counterbalanced within *S*s and the spatial arrangement was counterbalanced across *S*s.

Within the test block of eighteen trials, twelve trials were SS presentations and six trials were DS presentations. Since there were two trials for each single test stimulus, and since *S* was permitted the option of selecting either or both stimuli on a DS presentation trial, each *S* could respond a maximum of two times to each orientation test stimulus on SS trials and two times to each on DS trials.

Before each single or double test trial, *E* asked *S* whether he thought "this picture..." or "these pictures or any of these pictures..." had the name "vec."

III

RESULTS: EXPERIMENT 1

Post-Discrimination Generalization

Group Data

The results for generalization were considered separately for each discrimination condition. The statistical analyses consisted of comparisons among age (children and adults), test order (O1 and O2), test stimuli (30°, 60°, 90°, 120°, 150°, 180°), and mode of presentation (SS and DS).

There were five four-factor unequal groups mixed analyses of variance, one for each of the following discrimination conditions: 90-W, 120-W, 90-150, 120-90, 90-120. Since thirteen of the fourteen 120-60 children failed to attain criterion and since the one remaining S refused to remain for testing, a three-factor mixed analysis was performed on the 120-60 data. The between group factors for each discrimination condition were age and order. There were seven children and ten adults in each order subgroup. The within subjects factors were test stimuli and mode of presentation.

The SS measure of generalization was computed by counting the number of responses made to each singly presented test stimulus. The maximum possible number for each _S_ was two. The DS measure was calculated by counting the number of responses made to each test stimulus in a pair (0 or 1), and then summing responses to the same test stimulus across pairs. The maximum possible number for each _S_ was two. In all of the analyses to be reported, no significant differences involving mode (SS and DS) were found. The SS and DS measures were therefore combined, providing for a possible maximum of four responses to each test stimulus per _S_.

The PDG results for all six discrimination conditions may be seen in the six frames of Figures 3 and 4. Figures 3a, b, and c show PDG for the 90-W, 90-150, and 90-120 discriminations respectively. Figures 4a, b, and c show PDG for the 120-W, 120-60 and 120-90 discriminations respectively.

Each of the figures exhibits the highest order interaction obtained in each of the six analyses of variance. These are summarized in Table 2 which shows only significant main effects and interactions for each discrimination condition. Tables 3-8 present the complete summaries of the analyses of variance for each discrimination condition.

$S+ = 90^{\circ}$ (Figures 3a, b, and c). In the 90-W condition ($S+$, S_D-) O1 and O2 children gradients were flat. The O1 adult gradients exhibited a peak at S+ and response decrement directly related to S+--test stimulus distance. The O2 adults produced a positive, vertical-horizontal pattern; that is, responded almost exclusively to 90° and 180°. In the 90-150 and 90-120 conditions (S+, S- distance 60° and 30°, respectively), children produced a positive vertical pattern (i.e., responded almost exclusively to 90°), while adults generated a positive, vertical-horizontal pattern.

$S+ = 120^{\circ}$ (Figures 4a, b, and c). In the 120-W condition ($S+$, S_D-), O1 and O2 children gradients were flat. The O1 adult gradient was essentially a positive oblique or negative, vertical-horizontal pattern (i.e., responding occurred to all stimuli except 90° and 180°). The O2 adults produced

Fig. 3 Mean number responses to generalization stimuli by Ss in the (a) 90-W, (b) 90-150 and (c) 90-120 conditions. Responses are combined across SS and DS trials.

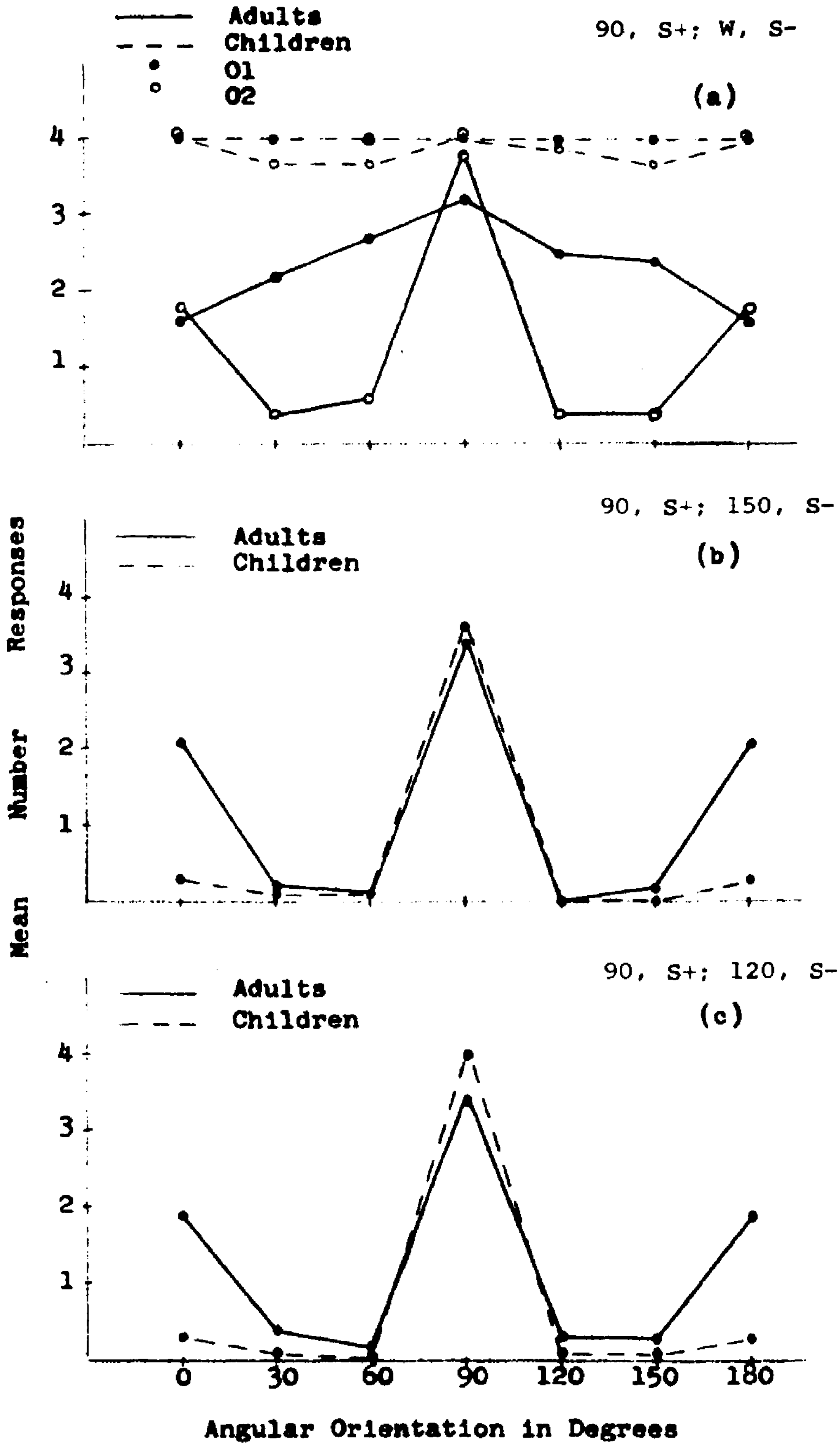
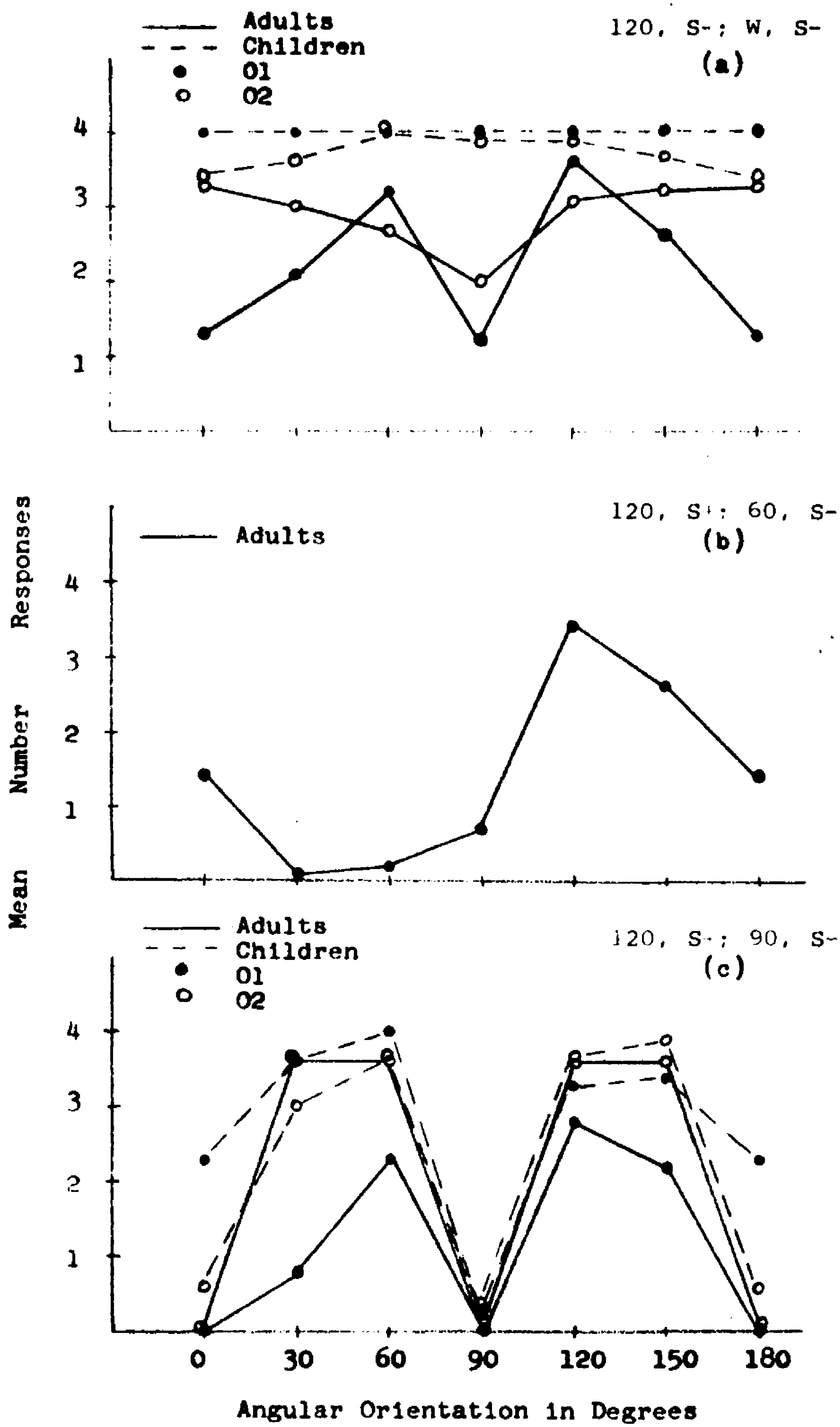

Adults
Children
O1
O2
90, S+; W, S-
(a)
90, S+; 150, S-
Adults
Children
(b)
90, S+; 120, S-
Adults
Children
(c)
4
3
2
1
Mean Number Responses
0
30
60
90
120
150
180
Angular Orientation in Degrees

Fig. 4 Mean number responses to generalization stimuli by Ss in the (a) 120-W, (b) 120-60, and (c) 120-90 conditions. Responses are combined across SS and DS trials.


Adults
Children
O1
O2
120, S-; W, S-
(a)
Adults
120, S+; 60, S-
(b)
Adults
Children
O1
O2
120, S-; 90, S-
(c)
Mean Number Responses
4
3
2
1
0
30
60
90
120
150
180
Angular Orientation in Degrees

a _negative, vertical pattern_ (i.e., responding occurred to all stimuli except 90°). In the 120-60 condition (S+, S- distance, 60°; adults only), the adult gradient exhibited a peak at S+, gradual response decrement from S+ to stimuli farthest from S-, and response suppression to S- and 30°. In the 120-90 condition (S+, S- distance, 30°), O1 children generated a _negative, vertical pattern_, and O2 children and O1 and O2 adults produced a _negative, vertical-horizontal pattern_; the pattern for the O1 adults was somewhat more asymmetrical than that of the O2 children and adults.

Individual Data

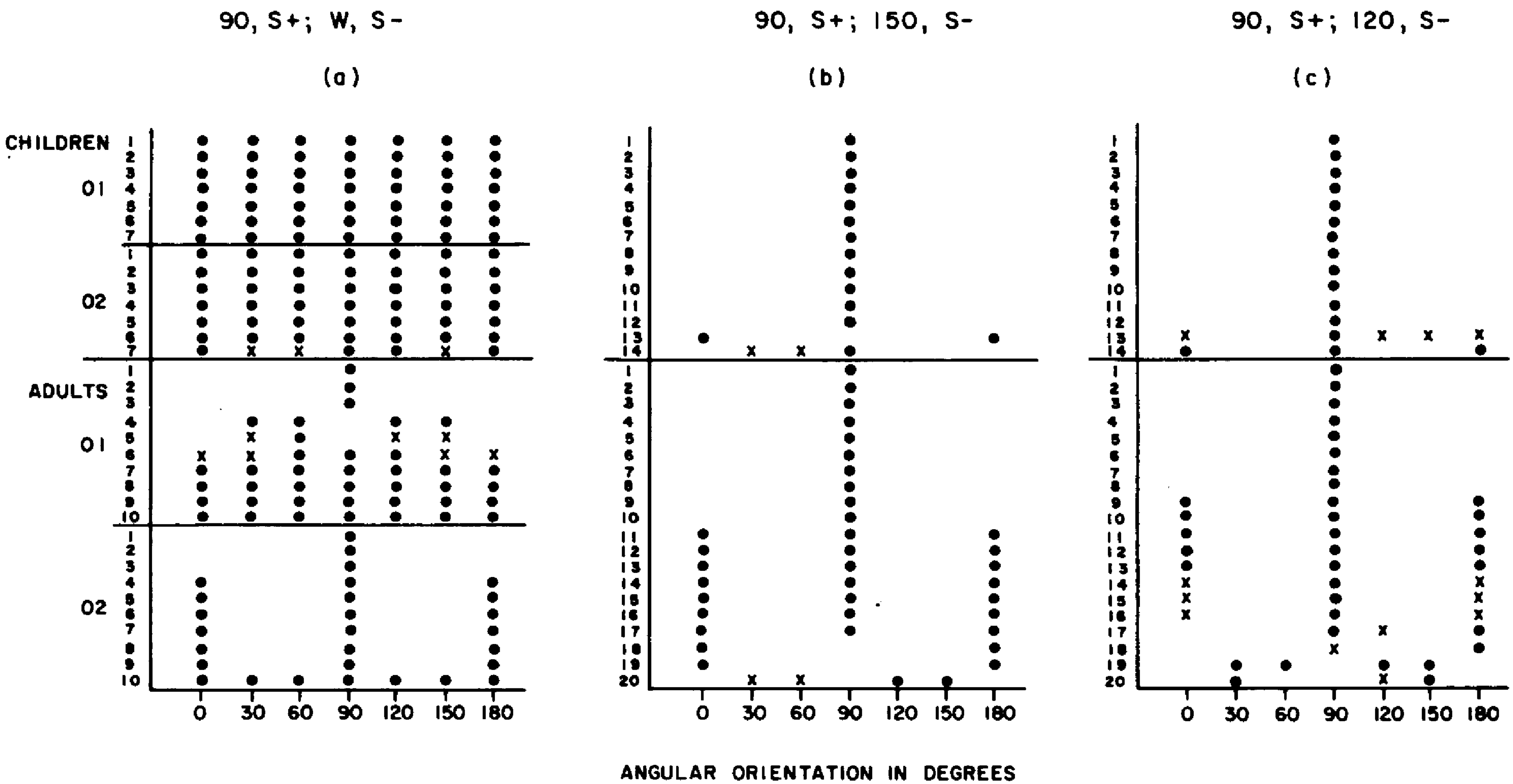
The following questions may be asked regarding the group patterns of Figures 3 and 4: (1) Are the group curves the sum of the same type of individual curves or are they derived from the combination of _different_ individual generalization patterns? (2) If the latter is true, are systematic individual patterns being obscured?

Figures 5 and 6 show a representation of each individual's PDG pattern under each of the discrimination conditions. The arrangement of individuals within groups corresponds to that of Figures 3 and 4, respectively. That is, Figures 5a, b, and c represent individuals in the 90-W, 90-150 and 90-120 conditions; Figures 6a, b, and c represent individuals in the 120-W, 120-60, and 120-90 conditions. Where interactions within discrimination conditions were shown in Figures 3 and 4, the appropriate number of subgroups within discrimination conditions is shown in Figures 5 and 6. Thus, where a triple interaction was represented as four group generalization curves in Figure 3a(90-W), four subgroups of individual patterns are shown in Figure 5a (90-W).

Each S's generalization pattern is represented by circles and crosses. Each circle equals 3 or 4 responses, and each cross equals 1 or 2 responses (the exact number of responses for each S in each condition may be found in Tables 9, 10, 11, 12, 13 and 14). Any individual's pattern may be located simply by identifying the discrimination condition and subgroup of interest, and then scanning across individual rows. Thus, the first O1, 90-W child gradient may be found in Figure 5a in the top row of the O1 children subgroup. This S produced a flat gradient.

S+ = 90° (Figures 5a, b, and c). Inspection of per-

Fig. 5 Responses made to generalization stimuli by individual _S_s in the (a) 90-W, (b) 90-150, and (c) 90-120 conditions. Each cross equals 1 or 2 responses and each circle equals 3 or 4 responses. SS and DS trials are combined.


90, S+; W, S-
(a)
90, S+; 150, S-
(b)
90, S+; 120, S-
(c)
CHILDREN
O1
O2
ADULTS
O1
O2
0 30 60 90 120 150 180
ANGULAR ORIENTATION IN DEGREES

formance across the S+ = 90° conditions shows the following:

(1) The <u>flat</u> gradient which had only been exhibited by the 90-W children group curves is exhibited by several 90-W adults (n = 5).

(2) The <u>positive, vertical pattern</u> which had only been observed for the 90-150 and 90-120 children group curves is exhibited by several adults in the 90-W (n = 6), 90-150 (n = 10), and 90-120 (n = 8) conditions.

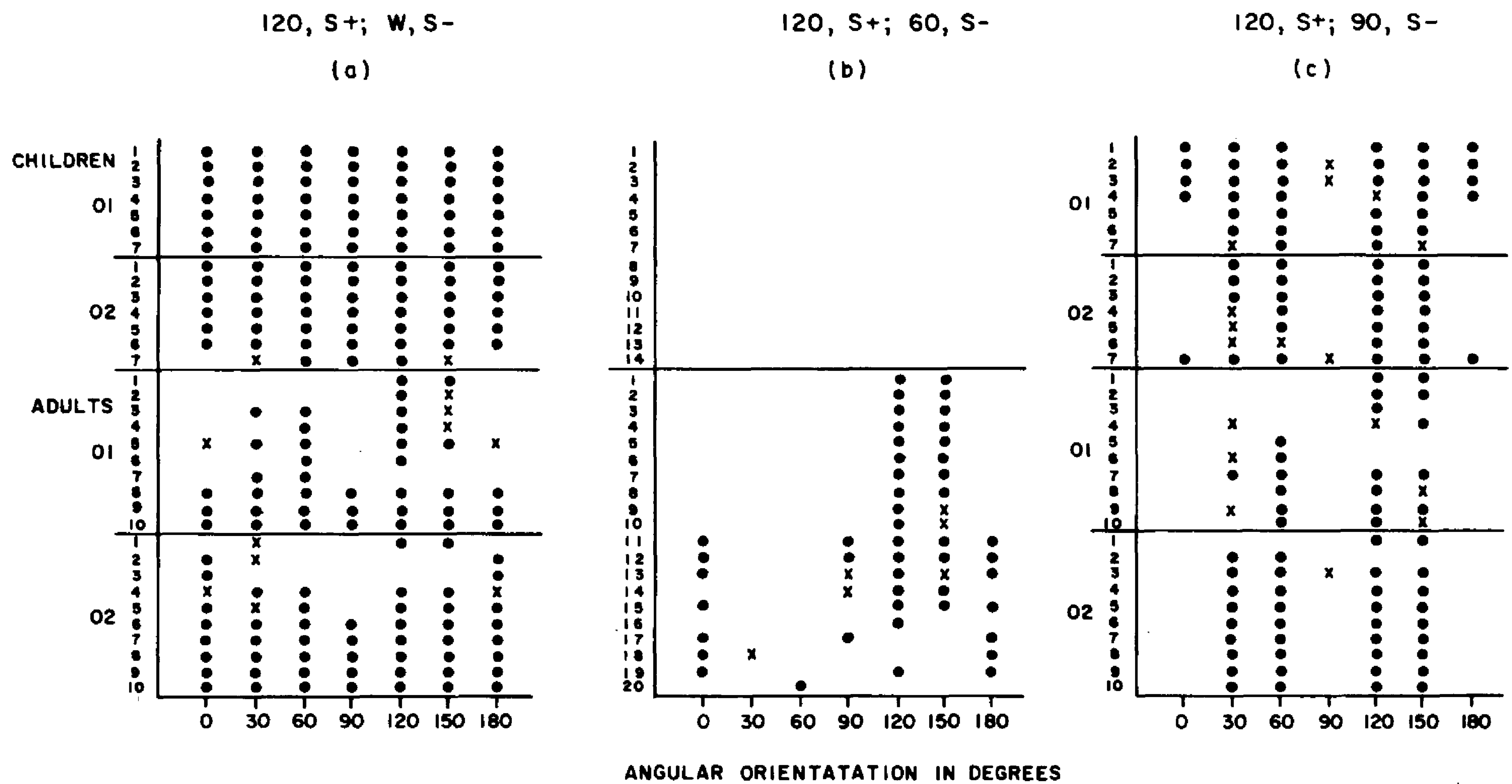
(3) The <u>positive, vertical-horizontal pattern</u> which had only been exhibited by adults in the S+ = 90° conditions is observed for three children, one in the 90-W and two in the 90-120 condition.

S+ = 120° (Figures 6 a, b, and c). Inspection of performance across S+ = 120° conditions reveals the following:

(1) As in the 90-W (S+, S_D-) condition, the <u>flat</u> gradient which had only been exhibited by the 120-W children group curves is exhibited by several 120-W adults (n = 8).

(2) Response to 120° and 150° only is observed for adults in the 120-W (n=2) and 120-90 (n=3) conditions, as well as for adults in the 120-60 condition (n=10). Maximal response to

Fig. 6 Responses made to generalization stimuli by individual _S_s in the (a) 120-W, (b) 120-60, and (c) 120-90 conditions. Each cross equals 1 or 2 responses and each circle equals 3 or 4 responses. SS and DS trials are combined.


120, S+; W, S-
(a)
120, S+; 60, S-
(b)
120, S+; 90, S-
(c)
CHILDREN
ADULTS
01
02
0 30 60 90 120 150 180
ANGULAR ORIENTATATION IN DEGREES

120° and 150° was observed previously only for the 120-60 adult group curve.

Inspection of the individual patterns revealed that, in general, the group curves were not the sum of the same type individual curves. Child-adult similarites were obscured by the group curves; and a pattern characteristic of a particular group curve could be found for individuals in a group with a different predominant pattern.

Discrimination Acquisition as a Function of S+, S- Distance

Table 15 shows the number of errors to criterion for individual Ss in each of the twelve discrimination groups. An F-max test indicated heterogeneity of variance (F-max=156.88 df = 13-21, $p < .01$). The scores were transformed ($\sqrt{x} + \sqrt{x+1}$) and although the variance differences were reduced considerably, F-max remained significant (F-max = 11.15, df = 13-21, $p < .01$). Considering the robustness of F (Winer, 1961, p. 93), a three-factor unequal n's analysis of variance was performed. The A factor was age (children and adults), the B factor was distance between S+

and S- (30°, 60°, and S+, S_D-), and the C factor was the value of the S+ stimulus (90° and 120°). Table 16 shows the results of this analysis. All main effects and interactions were significant at $p < .001$. The Newman-Keuls multiple mean test (Table 17) showed the following (where differences are indicated, $\alpha = .01$):

(1) There were no differences among the S+, S_D- and S+, S- discriminations for adults; adult performance was either equal or superior to that of children.

(2) The S+, S_D- discriminations (90-W, 120-W) were the least difficult for the children. The 90-W group did not differ from the 120-W group; and neither of these groups differed from any of the adult groups.

(3) Three of the S+, S- discriminations were of intermediate difficulty for children. The 90-150 (60° distance), 90-120 (30° distance), and 120-90 (30° distance) groups did not differ. These groups differed from all adult and S+, S_D- children groups. The one exception was that the 90-150 children did not differ from 120-60 adults.

(4) The 120-60 (60° distance) discrimination was the most difficult for children. This group differed from all other groups.

IV

METHOD: EXPERIMENT 2

A predominant PDG pattern in experiment 1 was the positive, vertical-horizontal pattern. The purpose of experiment 2 was to determine whether this gradient resulted from unique aspects of the mixed discrimination procedure and/or interactions between SS and DS presentations during testing.

Subjects. Twenty-four students in attendance at Antioch College in Yellow Springs, Ohio, served as Ss.

Apparatus. The apparatus and stimuli were the same as those used in experiment 1.

Procedure. All Ss were given the following instructions:

> I am going to show you some pictures. Some of these pictures have been given a name. They are called 'vec.' Before I show you the pictures I will ask you whether you think they have the name 'vec.' If you do think the picture has the name 'vec,' say 'yes' and point to it. If you don't think it has the name 'vec,' say 'no.' I will tell you whether you have guessed correctly or not.

Two groups (n=12) were given either SS or DS discrimination training in which S+ was 90° and S- was 120°. The training stimuli were presented in blocks of six trials. In the SS condition, S+ or S- appeared alone in either the left or right window. (The masonite board, M, masked the window not containing a stimulus). Within blocks of six trials, S+ and S- appeared equally often; ordinal and spatial position was randomly assigned. In the DS condition, S+ and S- appeared in both the left and right windows (left-right position counterbalanced). Criterion was attained when _S_ responded without error on any one block of six trials.

In the test phase, all _S_s were given the exact same instructions and tested with the same stimuli as in experiment 1. Half of the _S_s in each of the discrimination groups (n=6) were given an SS test consisting of twelve trials, while the remaining _S_s were given a DS test consisting of six trials.

One third of the _S_s in each of the test subgroups (n=2) were given different randomly determined orders. There were, however, two restrictions on the randomization procedure: first, S+ and/or S- could not appear on the first test trial; and second, the first test trial for each third of each of the SS subgroups contained either a 180°, 60°, or 30°

stimulus, and for each third of each of the DS subgroups contained either a 30-60, 180-30, or 180-150 stimulus pair. The test design thus permitted the construction of first trial as well as repeated measurement gradients.

Additional information was obtained by extending the test sequence for each of the SS and DS subgroups. This was accomplished by alternating SS and DS test blocks. Thus, an SS discrimination S who first received an SS generalization test (12 trials), then received a DS test (6 trials), followed by an SS and then another DS test (36 trials in total). Similarly, an SS discrimination S who first received a DS test, then received an SS, DS, and SS test. The two test subgroups who were given DS discrimination training also received these two sequences.

V

RESULTS: EXPERIMENT 2

Discrimination

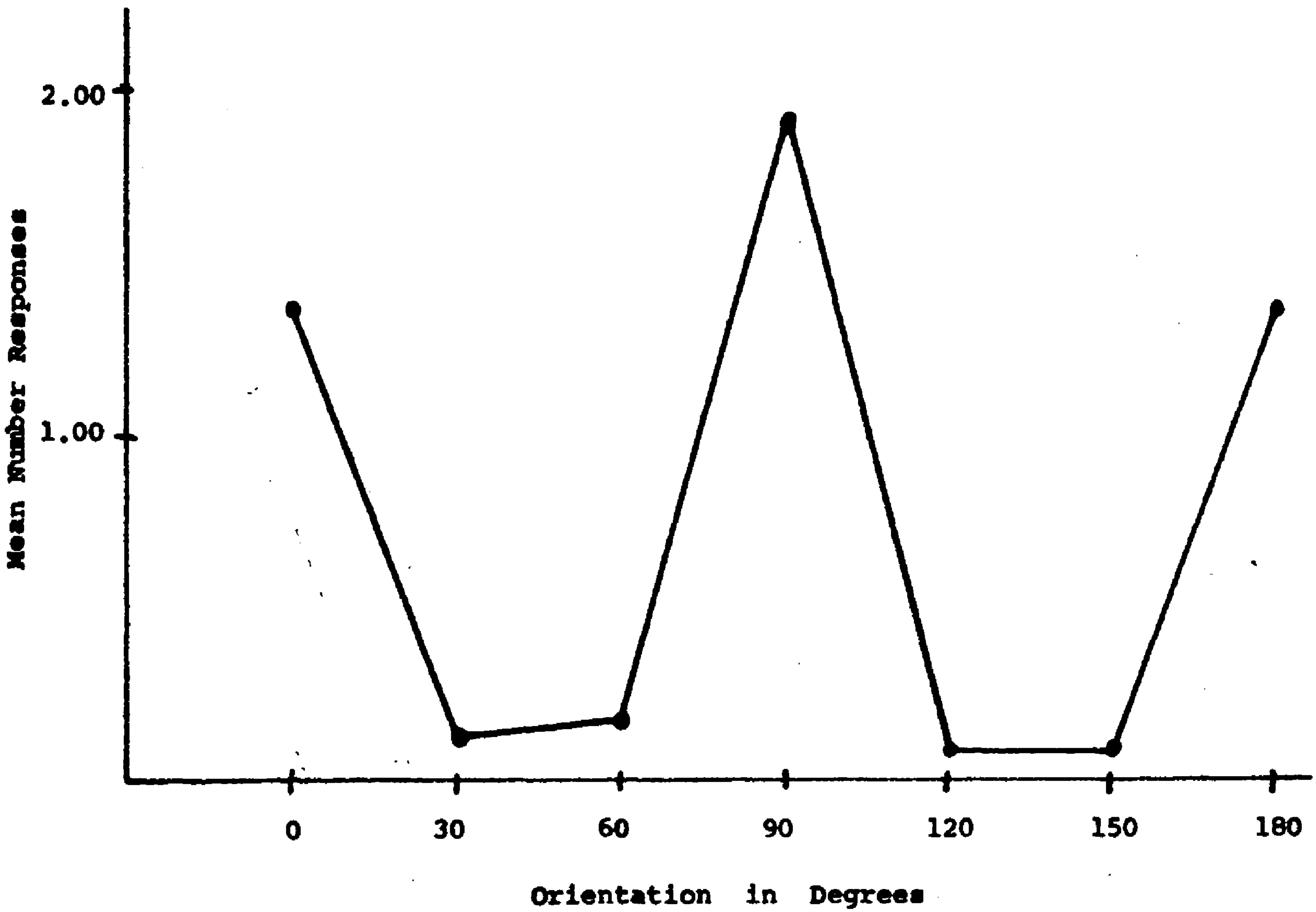
A comparison of the SS and DS discrimination groups showed that each of these groups made a mean of 0.92 errors to criterion with a range of from 0 to 2 errors. This is comparable to the performance of adults in experiment 1.

Generalization, Repeated Measurement

A three-factor mixed analysis of variance was performed. The analysis consisted of comparisons among discrimination training (SS and DS), mode of presentation (SS and DS, first block only), and stimuli (30°, 60°, 90°, 120°, 150°, and 180°). The results of this analysis may be seen in Table 18. Only the main effect for stimuli was statistically significant (F = 60.50, df = 5/100, $p < .001$). This effect may be seen in Figure 7. As in experiment 1, adults generated a positive, vertical-horizontal gradient.

Table 19 shows the number of responses made to each of the test stimuli by _S_s in each of the training-test condi-

Fig. 7 Mean number of responses to each of the test stimuli by adults after 90-120 discrimination training: experiment 2.


Mean Number Responses
2.00
1.00
0
30
60
90
120
150
180
Orientation in Degrees

tions. Considering the first test block only, seventeen Ss responded maximally to the 90° and 180° stimuli, four Ss responded to 90° only, one S responded to 180° only, and two Ss responded mainly to 30°, 60°, and 90° stimuli. These individual patterns are comparable to those of adults in experiment 1.

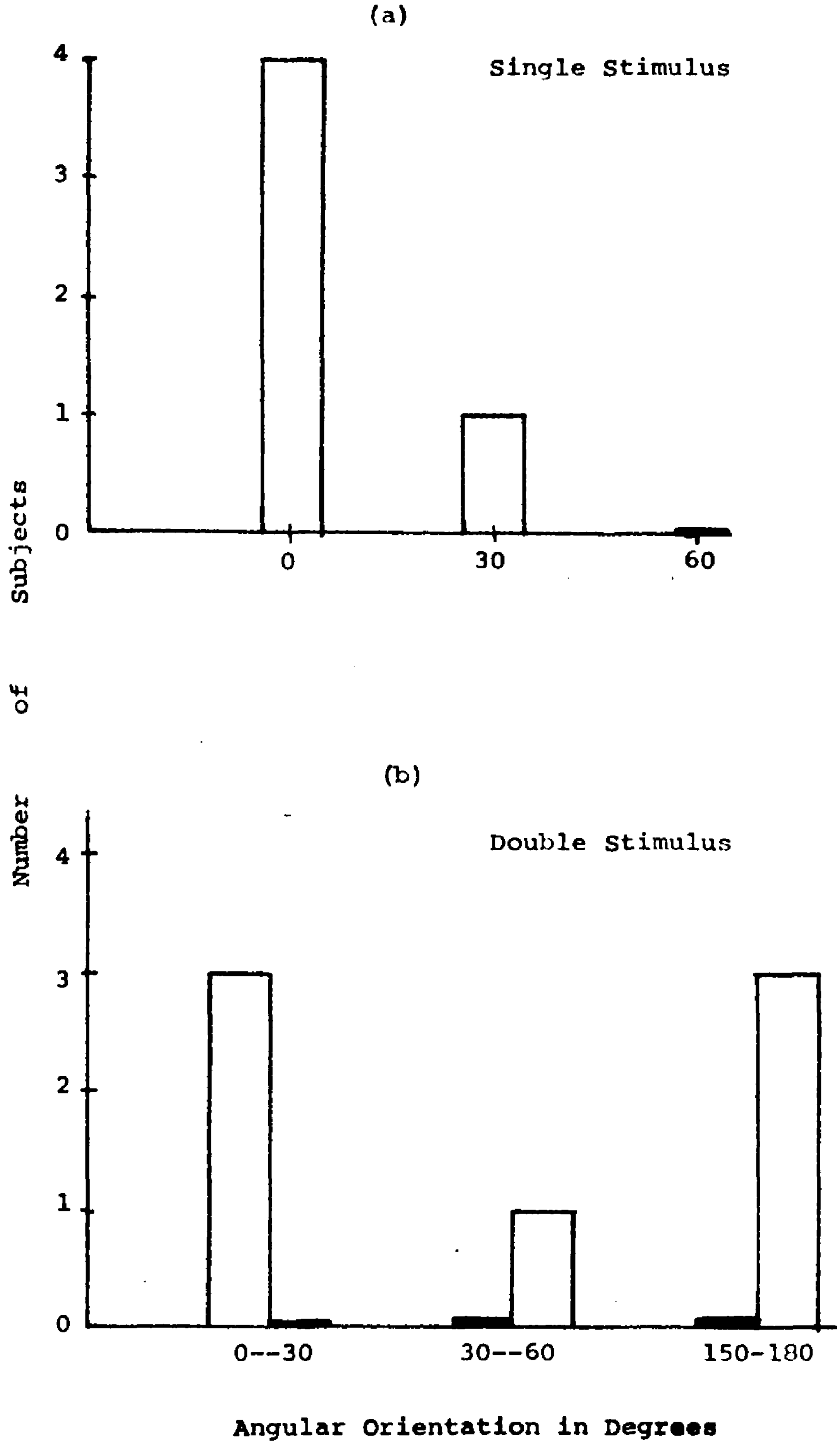
It may be concluded that the adult positive, vertical-horizontal pattern of experiment 1 was not a result of unique aspects of the mixed training procedure and/or interactions between SS and DS trials in testing. This conclusion receives additional support when the performance of individual Ss over SS and DS test blocks is considered. Inspection of individual performance in Table 19 reveals only an occasional change in the gradient form of individuals.

First Trial Generalization

Figure 8 shows the number of Ss who responded on the first trial to SS presentations of the 180°, 30° and 60° stimuli (n = 4 per stimulus), as well as the number of Ss who responded to each of the stimuli in DS pairs (n = 4 per

Fig. 8 (a) Number of *S*s who responded on the first trial to SS presentations of 180°, 30°, and 60°: Experiment 2.

(b) Number of *S*s who responded on the first trial to DS presentations of 0-30, 30-60, 150-180: Experiment 2.


(a)
Single Stimulus
4
3
2
1
0
0
30
60
Number of Subjects
(b)
Double Stimulus
4
3
2
1
0
0--30
30--60
150-180
Angular Orientation in Degrees

pair). In agreement with the adult 90-W 02, 90-120, and 90-150 groups of experiment 1, and the repeated measurement gradients of this experiment, maximal response occurred to the 180° stimulus either when presented singly or in pairs.

VI

DISCUSSION

The primary purpose of the present study was to investigate the effects of S+, S_D- and S+, S- distance differences on line orientation PDG. In addition, observations were made on the relationship between S+, S- distance and discrimination acquisition, PDG and choice behavior, test order and PDG, and age and PDG.

Hull-Spence Theory, Post-Discrimination Generalization

The essential aspects of the hypothesis under investigation were as follows:

1. A small S+, S- distance yields a PDGG with the following properties:

    a. a peak height at S+ (Hull) or a "peak shift" (Spence), and

    b. a bilateral asymmetrical form in which greater responsivity occurs to stimuli on that side of S+ farthest from S-.

2. A large S+, S- distance or S+, S_D- training yields a PDGG with the following properties:

a. a peak height at S+,

b. bilateral response decrement directly related to S+--test stimulus distance, and

c. a concave (Hull) or convex (Spence) form.

Findings of the Present Investigation in Relation to Hull-Spence Theory

The results of the present study did not support Hull-Spence PDG theory. Only two of the seventeen group PDG curves resembled those predicted by theory. That is, the 120-60 adult group PDG agreed withhypothesis 1 (Hull) and the 90-W O1 adult group PDG agreed with hypothesis 2. The 90-W O1 adult curve, however, was found to be composed of several different patterns, none of which resembled the group curve, and thus none of which agreed with theory.

Conditionsin the Present Experiment Which May Have Obscured the Theoretical Gradients

The Units Problem. Hull and Spence assumed that PDG would have invariant properties when the stimulus units were invariant; that is, when the stimulus dimension was continuous and when the intervals between stimuli were equal within and across stimulus dimensions. J.n.d. units were assumed to have these properties.

The PDGG may be radically changed when the units of the stimulus dimension are changed. This may be seen in an example from the present experiment. If it is assumed that discrimination acquisition is inversely related to j.n.d. distance, then the finding that the 120-60 discrimination was more difficult than the 120-90 discrimination for children suggests that the j.n.d. distance between 120° and 60° is smaller than that between 120° and 90°. The transformation from physical units to j.n.d. units yields a stimulus dimension in which the distance between S+ and S- is quite large; and in which the test stimulus is located very near S+ and <u>between</u> S+ and S-. In j.n.d. units the children 120-90 PDG pattern would resemble that predicted by Hull. That is, the PDGG would have a single peak at S+ (120°), almost no response decrement to the 60° test stimulus, and a sharp drop from the test stimulus to S- (90°). Thus, discrepancies between the present results and those of theory may be due to differences in the units used to represent the stimulus dimension.

There are a number of factors which argue against generalizing the above conclusions to the different conditions of the present experiment:

(1) Although two adults failed to learn, most adults learned the 120-60 discrimination as readily as the 120-90 discrimination. Thus, this would suggest that under the present conditions of measurement, the j.n.d. distance between 120° and 60° may be assumed to be functionally equivalent to that between 120° and 90°. These adults, however, produced the same type of PDGG as the children (i.e., they responded equivalently to 120° and 60° in the 120-90 condition).

(2) Rudel and Teuber (1963) have obtained evidence with children five years of age which suggests that a vertical stimulus is as readily discriminated from an oblique stimulus as from a horizontal stimulus. This would suggest that the j.n.d. distance between a vertical and oblique stimulus is the same as that between a vertical and horizontal stimulus. On this basis, generalized responding from a vertical stimulus to an oblique or horizontal stimulus should not differ. It was found, however, that the horizontal stimulus was responded to maximally when S+ was 90°. Thus, whether

the stimulus dimension is defined in j.n.d. or degree difference units, the positive, vertical-horizontal pattern does not support Hull-Spence theory.

(3) Finally, the <u>flat</u> gradient, which was found for both children and adults, would not be altered by a j.n.d. scale transformation. That is, irrespective of j.n.d. distance, responding would remain equivalent to all stimuli.

It is important to note the following with respect to the flat gradient. Hull (1949) has stated that during conditioning incidental stimuli (e.g., apparatus noises) acquire the capacity to elicit the conditioned response. If these stimuli are present during generalization testing they would evoke responding and thus obscure a descending generalization gradient. However, in the case of discrimination training in which incidental stimuli are both reinforced and extinguished the effectiveness of incidental stimuli to evoke responding would be neutralized and a descending empirical generalization gradient would be obtained. Since discrimination training preceded generalization testing in the present investigation, this source of error could not be responsible for the flat PDGG's that were found.

On the basis of the analyses which have been presented, it is concluded that the results of the present experiment are not consistent with Hull-Spence PDG predictions, when either physical or j.n.d. units define the stimulus dimension.

The Problem of the Organism: The Distinction Between Primary and Secondary Organisms. Hull and Spence assume that the theoretical generalization gradients will be obtained under conditions in which the organism does not have pre-experimental associations involving the stimulus dimension under investigation. That is, when the organism does not have secondary generalization associations mediating overt performance. Secondary generalization is defined as follows: Through conditioning S_x and S_y acquire the capacity to evoke R_j and S_y acquires the capacity to evoke R_k; as a result, S_x will evoke R_k even though this response has never been directly conditioned to S_x. This paradigm has served as the basic mechanism by which cognitive or secondary classifications associated with more advanced stages in human development are acquired and elaborated (Kendler α Kendler, 1962; Osgood, 1957; Staats, 1961).

The implication of the preceding analysis is that discrepancies between the PDG patterns found in the present investigation and those predicted by Hull-Spence theory were due to the fact that the subjects of the present experiment were at a stage in human development in which cognitive or secondary processes mediated performance.

The question arises as to how one can operationally distinguish between primary and secondary organisms. Although Hull did consider this problem, he did not solve it. His inability to do so led to the conclusion that the phenomenon of secondary generalization provides for almost insurmountable difficulties in predicting generalization effects. He did suggest, however, that since speech reactions mediate secondary generalization in human subjects, generalization gradients obtained with these Ss "which do not conform with a reasonable approximation to some objective stimulus continuum" [should be compared to those produced by] "naive organisms presumably lacking the mediating speech habits" (1943, p. 194).

It is to be noted that the absence of mediating speech habits does not preclude the operation of non-verbal mediation since the secondary generalization paradigm is not specific to verbal stimuli. Thus, the problem of operationally distinguishing between primary and secondary organisms remains. However, the present findings may be evaluated according to the criteria Hull has provided (i.e., the detection of relevant speech patterns in human Ss, and the subsequent comparison of human PDGG's to those of infrahuman Ss). Both the children and adults of the present investigation spontaneously and in response to post-PDG test questioning often labeled the "correct" stimulus (e.g., Ss who produced the flat gradient labeled the correct stimulus"a line;" Ss who produced the positive-vertical pattern labeled the "correct" stimulus "a straight or vertical line," etc.). These results suggest that the PDG patterns of the present experiment are those of secondary generalization mediated by speech responses. According to Hull, it is therefore particularly relevant to determine whether these same patterns are found with infrahuman Ss. These data have recently become available.

The flat PDG pattern has been observed for operantly trained pigeons when S+ was a vertical line and S- was the absence of the line (Boneau α Honig, 1964; Newman α Baron, 1965). The negative-vertical pattern has also been obtained for operantly trained pigeons. Mello (1965, 1966) demonstrated that when pigeons were trained to respond monocularly to an oblique stimulus, the generalization gradient obtained with the trained eye was unimodal with a peak at S+, while the gradient obtained with the untrained eye was unimodal with a peak at the S+ mirror image. In an unpublished paper, Thomas, Klipec, and Lyons (1965) demonstrated that when pigeons were trained binocularly to respond to an oblique stimulus, the generalization gradient was bimodal with peaks at S+ and its mirror image.

In summary, two of the PDG patterns found with the human _S_s of this investigation have also been found with pigeons. It is also noteworthy that the present findings are in agreement with those earlier reported by Rudel and Teuber (1963). Their study demonstrated that when S+ was a vertical line and S- an oblique line, children five years of age responded to S+ but not to S- or the mirror image of S-. In addition, it was found that when S+ was an oblique line and S- was a vertical line, responding occurred to S+ and the mirror image of S+.

On the basis of the preceding cross-experimental comparisons, it is concluded that the results of the present investigation are not unique to the subjects and procedures utilized. However, what conclusions may be made with respect to Hull-Spence theory? If the infrahuman PDG patterns had been different from those of humans, then it would have appeared that secondary generalization mediated by speech responses determined the form of human PDG. However, the comparability of patterns across species raises the question of the verbal and/or non-verbal mediational status of both infrahuman and human Ss, since these patterns "do not conform with reasonable approximation to some objective stimulus continuum." Thus, the results of the cross species comparisons emphasize the problem of pre-experimentally distinguishing between primary and secondary organisms in non-verbal terms.

On the basis of the preceding analysis, it is concluded that the results of the present investigation are equivocal with respect to Hull-Spence theory; that is, the PDG findings may have been due to the fact that secondary generalizations mediated performance outcomes. However, the equivocalness of these conclusions points to the necessity of either non-verbally distinguishing between primary and secondary organisms or abandoning the concept of primary generalization as a predicted effect and utilizing the generalization test as a method of inferring the effects of training. That is, as an additional method of making inferences about the learning process, as a method of specifying the effective stimulus or <u>what</u> has been learned (Campbell, 1954; Lashley α Wade, 1946) and as a method of specifying the mediational properties of the organism under investigation (Guttman, 1963; Prokasy α Hall, 1963). A subsequent section of the discussion, concerned with the interpretation of the present findings, will consider these problems.

The possibility that both the children and adults of the present experiment were mediational organisms makes it difficult to interpret in terms of Hull-Spence theory, the effects of S+, S_D- and S+, S- distance on discrimination acquisition, the relationship between PDG and choice behavior, test order effects, and age effects. Nevertheless, each of these effects will be considered first within the context of Hull-Spence theory and subsequently within the context of an alternative interpretation of the experimental findings.

Discrimination Acquisition: Hull-Spence Theory

The hypothesis under investigation was that discrimination acquisition difficult is inversely related to S+, S- distance.

No differences were found among adult discrimination groups. For children, S+, S_D- discriminations were the least difficult; the 90-150, 90-120, and 120-90 discriminations were of intermediate difficulty; and the 120-60 discrimination was the most difficult. These results indicate that S+, S_D- and S+, S- distance (a) had no effect on adult acquisition performance and (b) affected children performance in a direction either contrary to theory (120-60 was more difficult than either 90-120 or 120-90) or in agreement with theory (90-W and 120-W were the least difficult).

As was noted previously, the difficulty associated with the 120-60 discrimination in contrast to the 120-90 discrimination suggests that the j.n.d. distance between 120° and 60° is smaller than that between 120° and 90°. Thus, in j.n.d. units, the 120-60 discrimination results would be in agreement with theory.

In the present experiment, the concept that a j.n.d. mechanism mediated discrimination acquisition difficulty must be questioned. The properties of stimulus equivalence resulting from a j.n.d. mechanism may, in part, be different from those resulting from secondary generalization. For example, in the former case, similarity may be due primarily to a sensory inability to detect stimulus differences; while in the latter case, the discrimination of stimulus differences may be prerequisite to similarity classifications (Gibson, 1959). If the difficulty of discrimination acquisition is dependent, in part, on stimulus equivalence, then the mechanism mediating performance must be identified. If, on the basis of the analyses presented for PDG, the Ss in the present investigation are assumed to be mediating or secondary organisms with respect to the stimulus values utilized, then the mechanism underlying discrimination acquisition difficulty will be assumed to be similarity based on secondary classifications. It is to be noted, in this regard, that two 120-60 adults failed to learn. When these Ss were subsequently questioned, however, they readily reported the difference between the stimuli; thus, suggesting that a j.n.d. mechanism was not responsible for their poor performance.

The Relationship Between PDG and Choice Behavior

The hypothesis under investigation was that the form of the PDG determines the probability of response to each of a set of stimuli presented simultaneously. In the present investigation, for example, it would be expected that an S who responded only to 90° and 180° when presented singly would respond only to 90° in the 60°-90° and 90°-120° pairs, and only to 180° in the 180°-30° and 150°-180° pairs.

The results of the statistical analyses showed that in no case did SS and DS main effects or interactions approach significance. In addition, correspondence was found between individual PDG's (Tables 9, 10, 11, 12, 13 and 14) and responding within DS pairs (Tables 20, 21, 22, 23, 24 and 25). These findings indicate that under the specific conditions of the present experiment (a) SS and DS measures are equivalent indicators of generalization, and (b) either of these measures may be used to predict choice or DS performance. Thus, Spence's postulated relationship between PDG and choice behavior is supported, while predictions regarding the PDGG were not.

Test Order Effects

The question under consideration was whether generalization may be conceived of as being primarily determined by training or by the relationship between training and testing. The results of the present investigation suggest that both of these alternatives may be operative, depending on the type of discrimination training which precedes PDG testing. That is, the 90-120, 90-150, and 120-60 PDG patterns did not interact with order while S+, S_D- and 120-90 patterns did.

Generalization test context effects have previously been observed for adults after repeated presentations of wavelength stimuli (Kalish, 1958; Thomas & Hiss, 1963; Thomas & Jones, 1962; Thomas & Mitchell, 1962). Those of the present investigation, however, were apparently due to the effects of initial test trials. An explanation for this finding will be suggested in a later section.

Age Effects

The questions of interest were as follows: (1) Would both child and adult PDG patterns correspond to Hull-Spence theory? and (2) If age differences were found, what inferences could be made with repsect to the mediational properties associated with the two age groups?

The first question has been answered in the preceding sections. The second question will be considered in a subsequent section.

Interpretation of Results

The findings of the present investigation suggest the following: (1) Discrimination training was primarily effective in activating, or activating, extinguishing and replacing pre-experimental subject classifications which mediated discrimination performance. (2) Age-correlated differences in the properties of activation, extinction and replacement were responsible for age-related performance differences with respect to discrimination acquisition, PDG and test order effects. The following sections will elaborate these statements within the context of the following questions: (1) What was learned? (2) How did learning occur? (3) What were the mediational properties which distinguished young children from adults? (4) How did these differences relate to the learning process and to what was learned?

The assumptions to be proposed regarding organismic classifications and properties of classifications have for the most part been described and diagrammed in detail by Kendler and Kendler (1962), Osgood (1957) and Staats (1961). (The reader is referred to these authors for a complete description.) The present interpretations may be considered an extension of their ideas to the specific conditions of this experiment.

Activation (S+, S_D- discrimination)

(1) 90-W and 120-W children and adults generated flat gradients. This suggests that during discrimination train-

ing 90° and 120° activated "a line" classification which mediated performance coincident with the experimental criterion.

(2) 90-W adults generated positive, vertical or positive vertical-horizontal patterns. 120-W adults produced negative vertical or 120° and 150° patterns. This suggests that 90° activated a "vertical" or "straight" category and that 120° activated a "tilted line" or "slant to the left" category. Each of these classifications could mediate performance coincident with the experimental criterion.

It should be noted that the classifications which mediated adult criterion performance cannot be specified since PDG interacted with test order for adults. It will be assumed, however, that the more gross classifications ("a line") represent an early stage of activation and reflect the criterion classification while relatively specific classifications ("straights") represent a later stage of activation and indicate the cumulative effect of training and test stimulus presentations. This will be elaborated further in a later section.

In the S+, S_D- discriminations 90° or 120° activated classifications which were relevant to criterion performance. What was learned may be represented by the particular classification(s) activated. How learning occurred may be represented by changes in the state of the classification from inactive to activated.

Activation, Extinction, and Replacement (S+, S- discriminations)

Classifications which could be assigned to both a "yes" and "no" category could not mediate criterion performance. In the S+, S- discriminations, "a line" classification could not produce criterion performance since both S+ and S- shared the properties of this classification. In the 90-150, 90-120 and 120-90 conditions the classification "a line" was extinguished and replaced with classifications related to criterion performance. As indicated in PDG testing, 90-150 and 90-120 Ss classified the "correct" stimulus as "vertical" or "straight" (the positive, vertical and positive, vertical-horizontal patterns); whereas 120-90 Ss primarily classified the "correct" stimulus as "a slant" (negative, vertical-horizontal pattern). In the 120-60 condition, neither the "line" nor "slant" classifications could mediate criterion performance. These classifications were thus extinguished and replaced with criterion related classifications, primarily "slants to the left" (response to 120^{o} and 150^{o}).

In the S+, S- discriminations initially activated non-criterion classifications were extinguished and replaced by criterion related classifications. What was learned may be represented by each of the classifications activated during the course of training. How learning occurred may be represented by changes in the state and type of classification.

Mediational Properties

It is suggested in this section that what was learned and the learning process are the same for both children and adults; and that age differences in the rate of activation, extinction, and replacement determined age-related performance differences.

Children and Adults Differ With Respect to the Rate at Which Different Classifications are Evoked by an Effective Stimulus. In the present experiment, gross classifications are assumed to be of equal sensitivity for both children and adults, while relatively specific categories are assumed to be less sensitive for children than for adults. These assumptions suggest that the repeated presentation of a single line, tachistoscopically, or in a discrimination apparatus, would initially evoke a gross classification; i.e., "a line" response for both children and adults, and subsequently evoke relatively specific classifications principally for adults.

In the present experiment, child-adult discrimination acquisition differences may, in part, be related to the rate at which a classification is activated in relation to a particular S+, S- combination. For example, in the 90-W and 120-W discriminations, if "a line" category is easily activated (e.g., one or two presentations in training) for both children and adults, then criterion performance will be rapidly attained by both age groups since this category is coincident with criterion performance. However, in the 90-120 and 90-150 discriminations, for example, this no longer is the case. If after a few trials, adults categorize 90^{o} as a "vertical line" then S- (e.g., 120^{o}, 150^{o}) will not activate "a line" category, will not activate "a vertical" category, and thus will not be responded to. However, if after a few trials children still categorize 90^{o} as "a line" then S- will activate "a line" category and will be incorrectly responded to.

The assumption of a faster rate of category activation for adults suggests an explanation for test order effects. If after a relatively few trials, a number of classifications have been activated (e.g., "a line," "a vertical line," "straight") all of which mediate criterion performance and all of which differ with respect to amount of activation, then the initial test trials may provide additional stimulation for the increased activation of a less active category. PDG performance would then reflect the predominant activated category. For example, if adults in the 90-W condition primarily categorize the "correct" stimulus as "a line," secondarily as "a vertical," and thirdly as "straight," the presentation of the horizontal (O2) stimulus would increasingly activate the "straight" category (resulting in the positive, vertical-horizontal 90-W PDG pattern) while the presentation of an oblique stimulus (O1) would have no effect on this category. These initial test trial effects would not be found for children since for these _S_s only a gross category is assumed to be activated after a relatively few trials.

Children and Adults Differ with Respect to the Rate at Which a Non-Criterion Classification is Eliminated or Extinguished. Extinction begins on the first trial in which both a positive (S+) and negative (S-) category share the same attributes. For example, (1) assume that on the first discrimination trial (S+ = 90°) "a line" category is activated and assigned to a "yes" classification; (2) assume that on trial 2 (S- = 120°), "a line" category is activated and assigned to a "no" classification; then (3) the end of trial 2 will indicate the beginning of extinction.

If adults extinguish immediately while children tend to perseverate, then children will produce more errors than adults in those conditions in which the relation between the training stimuli in relation to pre-experimental classifications is such that extinction is a necessary condition for the attainment of criterion performance. In the present experiment, the S+, S- discriminations satisfied these requirements and children performed more poorly than adults.

Children and Adults Differ With Respect to the Rate at Which an Extinguished Category is Replaced. This last assumption may be a result of two factors. Children may have fewer categories and elements within categories which are relevant to line orientation performance. This factor would suggest, for example, that the poor performance of children in the 12-60 discrimination was due, in part, to secondary similarity (e.g., "slants") which produced response competition, and to the absence of a differentiating classification (e.g., left-right) which could have replaced the extinguished "slants" classification. And, children may not have been presented with a sufficient number of trials for the next most likely category to be activated and ready to replace an extinguished category. This factor would suggest that due to the non-activation of the next most likely category, children produced and accumulated "random" errors until the next category was activated.

Summary of Interpretive Statements

1. Children and adults were assumed to have pre-experimental classifications which varied from gross to relatively specific and correspondingly from most to least easily activated. Adult classifications were assumed to be more easily activated than those of children.

2. Discrimination training was assumed to involve the activation, or activation, extinction and replacement of classifications which mediated performance.

3. S+, S_D- discriminations involved activation only. The classifications initially activated by S+ mediated criterion related performance.

4. S+, S- discriminations involved, activation, extinction and replacement. The classification initially activated could not mediate criterion performance since both S+ and S- shared the properties of these classifications. They were, therefore, extinguished, and replaced by relatively specific criterion related classifications.

5. In the present experiment, as the number of classifications shared by the training stimuli increased (90-W, 120-W $<$ 90-150, 90-120, 120-90 $<$ 120-60) the specificity of the criterion classification increased, and discrimination acquisition difficulty increased.

6. Child-adult performance differences were attributed to differences in the rate of activation, extinction and re-

placement; and not to differences in the learning process or what was learned.

7. It was suggested that what was learned was represented by each of the classifications activated during training (and testing); and that the learning process involved changes in the state (from inactive to activated) and type of classification.

VII

SUMMARY AND CONCLUSIONS

An experiment was conducted in order to determine the effects of S+, S_D- and S+, S- line orientation distance training on the post-discrimination generalization (PDG) performance of children 3-1/2--4-1/2 years and college adults. In addition, observations were made to determine the relations between S+, S- distance and discrimination acquisition, PDG and choice behavior, and test order and PDG.

The major hypotheses were as follows:

1. S+, S_D- PDG would have a peak at S+, and bilateral response decrement directly related to S+--test stimulus distance (Hull and Spence).

2. S+, S- PDG would have a peak at S+ (Hull) or displaced from S+ (Spence) and would exhibit a bilateral asymmetrical form in which greater responding was found to stimuli on that side of S+ farthest from S-.

Related hypotheses were as follows:

1. Discrimination acquisition would be inversely related to S+, S- distance.

2. The form of the PDG would determine the probability of response to each of any pair of test stimuli presented simultaneously.

Six groups of children (N=92) and adults (N=122) received discrimination training. For groups I, II, and III, S+ was a 90° (vertical) black line on a white circular background and S- was, respectively, the white background (90-W, S+, S_D-), 150° (90-150, S+, S-), and 120° (90-120, S+, S-). For groups IV, V, and VI, S+ was 120° and S- was, respectively, W (120-W, S+, S_D-), 60° (120-60, S+, S-), and 90° (120-90, S+, S-).

After attaining criterion (children, N=70; adults, N=120), all _S_s were given a generalization test (30°, 60°, 90°, 120°, 150°, 180°). Half of the _S_s in each group were given a test order in which a 60° (oblique) stimulus appeared initially (O1) while the other half were given a test order in which a 180° (horizontal) stimulus appeared initially (O2). All test orders, however, contained both single stimulus presentations (e.g., 60° alone, 120° alone, etc.) and double stimulus presentations (e.g., 60° + 90°, 120° + 150°, etc.).

The major findings may be summarized as follows:

1. When S+ was 90° (PDG),

a. All 90-W children and several 90-W adults produced a flat gradient.

b. 90-W adults and 90-150 and 90-120 children and adults produced a positive, vertical pattern (responded to 90° only).

c. Several 90-W O2 and 90-150 and 90-120 adults (and occasionally a child) produced a positive, vertical-horizontal pattern (responded to 90° and 180°).

2. When S+ was 120° (PDG),

a. All 120-W children and several 120-W adults produced a flat gradient.

b. 120-W adults and 120-90 children and adults produced a positive oblique or negative, vertical-horizontal pattern (responded primarily to oblique stimuli).

c. A few 120-W and 120-90 adults and several 120-60 adults responded primarily to 120° and 150°. (Children did not learn the latter discrimination and thus were not available for testing).

3. Discrimination acquisition:

a. Adults rapidly attained criterion in all discrimination conditions.

b. 90-W and 120-W children did not differ from adults.

c. 90-150 (60° distance), 90-120 (30° distance), and 120-90 (30° distance) discriminations were of intermediate difficulty for children.

d. The 120-60 discrimination (60° distance) was the most difficult for children.

4. PDG and Choice:

The form of the PDG was found to correspond with performance on DS trials. Thus, a 90-W S who responded to 90° and 180° when presented singly responded to 90° in the 90-120 and 90-60 pairs and to 180° in the 0-30 and 150-180 pairs.

As a result of these findings it was concluded that the effects of S+, S_D- and S+, S- training on PDG and discrimination acquisition did not support the hypotheses under investigation while the relations obtained between PDG and choice behavior did.

The following interpretations were offered for the present findings:

1. Discrimination training involved the activation

(in the S+, S_D- condition), or activation, extinction and replacement (in the S+, S- conditions) of pre-experimental subject classifications which mediated criterion performance (e.g., "a line," "a slant," "a slant to the left," etc.).

2. As the number of classifications shared by S+ and S- increased (90-W, 120-W $<$ 90-150, 90-120, 120-90 $<$ 120-60), the specificity of the criterion relevant classification increased, and discrimination acquisition difficulty increased.

3. Children and adults were assumed to differ with respect to the rate at which classifications were activated, extinguished and replaced; faster rates were assumed for adult subjects. These assumptions suggested that under conditions in which activation alone was sufficient to mediate discrimination criterion performance (90-W and 120-W), children and adult performance would be comparable; however, under conditions in which activation, extinction and replacement were involved (S+, S- discriminations), children would perform more poorly than adults. In addition, these assumptions suggested that, for adults in the S+, S_D- conditions, initial test trials would provide additional stimulation for classifications which did not mediate discrimination criterion performance but which would be reflected in the generalization test.

APPENDIX

Table 1

Generalization Test Orders

Trial	Order 1a[a] Left Window	Order 1a[a] Right Window	Order 2a[a] Left Window	Order 2a[a] Right Window
1	60°	M[b]	180°	M
2	M	60°	M	180°
3	60°	30°	30°	180°
4	M	30°	M	30°
5	180°	150°	180°	150°
6	120°	M	120°	M
7	M	150°	M	150°
8	M	120°	M	120°
9	90°	60°	90°	60°
10	180°	M	60°	M
11	M	180°	M	60°
12	30°	180°	60°	30°
13	150°	120°	150°	120°
14	M	90°	M	90°
15	30°	M	30°	M
16	150°	M	150°	M
17	120°	90°	120°	90°
18	90°	M	90°	M

[a] There were also 1b and 2b test orders. These orders differed from those above in that the spatial position of the stimuli on DS trials was reversed; e.g., where 60° appeared in the left and 30° appeared in the right window on trial 3 of 1a, 30° appeared in the left and 60° appeared in the right window on trial 3 of 1b.

[b] means the masonite board covered the window not containing a stimulus.

Table 2

Significant Main Effects and Interactions in Each of the Six PDG Conditions.[a, b]

	Age	Stimuli	Age x Order	Age x Stimuli	Order x Stimuli	Age x Order x Stimuli
90-W	*	*		*	*	*
90-150	*	*		*		
90-120	*	*		*		
120-W	*	*		*		*
120-60	---	*	---	---		---
120-90	*	*	*		*	*

[a] p varies from .05 to .001 and is indicated by *. The exact values may be found in the detailed summaries of Tables 3-8.

[b] The dashes in the 120-60 condition indicate that children were not available for testing and that statistical tests of age effects could not be made.

Table 3

Analysis of Variance on the
90-W Discrimination Condition

Source	df	MS	F
Between Subjects	33		
A (age)	1	98.92	33.31*
B (order)	1	8.89	2.99
AB	1	4.61	1.55
Subj w. groups	30	2.97	
Within Subjects	374		
C (test stimuli)	5	3.29	8.89*
AC	5	2.55	6.89*
BC	5	2.75	7.43*
ABC	5	2.01	5.43*
C x subj w. groups	150	.37	
D (mode of presentation)	1	.08	1.60
AD	1	.00	.00
BD	1	.00	.00
ABD	1	.08	1.60
D x subj w. groups	30	.05	
CD	5	.02	.67
ACD	5	.03	1.00
BCD	5	.02	.67
ABCD	5	.00	.00
CD x subj w. groups	150	.03	

* Significant at .001 level.

Table 4

Analysis of Variance on the 90-150 Discrimination Condition

Source	df	MS	F
Between Subjects	33		
A (age)	1	1.89	7.00*
B (order)	1	.16	.59
AB	1	.00	.00
Subj w. groups	30	.27	
Within Subjects	374		
C (test stimuli)	5	31.27	69.49**
AC	5	2.29	5.09**
BC	5	.13	.29
ABC	5	.81	1.80
C x subj w. groups	150	.45	
D (mode of presentation)	1	.00	.00
AD	1	.08	2.00
BD	1	.00	.00
ABD	1	.00	.00
D x subj w. groups	30	.04	
CD	5	.00	.00
ACD	5	.02	.67
BCD	5	.02	.67
ABCD	5	.03	1.00
CD x subj w. groups	150	.03	

* Significant at .05 level.
**Significant at .01 level.

Table 5

Analysis of Variance on the 90-120 Discrimination Condition

Source	df	MS	F
Between Subjects	33		
A (age)	1	2.63	5.37*
B (order)	1	.16	.33
AB	1	1.40	2.86
Subj w. groups	30	.49	
Within Subjects	374		
C (test stimuli)	5	32.84	67.02**
AC	5	1.99	4.06**
BC	5	.30	.61
ABC	5	.25	.51
C x subj w. groups	150	.49	
D (mode of presentation)	1	.00	.00
AD	1	.00	.00
BD	1	.00	.00
ABD	1	.08	.22
D x subj w. groups	30	.36	
CD	5	.12	.16
ACD	5	.07	.09
BCD	5	.25	.34
ABCD	5	.00	.00
CD x subj w. groups	150	.74	

* Significant at .05 level.
** Significant at .01 level.

Table 6

Analysis of Variance on the
120-W Discrimination Condition

Source	df	MS	F
Between Subjects	33		
A (age)	1	40.24	12.54[c]
B (order)	1	.58	.18
AB	1	4.53	1.41
Subj w. groups	30	3.21	
Within Subjects	374		
C (test stimuli)	5	1.58	3.10[b]
AC	5	1.37	2.69[a]
BC	5	.54	1.06
ABC	5	1.22	2.39[a]
C x subj w. groups	150	.51	
D (mode of presentation)	1	.16	1.78
AD	1	.16	1.78
BD	1	.16	1.78
ABD	1	.00	.00
D x subj w. groups	30	.09	
CD	5	.02	.50
ACD	5	.07	1.75
BCD	5	.05	1.25
ABCD	5	.07	1.75
CD x subj w. groups	150	.04	

[a] Significant at .05 level.
[b] Significant at .025 level.
[c] Significant at .01 level.

Table 7

Analysis of Variance on the 120-60 Discrimination Condition

Source	df	MS	F
Between Subjects	19		
A (order)	1	.94	1.21
Subj w. groups	18	.78	
Within Subjects	220		
B (mode of presentation)	1	.04	1.33
AB	1	.10	3.33
B x subj w. groups	18	.03	
C (stimuli)	5	17.49	16.82*
AC	5	1.23	1.18
C x subj w. groups	90	1.04	
BC	5	.03	1.00
ABC	5	.02	.67
BC x subj w. groups	90	.03	

* Significant at .001 level.

Table 8

Analysis of Variance on the 120-90
Discrimination Condition

Source	df	MS	F
Between Subjects	33		
A (age)	1	14.73	12.48[b]
B (order)	1	3.54	3.00
AB	1	11.60	9.83[b]
Subj w. groups	30	1.18	
Within Subjects	374		
C (test stimuli)	5	34.35	58.22[c]
AC	5	.86	1.46
BC	5	2.07	3.51[b]
ABC	5	1.45	2.46[a]
C x subj w. groups	150	.59	
D (mode of presentation)	1	.00	.00
AD	1	.08	1.14
BD	1	.08	1.14
ABD	1	.08	1.14
D x subj w. groups	30	.07	
CD	5	.10	2.00
ACD	5	.07	1.40
BCD	5	.05	1.00
ABCD	5	.05	1.00
CD x subj w. groups	150	.05	

[a] Significant at .05 level.
[b] Significant at .01 level.
[c] Significant at .001 level.

Table 9

Number of Responses Made to Each of the Test Stimuli by Children and Adults in Each of the Order Conditions After 90-W Discrimination Training

	Orientation Test Stimuli											
	Order I						Order II					
Children Subjects	30	60	90	120	150	180	30	60	90	120	150	180
1	4	4	4	4	4	4	4	4	4	4	4	4
2	4	4	4	4	4	4	2	2	4	3	2	4
3	4	4	4	4	4	4	4	4	4	4	4	4
4	4	4	4	4	4	4	4	4	4	4	4	4
5	4	4	4	4	4	4	4	4	4	4	4	4
6	4	4	4	4	4	4	4	4	4	4	4	4
7	4	4	4	4	4	4	4	4	4	4	4	4
Total	28	28	28	28	28	28	26	26	28	27	26	28
Mean	4.0	4.0	4.0	4.0	4.0	4.0	3.7	3.7	4.0	3.9	3.7	4.0
Adult Subjects												
1	1	3	0	2	2	0	0	0	3	0	0	4
2	4	4	4	4	4	4	0	2	4	0	0	4
3	0	0	4	0	0	0	0	0	4	0	0	4
4	4	4	4	4	4	4	0	0	4	0	0	4
5	4	4	4	4	4	3	4	4	4	4	4	4
6	1	4	4	3	2	1	0	0	4	0	0	0
7	0	0	4	0	0	0	0	0	4	0	0	0
8	4	4	0	4	4	0	0	0	4	0	0	4
9	0	0	4	0	0	0	0	0	3	0	0	4
10	4	4	4	4	4	4	0	0	4	0	0	0
Total	22	27	32	25	24	16	4	6	38	4	4	28
Mean	2.2	2.7	3.2	2.5	2.4	1.6	0.4	0.6	3.8	0.4	0.4	2.8

Table 10

Number of Responses Made to Each of the Test Stimuli by Children and Adults in Each of the Order Conditions After 90-150 Discrimination Training

	Orientation Test Stimuli											
	Order I						Order II					
Children Subjects	30	60	90	120	150	180	30	60	90	120	150	180
1	0	0	4	0	0	0	0	0	3	0	0	0
2	0	0	4	0	0	0	0	0	4	0	0	0
3	0	0	0	0	0	4	0	0	4	0	0	0
4	0	0	4	0	0	0	0	0	4	0	0	0
5	0	0	4	0	0	0	0	0	4	0	0	0
6	0	0	4	0	0	0	0	0	4	0	0	0
7	1	2	4	0	0	0	0	0	4	0	0	0
Total	1	2	24	0	0	4	0	0	27	0	0	0
Mean	0.1	0.3	3.4	0.0	0.0	0.6	0.0	0.0	3.9	0.0	0.0	0.0
Adult Subjects												
1	0	0	4	0	0	4	0	0	4	0	0	4
2	2	1	0	0	3	3	0	0	3	0	0	4
3	0	0	4	0	0	0	0	0	0	0	0	4
4	0	0	4	0	0	0	0	0	0	0	0	4
5	0	0	4	0	0	0	0	0	4	0	0	0
6	0	0	4	0	0	0	0	0	4	0	0	0
7	0	0	4	0	0	4	0	0	4	0	0	4
8	0	0	4	0	0	0	0	0	4	0	0	2
9	0	0	4	0	0	0	0	0	4	0	0	4
10	1	0	4	0	1	4	0	0	4	0	0	0
Total	3	1	36	0	4	15	0	0	31	0	0	26
Mean	0.3	0.1	3.6	0.0	0.4	1.5	0.0	0.0	3.1	0.0	0.0	2.6

Table 11

Number of Responses Made to Each of the Test Stimuli by Children and Adults in Each of the Order Conditions After 90-120 Discrimination Training

	Orientation Test Stimuli											
	Order I						Order II					
Children Subjects	30	60	90	120	150	180	30	60	90	120	150	180
1	0	0	4	0	0	0	0	0	4	0	0	0
2	0	0	4	0	0	0	1	0	4	0	0	0
3	0	0	4	0	0	0	0	0	4	1	1	2
4	0	0	4	0	0	0	0	0	4	0	0	0
5	0	0	4	0	0	0	0	0	4	0	0	0
6	0	0	4	0	0	0	0	0	4	0	0	2
7	0	0	4	0	0	0	0	0	4	0	0	0
Total	0	0	28	0	0	0	1	0	28	1	1	4
Mean	0.0	0.0	4.0	0.0	0.0	0.0	0.1	0.0	4.0	0.1	0.1	0.6
Adult Subjects												
1	0	0	4	0	0	0	0	0	4	0	0	0
2	3	0	0	0	2	4	0	0	4	0	0	0
3	4	4	0	4	4	0	0	0	4	0	0	2
4	0	0	4	0	0	2	0	0	4	0	0	4
5	0	0	4	0	0	0	0	0	4	0	0	1
6	0	0	4	0	0	4	0	0	1	0	0	4
7	1	0	4	2	0	4	0	0	4	0	0	0
8	0	0	4	0	0	0	0	0	4	0	0	4
9	0	0	4	0	0	0	0	0	3	0	0	4
10	0	0	4	0	0	4	0	0	4	0	0	0
Total	8	4	32	6	6	18	0	0	36	0	0	19
Mean	0.8	0.4	3.2	0.6	0.6	1.8	0.0	0.0	3.6	0.0	0.0	1.9

Table 12

Number of Responses Made to Each of the Test Stimuli by Children and Adults in Each of the Order Conditions After 120-W Discrimination Training

	Orientation Test Stimuli											
	Order I						Order II					
Children	30	60	90	120	150	180	30	60	90	120	150	180
Subjects												
1	4	4	4	4	4	4	4	4	3	4	4	4
2	4	4	4	4	4	4	4	4	4	4	4	4
3	4	4	4	4	4	4	1	4	4	3	2	0
4	4	4	4	4	4	4	4	4	4	4	4	4
5	4	4	4	4	4	4	4	4	4	4	4	4
6	4	4	4	4	4	4	4	4	4	4	4	4
7	4	4	4	4	4	4	4	4	4	4	4	4
Total	28	28	28	28	28	28	25	28	27	27	26	24
Mean	4.0	4.0	4.0	4.0	4.0	4.0	3.6	4.0	3.9	3.9	3.7	3.4
Adult Subjects												
1	4	4	4	4	4	4	0	0	0	0	0	4
2	3	4	4	3	4	4	4	4	4	4	4	4
3	4	4	0	4	4	1	4	4	4	4	4	4
4	3	4	0	0	0	0	2	0	0	4	4	0
5	0	4	0	4	0	0	4	4	0	4	4	2
6	0	0	0	4	2	0	2	0	0	0	0	4
7	0	4	0	3	2	0	4	4	4	4	4	4
8	3	4	0	4	2	0	2	3	0	3	4	3
9	0	0	0	4	4	0	4	4	4	4	4	4
10	4	4	4	4	4	4	4	4	4	4	4	4
Total	21	32	12	34	26	13	30	27	20	31	32	33
Mean	2.1	3.2	1.2	3.4	2.6	1.3	3.0	2.7	2.0	3.1	3.2	3.3

Table 13

Number of Responses Made to Each of the Test Stimuli
By Adults in Each of the Order Conditions
After 120-60 Discrimination Training

	Orientation Test Stimuli											
	Order I						Order II					
Adult Subjects	30	60	90	120	150	180	30	60	90	120	150	180
1	0	0	4	4	4	4	0	0	4	0	0	4
2	0	0	2	4	1	4	0	0	0	4	4	4
3	0	0	1	4	4	0	2	0	0	0	0	4
4	0	0	3	4	4	3	0	0	0	4	0	4
5	0	0	0	4	4	0	0	0	0	4	1	0
6	0	0	0	3	4	0	0	4	0	0	0	0
7	0	0	0	4	0	0	0	0	0	4	4	0
8	0	0	0	4	1	0	0	0	0	4	4	0
9	0	0	0	4	4	0	0	0	0	4	4	0
10	0	0	0	4	4	0	0	0	0	4	4	0
Total	0	0	10	39	30	11	2	4	4	28	21	16
Mean	0.0	0.0	1.0	3.9	3.0	1.1	0.2	0.4	0.4	2.8	2.1	1.6

Table 14

Number of Responses Made to Each of the Test Stimuli by Children and Adults in Each of the Order Conditions After 120-90 Discrimination Training

	Orientation Test Stimuli											
	Order I						Order II					
Children Subjects	30	60	90	120	150	180	30	60	90	120	150	180
1	4	4	0	4	4	0	4	4	0	4	4	0
2	4	4	1	4	4	4	2	4	0	4	4	0
3	4	4	0	4	4	4	4	4	0	4	4	0
4	1	4	0	3	1	0	4	4	2	4	4	4
5	4	4	0	3	3	0	4	4	0	4	4	0
6	4	4	1	4	4	4	2	2	0	3	4	0
7	4	4	0	1	4	4	1	3	0	3	3	0
Total	25	28	2	23	24	16	21	25	2	26	27	4
Mean	3.6	4.0	0.3	3.3	3.4	2.3	3.0	3.6	0.3	3.7	3.9	0.6
Adult Subjects												
1	3	3	0	4	3	0	4	4	0	0	0	0
2	1	4	0	0	0	0	4	4	1	4	4	0
3	0	4	0	0	0	0	4	4	0	4	4	0
4	0	4	0	4	1	0	4	4	0	4	4	0
5	0	0	0	3	4	0	4	4	0	4	4	0
6	0	0	0	4	4	0	4	4	0	4	4	0
7	2	4	0	4	4	0	4	4	0	4	4	0
8	2	0	0	1	4	0	0	0	0	4	4	0
9	0	0	0	4	0	0	4	4	0	4	4	0
10	0	4	0	4	2	0	4	4	0	4	4	0
Total	8	23	0	28	22	0	36	36	1	36	36	0
Mean	0.8	2.3	0.0	2.8	2.2	0.0	3.6	3.6	0.1	3.6	3.6	0.0

Table 15

Number of Errors to Criterion for Children and Adults in Each of the Discrimination Training Conditions.

Group	Subjects	90-W	90-150	90-120	120-W	120-60	120-90
	S1[a]-01	2	7	10	0	-	7
	S2-01	0	2	14	0	-	2
	S3-01	1	10	7	0	-	11
	S4-01	2	3	5	0	-	3
	S5-01	2	7	8	2	-	10
	S6-01	2	0	4	1	-	13
	S7-01	0	1	14	3	-	2
	S1-02	2	1	1	3	-	8
	S2-02	0	0	7	1	-	3
	S3-02	4	12	2	3	-	3
	S4-02	1	18	22	0	-	2
	S5-02	0	2	2	0	-	5
	S6-02	0	2	1	2	-	10
	S7-02	0	1	2	6	-	13
Children	A[b]-1	-	21	28	-	26	28
	A-2	-	-	-	-	30	25
	A-3	-	-	-	-	33	28
	A-4	-	-	-	-	20	-
	A-5	-	-	-	-	25	-
	A-6	-	-	-	-	24	-
	A-7	-	-	-	-	36	-
	A-8	-	-	-	-	28	-
	A-9	-	-	-	-	23	-
	A-10	-	-	-	-	28	-
	A-11	-	-	-	-	26	-
	A-12	-	-	-	-	30	-
	A-13	-	-	-	-	27	-
	B[c]-1	-	-	2	-	18	9
	B-2	-	-	-	-	-	9

[a] Subject designations (e.g., 90-W S1-01, 90-150 S3-02, etc.) are consistent with those reported in all tables of individual performance dealing with the test phase of the experiment.

[b] Failures to learn

[c] Refused to remain for testing

Table 15 (continued)

Number of Errors to Criterion for Children and Adults in Each of the Discrimination Training Conditions.

Group	Subjects	90-W	90-150	90-120	120-W	120-60	120-90
	S1[a]-O1	2	1	1	1	2	1
	S2-O1	0	1	3	0	11	0
	S3-O1	1	3	1	0	3	1
	S4-O1	1	1	1	1	1	1
	S5-O1	1	3	2	0	4	0
	S6-O1	1	2	0	1	3	2
	S7-O1	0	1	0	0	1	1
	S8-O1	1	1	0	1	0	1
	S9-O1	1	0	2	1	1	2
	S10-O1	0	2	1	2	11	1
Adults	S1-O2	0	1	0	8	2	2
	S2-O2	1	0	1	1	1	0
	S3-O2	1	1	0	1	0	0
	S4-O2	1	0	1	1	2	1
	S5-O2	0	2	0	0	0	0
	S6-O2	0	2	1	0	5	0
	S7-O2	1	0	2	1	1	1
	S8-O2	2	3	0	3	1	5
	S9-O2	1	1	1	0	0	0
	S10-O2	2	0	0	0	0	0
	A[b]-1	-	-	-	-	27	-
	A-2	-	-	-	-	10	-

[a] Subject designations (e.g., 90-W S1-O1, 90-150 S3-O2, etc.) are consistent with those reported in all tables of individual performance dealing with the test phase of the experiment.

[b] Failures to learn

Table 16

Analysis of Variance on the Transformed Error Scores for the Discrimination Training Conditions

Source	df	MS	F
A (age)	1	396.84	142.24*
B (stimulus distance)	2	151.03	54.13*
C (S+ value)	1	96.69	34.66*
AB	2	89.04	31.92*
AC	1	48.69	17.45*
BC	2	63.74	22.85*
ABC	2	31.57	11.32*
Within cell (error)	202	2.79	

* Significant at .001 level.

Table 17

Comparisons Between Pairs of Transformed Score Means for All Discrimination Conditions: The Newman-Keuls Method[a,b]

Age	Adult	Adult	Adult	Adult	Child	Child	Adult	Adult	Child	Child	Child	Child
Disc	90-120	120-90	90-W	120-W	90-W	120-W	90-150	120-60	90-150	90-120	120-90	120-60
Mean	1.97	2.07	2.10	2.12	2.20	2.39	2.40	3.45	4.32	5.31	6.04	10.40

a $\alpha = .01$, df = 202, $\sqrt{MS\ error/\tilde{n}} = .40$

b means underlined by the same line do not differ.

Table 18

Analysis of Variance on Generalization After 90-120 Discrimination Training: Experiment 2.

Source	df	MS	F
Between Subjects	23		
A (training)	1	.11	.42
B (mode of presentation)	1	.69	2.65
AB	1	.12	.46
Subjects w. groups	20	.26	
Within Subjects	120		
C (stimuli)	5	15.73	60.50*
AC	5	.13	.50
BC	5	.38	1.46
ABC	5	.06	.23
C x subj. w. groups	100	.26	

* Significant at .001 level.

Table 19

Number of Responses Made to Each of the Test Stimuli by Adults in Each of the Training-Test Conditions: Experiment 2

Orientation Test Stimuli
Simultaneous Discrimination

Block:	1 (SS)						2 (DS)						3 (SS)						4 (DS)					
S	30	60	90	120	150	180	30	60	90	120	150	180	30	60	90	120	150	180	30	60	90	120	150	180
1	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	1	0	0	2	0	0	2
2	0	0	2	0	1	2	0	0	2	0	1	2	0	0	2	0	0	2	0	0	2	0	0	2
3	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
4	2	2	2	0	0	0	2	2	2	0	0	0	2	2	2	0	0	0	2	2	2	0	0	0
5	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
6	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2
Total	2	2	10	0	1	10	2	2	10	0	1	10	2	2	10	0	0	9	2	2	10	0	0	10
Mean	.3	.3	1.7	0	.2	1.7	.3	.3	1.7	0	.2	1.7	.3	.3	1.7	0	0	1.5	.3	.3	1.7	0	0	1.7
Block:	1 (DS)						2 (SS)						3 (DS)						4 (SS)					
1	1	1	2	1	0	0	0	0	2	0	0	0	0	1	2	1	0	0	0	0	2	0	0	0
2	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
3	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
4	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
5	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
6	0	0	2	0	0	1	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
Total	1	1	12	1	0	7	0	0	12	0	0	6	0	1	12	1	0	6	0	0	12	0	0	6
Mean	.2	.2	2.0	.2	0	1.2	0	0	2.0	0	0	1.0	0	.2	2.0	.2	0	1.0	0	0	2.0	0	0	1.0

Table 19 (continued)

Number of Responses Made to Each of the Test Stimuli by Adults in Each of the Training-Test Conditions: Experiment 2

Orientation Test Stimuli
Successive Discrimination

Block:	1 (SS)						2 (DS)						3 (SS)						4 (DS)					
S	30	60	90	120	150	180	30	60	90	120	150	180	30	60	90	120	150	180	30	60	90	120	150	180
1	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
2	0	1	2	1	1	2	1	2	2	2	0	2	0	2	2	1	0	2	0	2	2	0	0	2
3	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
4	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
5	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
6	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
Total	0	1	12	1	1	10	1	2	12	2	0	10	0	2	12	1	0	10	0	2	12	0	0	10
Mean	0	.2	2.0	.2	.2	1.7	.2	.3	2.0	.3	0	1.7	0	.3	2.0	.2	0	1.7	0	.3	2.0	0	0	1.7

Block:	1 (DS)						2 (SS)						3 (DS)						4 (SS)					
1	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
2	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
3	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
4	0	0	2	0	0	1	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0
5	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
6	0	0	2	0	0	1	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0	2
Total	0	0	12	0	0	6	0	0	12	0	0	6	0	0	12	0	0	6	0	0	12	0	0	6
Mean	0	0	2.0	0	0	1.0	0	0	2.0	0	0	1.0	0	0	2.0	0	0	1.0	0	0	2.0	0	0	1.0

Table 20

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 90-W Discrimination Training.

Orientation Test Pairs

Order 1

Children

Ss

	0---30		30---60		60---90		90--120		120--150		150--180	
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
Total	7	7	7	7	7	7	7	7	7	7	7	7
Mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Order 2

1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	0	0	1	1	1	0	1	0	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
Total	7	7	6	6	7	7	7	6	7	6	7	7
Mean	1.00	1.00	.86	.86	1.00	1.00	1.00	.86	1.00	.86	1.00	1.00

Table 20 (continued)

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 90-W Discrimination Training.

Orientation Test Pairs

Order 1

Adult Ss	0---30		30---60		60---90		90---120		120--150		150--180	
1	0	0	0	1	0	0	0	1	0	1	0	0
2	1	1	1	1	1	1	1	1	1	1	1	1
3	0	0	0	0	0	1	1	0	0	0	0	0
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	0
6	1	0	1	1	1	1	1	1	1	0	1	0
7	0	0	0	0	0	1	1	0	0	0	0	0
8	0	1	1	1	1	0	0	1	1	1	1	0
9	0	0	0	0	0	1	1	0	0	0	0	0
10	1	1	1	1	1	1	1	1	1	1	1	1
Total	5	5	6	7	6	8	8	7	6	6	6	3
Mean	.50	.50	.60	.70	.60	.80	.80	.70	.60	.60	.60	.30

Order 2

Adult Ss												
1	1	0	0	0	0	0	1	0	0	0	0	1
2	1	0	0	0	0	1	1	0	0	0	0	1
3	1	0	0	0	0	1	1	0	0	0	0	1
4	1	0	0	0	0	1	1	0	0	0	0	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	0	0	0	0	0	1	1	0	0	0	0	0
7	0	0	0	0	0	1	1	0	0	0	0	0
8	1	0	0	0	0	1	1	0	0	0	0	1
9	1	0	0	0	0	0	1	0	0	0	0	1
10	0	0	0	0	0	1	1	0	0	0	0	0
Total	7	1	1	1	1	8	10	1	1	1	1	7
Mean	.70	.10	.10	.10	.10	.80	1.00	.10	.10	.10	.10	.70

Table 21

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 90-150 Discrimination Training.

Orientation Test Pairs
Order 1

Children

Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	0	0	0	0	0	1	1	0	0	0	0	0
2	0	0	0	0	0	1	1	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	0	1	1	0	0	0	0	0
6	0	0	0	0	0	1	1	0	0	0	0	0
7	0	0	1	1	0	1	1	0	0	0	0	0
Total	1	0	1	1	0	6	6	0	0	0	0	1
Mean	.14	.00	.14	.14	.00	.86	.86	.00	.00	.00	.00	.14

Children

Order 2

Ss												
1	0	0	0	0	0	1	1	0	0	0	0	0
2	0	0	0	0	0	1	1	0	0	0	0	0
3	0	0	0	0	0	1	1	0	0	0	0	0
4	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	0	1	1	0	0	0	0	0
6	0	0	0	0	0	1	1	0	0	0	0	0
7	0	0	0	0	0	1	1	0	0	0	0	0
Total	0	0	0	0	0	7	7	0	0	0	0	0
Mean	.00	.00	.00	.00	.00	1.00	1.00	.00	.00	.00	.00	.00

Table 21 (continued)

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 90-150 Discrimination Training.

Orientation Test Pairs

Order 1

Adult Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	1	0	0	0	0	1	1	0	0	0	0	1
2	1	0	1	0	0	0	0	0	0	1	0	0
3	0	0	0	0	0	1	1	0	0	0	0	0
4	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	0	1	1	0	0	0	0	0
6	0	0	0	0	0	1	1	0	0	0	0	0
7	1	0	0	0	0	1	1	0	0	0	0	1
8	0	0	0	0	0	1	1	0	0	0	0	0
9	0	0	0	0	0	1	1	0	0	0	0	0
10	1	0	0	0	0	1	1	0	0	0	1	1
Total	4	0	1	0	0	9	9	0	0	1	1	3
Mean	.40	.00	.10	.00	.00	.90	.90	.00	.00	.10	.10	.30

Order 2

Adult Ss												
1	1	0	0	0	0	1	1	0	0	0	0	1
2	1	0	0	0	0	0	1	0	0	0	0	1
3	1	0	0	0	0	0	0	0	0	0	0	1
4	1	0	0	0	0	0	0	0	0	0	0	1
5	0	0	0	0	0	1	1	0	0	0	0	0
6	0	0	0	0	0	1	1	0	0	0	0	0
7	1	0	0	0	0	1	1	0	0	0	0	1
8	1	0	0	0	0	1	1	0	0	0	0	1
9	1	0	0	0	0	1	1	0	0	0	0	1
10	0	0	0	0	0	1	1	0	0	0	0	0
Total	7	0	0	0	0	7	8	0	0	0	0	7
Mean	.70	.00	.00	.00	.00	.70	.80	.00	.00	.00	.00	.70

Table 22

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 90-120 Discrimination Training.

Orientation Test Pairs

Order 1

Children Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	0	0	0	0	0	1	1	0	0	0	0	0
2	0	0	0	0	0	1	1	0	0	0	0	0
3	0	0	0	0	0	1	1	0	0	0	0	0
4	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	0	1	1	0	0	0	0	0
6	0	0	0	0	0	1	1	0	0	0	0	0
7	0	0	0	0	0	1	1	0	0	0	0	0
Total	0	0	0	0	0	7	7	0	0	0	0	0
Mean	.00	.00	.00	.00	.00	1.00	1.00	.00	.00	.00	.00	.00

Order 2

Children Ss												
1	0	0	0	0	0	1	1	0	0	0	0	0
2	0	0	0	0	0	1	1	0	0	0	0	0
3	1	0	0	0	0	1	1	0	0	0	0	1
4	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	0	1	1	0	0	0	0	0
6	1	0	0	0	0	1	1	0	0	0	0	1
7	0	0	0	0	0	1	1	0	0	0	0	0
Total	2	0	0	0	0	7	7	0	0	0	0	2
Mean	.29	.00	.00	.00	.00	1.00	1.00	.00	.00	.00	.00	.29

Table 22 (continued)

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 90-120 Discrimination Training.

Orientation Test Stimuli

Order 1

Adult Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	0	0	0	0	0	1	1	0	0	0	0	0
2	1	1	0	0	0	0	0	0	0	1	0	1
3	0	1	1	1	1	0	0	1	1	1	1	0
4	0	0	0	0	0	1	1	0	0	0	0	0
5	0	0	0	0	0	1	1	0	0	0	0	0
6	1	0	0	0	0	1	1	0	0	0	0	1
7	1	0	1	0	0	1	1	0	1	0	0	1
8	0	0	0	0	0	1	1	0	0	0	0	0
9	0	0	0	0	0	1	1	0	0	0	0	0
10	1	0	0	0	0	1	1	0	0	0	0	1
Total	4	2	2	1	1	8	8	1	2	2	1	4
Mean	.40	.20	.20	.10	.10	.80	.80	.10	.20	.20	.10	.40

Order 2

Adult Ss												
1	0	0	0	0	0	1	1	0	0	0	0	0
2	0	0	0	0	0	1	1	0	0	0	0	0
3	1	0	0	0	0	1	1	0	0	0	0	1
4	1	0	0	0	0	1	1	0	0	0	0	1
5	0	0	0	0	0	1	1	0	0	0	0	1
6	1	0	0	0	0	0	0	0	0	0	0	1
7	0	0	0	0	0	1	1	0	0	0	0	0
8	1	0	0	0	0	1	1	0	0	0	0	1
9	1	0	0	0	0	0	1	0	0	0	0	1
10	0	0	0	0	0	1	1	0	0	0	0	0
Total	5	0	0	0	0	8	9	0	0	0	0	6
Mean	.50	.00	.00	.00	.00	.80	.90	.00	.00	.00	.00	.60

Table 23

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 120-W Discrimination Training.

Orientation Test Pairs

Order 1

Children

Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
Total	7	7	7	7	7	7	7	7	7	7	7	7
Mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Children

Order 2

Ss												
1	1	1	1	1	1	1	0	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	0	0	1	1	1	1	1	0	1	1	0	0
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
Total	6	6	7	7	7	7	6	6	7	7	6	6
Mean	.86	.86	1.00	1.00	1.00	1.00	.86	.86	1.00	1.00	.86	.86

Table 23 (continued)

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 120-W Discrimination Training.

Orientation Test Pairs

Order 1

Adult Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	0	1	1	1	1	1	0	1	1	1	1
3	0	1	1	1	1	0	0	1	1	1	1	1
4	0	1	0	1	1	0	0	0	0	0	0	0
5	0	0	0	1	1	0	0	1	1	0	0	0
6	0	0	0	0	0	0	0	1	1	0	1	0
7	0	0	0	1	1	0	0	1	1	0	1	0
8	0	1	0	1	1	0	0	1	1	1	0	0
9	0	0	0	0	0	0	0	1	1	1	1	0
10	1	1	1	1	1	1	1	1	1	1	1	1
Total	3	6	4	8	8	3	3	8	8	6	7	4
Mean	.30	.60	.40	.80	.80	.30	.30	.80	.80	.60	.70	.40

Order 2

Adult Ss												
1	1	0	0	0	0	0	0	0	0	0	0	1
2	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1
4	0	1	0	0	0	0	0	1	1	1	1	0
5	0	1	1	1	1	0	0	1	1	1	1	0
6	1	1	0	0	0	0	0	0	0	0	0	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	0	0	1	0	0	0	1	0	1	1	0
9	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1
Total	8	8	6	7	6	5	5	8	7	8	8	7
Mean	.80	.80	.60	.70	.60	.50	.50	.80	.70	.80	.80	.70

Table 24

Within Pair Responding to Test Stimuli by Adults in Each of The Order Conditions After 120-60 Discrimination Training.

Orientation Test Pairs

Adult Ss	0---30		30---60		60---90		90--120		120--150		150--180	
						Order 1						
1	1	0	0	0	0	1	1	1	1	1	1	1
2	1	0	0	0	0	1	0	1	1	0	0	1
3	0	0	0	0	0	0	0	1	1	1	1	0
4	1	0	0	0	0	1	0	1	1	1	1	0
5	0	0	0	0	0	0	0	1	1	1	1	0
6	0	0	0	0	0	0	0	1	0	1	1	0
7	0	0	0	0	0	0	0	1	1	0	0	0
8	0	0	0	0	0	0	0	1	1	0	1	0
9	0	0	0	0	0	0	0	1	1	1	1	0
10	0	0	0	0	0	0	0	1	1	1	1	0
Total	3	0	0	0	0	3	1	10	9	7	8	2
Mean	.30	.00	.00	.00	.00	.30	.10	1.00	.90	.70	.80	.20
Adult Ss						Order 2						
1	1	0	0	0	0	1	1	0	0	0	0	1
2	1	0	0	0	0	0	0	1	1	1	1	1
3	1	0	1	0	0	0	0	0	0	0	0	1
4	1	0	0	0	0	0	0	1	1	0	0	1
5	0	0	0	0	0	0	0	1	1	0	1	0
6	0	0	0	1	1	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	1	1	1	1	0
8	0	0	0	0	0	0	0	1	1	1	1	0
9	0	0	0	0	0	0	0	1	1	1	1	0
10	0	0	0	0	0	0	0	1	1	1	1	0
Total	4	0	1	1	1	1	1	7	7	5	6	4
Mean	.40	.00	.10	.10	.10	.10	.10	.70	.70	.50	.60	.40

Table 25

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 120-90 Discrimination Training.

Orientation Test Pairs

Order 1

Children

Ss	0---30		30---60		60---90		90---120		120--150		150--180	
1	0	1	1	1	1	0	0	1	1	1	1	0
2	1	1	1	1	1	0	0	1	1	1	1	1
3	1	1	1	1	1	0	0	1	1	1	1	1
4	0	0	0	1	1	0	0	1	0	0	1	0
5	0	1	1	1	1	0	0	1	1	1	1	0
6	1	1	1	1	1	0	0	1	1	1	1	1
7	1	1	1	1	1	0	0	0	1	1	1	1
Total	4	6	6	7	7	0	0	6	6	6	7	4
Mean	.57	.86	.86	1.00	1.00	.00	.00	.86	.86	.86	1.00	.57

Children

Order 2

Ss												
1	0	1	1	1	1	0	0	1	1	1	1	0
2	0	1	0	1	1	0	0	1	1	1	1	0
3	0	1	1	1	1	0	0	1	1	1	1	0
4	1	1	1	1	1	1	0	1	1	1	1	1
5	0	1	1	1	1	0	0	1	1	1	1	0
6	0	1	0	0	1	0	0	0	1	1	1	0
7	0	1	0	1	0	0	0	1	1	1	1	0
Total	1	7	4	6	6	1	0	6	7	7	7	1
Mean	.14	1.00	.57	.86	.86	.14	.00	.86	1.00	1.00	1.00	.14

Table 25 (continued)

Within Pair Responding to Test Stimuli by Children and Adults in Each of the Order Conditions After 120-90 Discrimination Training.

Orientation Test Pairs
Order 1

Adult Ss	0---30		30---60		60---90		90--120		120--150		150--180	
1	0	0	1	1	0	0	0	1	1	1	0	0
2	0	0	0	1	1	0	0	0	0	0	0	0
3	0	0	0	1	1	0	0	0	0	0	0	0
4	0	0	0	1	1	0	0	1	1	0	1	0
5	0	0	0	0	0	0	0	0	1	1	1	0
6	0	0	0	0	0	0	0	1	1	1	1	0
7	0	1	0	1	1	0	0	1	1	1	1	0
8	0	1	0	0	0	0	0	0	0	1	1	0
9	0	0	0	0	0	0	0	1	1	0	0	0
10	0	0	0	1	1	0	0	1	1	0	1	0
Total	0	2	1	6	5	0	0	6	7	5	6	0
Mean	.00	.20	.10	.60	.50	.00	.00	.60	.70	.50	.60	.00

Order 2

Adult Ss												
1	0	1	1	1	1	0	0	0	0	0	0	0
2	0	1	1	1	1	0	0	1	1	1	1	0
3	0	1	1	1	1	0	0	1	1	1	1	0
4	0	1	1	1	1	0	0	1	1	1	1	0
5	0	1	1	1	1	0	0	1	1	1	1	0
6	0	1	1	1	1	0	0	1	1	1	1	0
7	0	1	1	1	1	0	0	1	1	1	1	0
8	0	0	0	0	0	0	0	1	1	1	1	0
9	0	1	1	1	1	0	0	1	1	1	1	0
10	0	1	1	1	1	0	0	1	1	1	1	0
Total	0	9	9	9	9	0	0	9	9	9	9	0
Mean	.00	.90	.90	.90	.90	.00	.00	.90	.90	.90	.90	.00

REFERENCES

Boneau, C. A. α Honig, W. K. Opposed generalization gradients based upon conditional discrimination training. J. exp. Psychol., 1964, 66, 89-93.

Campbell, D. T. Operational delineation of "What is learned" via the transposition experiment. Psychol. Rev., 1954, 61, 167-174.

Cross, D. V., α Lane, H. L. On the discriminative control of concurrent responses: the relations among response frequency, latency, and topography in auditory generalization. J. exp. Anal. Behav., 1962, 5, 487-496.

Gibson, E. J. A re-examination of generalization. Psychol. Rev., 1959, 66, 340-343.

Gollin, E. S. A developmental approach to learning and cognition. In L. P. Lipsitt & C. C. Spiker (Eds.), Advances in child development and behavior. New York: Academic Press, 1964.

Guttman, N. Laws of behavior and facts of perception. In S. Koch (Ed.), Psychology; a study of a science. New York: McGraw-Hill, vol. 5, 1963. Pp. 114-178.

Hanson, H. M. Effects of discrimination training on stimulus generalization. *J. exp. Psychol.*, 1959, *58*, 321-334.

Honig, W. K. Prediction of preference, transposition, and transposition-reversal from the generalization gradient. Doctoral dissertation at Duke University Library, 1958.

Honig, W. K. Prediction of preference, transposition, and transposition-reversal from the generalization gradient. *J. exp. Psychol.*, 1962, *64*, 239-248.

Honig, W. K., Boneau, C. A., Burstein, K. R. α Pennypacker, H. S. Positive and negative generalization gradients obtained after equivalent training conditions. *J. comp. physiol. Psychol.*, 1963, *56*, 111-116.

Honig, W. K., Thomas, D. R. α Guttman, N. Differential effects of continuous extinction and discrimination training on the generalization gradient. *J. exp. Psychol.*, 1959, *58*, 145-152.

Hull, C. L. The problem of stimulus equivalence in behavior theory. *Psychol. Rev.*, 1939, *46*, 9-30.

Hull, C. L. Principles of behavior. New York: Appleton-Century-Crofts, 1943.

Hull, C. L. Simple qualitative discrimination learning. Psychol. Rev., 1950, 57, 303-313.

Jenkins, H. M. & Harrison, R. H. Effect of discrimination training on auditory generalization. J. exp. Psychol., 1960, 59, 246-253.

Johnson, R. C. & Zara, R. C. Relational learning in young children. J. comp. physiol. Psychol., 1960, 53, 594-597.

Kalish, H. I. The relationship between discriminability and generalization: a re-evaluation. J. exp. Psychol., 1958, 55, 637-644.

Kendler, H. H. & Kendler, T. S. Vertical and horizontal processes in problem solving. Psychol. Rev., 1962, 69, 1-16.

LaBerge, D. Generalization gradients in a discrimination situation. J. exp. Psychol., 1961, 62, 88-94.

Lashley, K. S. & Wade, M. The Pavlovian theory of generalization. Psychol. Rev., 1946, 53, 72-87.

Lipsitt, L. P. Simultaneous and successive discrimination learning in children. Child Develpm., 1961, 32, 337-347.

Mackintosh, J. & Sutherland, N. S. Visual discrimination by goldfish: the orientation of rectangles. An. Behav., 1963, 11, 135-141.

Mednick, S. & Freedman, J. Stimulus generalization. Psychol. Rev., 1960, 57, 169-200.

Mello, N. K. Inter-hemispheric reversal of mirror image oblique lines following monocular training in pigeons. Science, 1965, 148, 252-254.

Mello, N. K. Interocular generalization: a study of mirror image reversal following monocular discrimination training in the pigeon. J. exp. Anal. Behav., 1966, 9, 11-16.

Newman, F. L. & Baron, M. R. Stimulus generalization along the dimension of angularity: a comparison of training procedures. J. comp. physiol. Psychol., 1965, 60, 59-63.

Osgood, C. E. A behavioristic analysis of perception and language as cognitive phenomena. In Contemporary approaches to cognition. Cambridge: Harvard Univer. Press, 1957. Pp. 75-118.

REFERENCES (continued)

Pierrel, R. & Sherman, J. G. Generalization and discrimination as a function of the S^D and S^{Δ} intensity difference. J. exp. Anal. Behav., 1962, 5, 67-71.

Prokasy, W. F. & Hall, J. F. Primary stimulus generalization. Psychol. Rev., 1963, 70, 310-322.

Razran, G. Stimulus generalization of conditioned responses. Psychol. Bull., 1949, 46, 337-365.

Rudel, R. G. & Teuber, H. L. Discrimination of line in children. J. comp. physiol. Psychol., 1963, 56, 892-898.

Spence, K. W. The nature of discrimination learning in animals. Psychol. Rev., 1936, 43, 427-449.

Spence, K. W. The differential response in animals to stimuli varying within a single dimension. Psychol. Rev., 1937, 44, 430-444.

Staats, A. W. Verbal habit families, concepts and the operant conditioning of word classes. Psychol. Rev., 1961, 68, 190-204.

Sutherland, N. S. Visual discrimination of orientation and shape by the octopus. Nature, 1957, 179, 11-13.

Sutherland, N. S. Cat's ability to discriminate oblique rectangles. Science, 1963, 139, 209-210.

Thomas, D. R. The effects of drive and discrimination training on stimulus generalization. J. exp. Psychol., 1962, 64, 24-28.

Thomas, D. R. α Hiss. R. H. A test of the "units hypothesis" employing wavelength generalization in human subjects. J. exp. Psychol., 1963, 65, 58-62.

Thomas, D. R. α Jones, C. G. Stimulus generalization as a function of the frame of reference. J. exp. Psychol., 1962, 64, 77-80.

Thomas, D. R., Klipec, W. α Lyons, J. Investigations of a mirror image reversal effect in pigeons. Unpublished paper, 1965.

Thomas, D. R. α Mitchell, K. Instructions and stimulus categorizing in a measure of stimulus generalization. J. exp. Anal. Behav., 1962, 5, 375-381.

Thomas, D. R., Ost, J. α Thomas, D. Stimulus generalization as a function of the time between training and testing procedures. J. exp. Anal. Behav., 1960, 3, 9-14.

Winer, B. J. Statistical principles in experimental design. New York: McGraw-Hill, 1962.