Constant and variable irrelevant cues during intra- and extradimensional transfer*

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Experiment I compared constant (CI), variable-between (VBI), and variable-within (WVI) irrelevant cues during an extradimensional (ED) shift discrimination. Performance was better for CI than for VBI and better for VBI than for VWI. Experiment II combined CI, VBI, and VWI cues with ED or intradimensional (ID) shifts. Irrelevant-cue conditions did not affect ID performance but did affect ED performance. The typical superiority of ID, as compared to ED, shifts was observed in the VWI condition but not in the CI condition. Implications for mediating-response (i.e., attention or observing-response) theories were indicated.

Several theorists have argued that in learning a simultaneous discrimination problem, an organism first learns a dimensional mediating response, e.g., an attending (Sutherland & Mackintosh, 1971; Lovejoy, 1968) or an observing (Zeaman & House, 1963) response, and then learns an appropriate instrumental response. If, following acquisition training, the organism is trained on an extradimensional (ED) shift (i.e., a new stimulus dimension is made relevant), then there should be *negative* transfer of the dimensional mediating response. If the organism is trained on an intradimensional (ID) shift (i.e., the relevant dimension in acquisition is also relevant in the shift problem) there should be *positive* transfer of the mediating response. Superior performance on ID, as compared to ED, shifts typically has been taken as support for the mediational position (cf. Shepp & Gray, 1971). Recent research (e.g., Dickerson, Wagner, & Campione, 1970; Shepp & Gray, 1971) suggests that the relationship between performance on ID and ED shifts depends on the arrangement of the irrelevant cues during the shift discrimination.

In a recent analysis of discrimination learning paradigms, Shepp and Turrisi (1966) described three procedures for making a stimulus dimension irrelevant during discrimination training. Following their terminology, as it applies to simultaneous discrimination training, a dimension can be: (a) *constant irrelevant* (CI), in which case only one value of the irrelevant dimension appears during training, and on all training trials that one value is paired with both rewarded (S+) and nonrewarded (S-) stimuli on the relevant dimension, (b) *variable-between irrelevant* (VBI), in which two values of the irrelevant dimension appear during training, but only one value appears on any single training trial, that one value being paired both with S+ and with S- on each single trial, or (c) *variable-within irrelevant* (WVI),

in which case two values of the irrelevant dimension appear on each training trial, one value paired with S+ and one value paired with S- but, during training, each value appearing equally often with S+ and S-.

In one investigation of the effect of various cue conditions, Dickerson et al (1970) trained children first on a discrimination with WVI cues and then on an ED or ID shift with the previously relevant cues, either VBI or VWI. The ED shift was learned faster with VBI cues than with VWI cues; on the ID shift, there was no effect of the irrelevant-cue condition. Further, the ID shift was learned faster than the ED shift, if the irrelevant cues were VWI but not if they were VBI. Presumably, there was negative transfer of the mediating response in the ED-shift condition only if the irrelevant cues varied within trials during transfer. Shepp and Gray (1971) obtained comparable results whether original training included VBI or VWI cues; i.e., regardless of acquisition conditions, there was no evidence for negative transfer of the mediating response unless the transfer discrimination included VWI cues. Such results have been taken as support for the hypothesis (cf. Eimas, 1965) that negative transfer of mediating response does not occur unless the relevant dimension from the original acquisition discrimination becomes irrelevant and is variable within trials. In effect, the position holds that organisms learning simultaneous discriminations are not distracted by a previously relevant stimulus dimension unless at least two values of that dimension are present at a given time.

EXPERIMENT I

The purpose of Experiment I was to investigate transfer performance with no variable irrelevant acquisition cues (except position) during acquisition (i.e., all irrelevant cues were CI in acquisition) and with the relevant acquisition dimension made irrelevant according to one of the three procedures given above. Thus, three groups of rats were trained on a texture discrimination with no variable irrelevant cues (except

*This research was supported by Grant AO-326 from the National Research Council of Canada. Requests for reprints should be sent to T. Gary Waller, Department of Psychology, University of Waterloo, Ontario, Canada.

Table 1
Experimental Design and Means of Errors to Criterion in
Acquisition and Transfer for Experiment I

Irrelevant Cue Condition	Treatment		Mean Errors to Criterion	
	Acqui- sition	Transfer	Acqui- sition	Transfer
Constant Irrelevant	SG-RG	WI-BI	33.88	9.62
Variable-Between Irrelevant	SG-RG	WS-BS WR-BR	28.00	13.75
Variable-Within Irrelevant	SG-RG	WS-BR WR-BS	35.50	18.50

position). Subsequently, all groups were trained on a brightness discrimination with the texture cues either constant (Group CI), variable-between (Group VBI), or variable-within (Group VWI) irrelevant. If a mediating response to texture is learned during acquisition and if there is no negative transfer to the ED shift unless the orientation cues are made VWI, then Groups CI and VBI should not differ during transfer and both should learn faster than Group VWI. If, however, negative transfer occurs when the irrelevant transfer cues are VBI, then Group CI should learn faster than Group VBI.

Method

Design. To facilitate communication of the design, Table 1 shows an example of the acquisition and transfer treatments for each of three groups of 16 rats. During the acquisition phase, all groups were trained to discriminate a smooth gray (SG) floor from a rough gray (RG) floor. During the transfer phase, all groups were trained to discriminate a white floor (W) from a black floor (B). The major experimental manipulation involved the treatment of the rough-smooth cues during transfer to the brightness discrimination. For Group CI, the texture dimension was not varied during transfer and floors were always of an intermediate texture (I). For Group VBI, texture was variable-between irrelevant during transfer. On any one transfer trial, only one value on the texture dimension was present, but the value of the texture cue was varied from trial to trial such that both texture cues were experienced by the rat during transfer training. For Group VWI, texture was a variable-within irrelevant dimension during transfer and both values of texture were present on every transfer trial. Each rat in Groups VBI and VWI received both training pairs equally often in each block of 20 trials. Similarly, for each training pair, the positive cue was equally often on the left and on the right. Appropriate counterbalancing for positive cue was done in each treatment.

Subjects. The Ss were 48 naive male albino rats supplied by the Holtzman Company of Madison, Wisconsin. They were approximately 70 days old upon arrival at the laboratory and they weighed 280-300 g.

Apparatus. The apparatus (described in Waller, 1971) was an enclosed wooden, single-unit T maze which was painted gray and covered with Plexiglas. The startbox was 15.2 x 20.30 cm, the stem was 8.9 x 38.0 cm, and each of the arms, which constituted the goalboxes, was 10.2 x 40.6 cm. Reward pellets were placed in gray foodcups located behind a wooden barrier at the rear of each arm. A guillotine door separated the startbox from the stem; horizontally sliding doors separated the stem from each goalbox.

Stimulus inserts for the floors of the arms of the maze were cut from Masonite and were painted flat-white, black, or gray. A

smooth floor was defined as the smooth side of painted Masonite. An intermediate texture was defined as the rough side of painted Masonite. A rough texture was devised by drilling 0.5-cm holes, centered every 1.25 cm, over the length and breadth of the Masonite insert. Each insert extended from the center of the choicepoint to the foodcup.

Procedure. Upon arrival, each rat was housed individually and placed on ad lib food (laboratory cubes) and water for approximately 60 days. On the first day of the experiment, each rat was weighed and put on a once-daily ration of 10-12 g of laboratory cubes designed to maintain a constant 85% of terminal ad lib body weight. On each of the next 8 days, each rat was prehandled for 2 min on a large gray table. During each prehandling session, each rat was picked up and replaced at least three times and was given access to five .045-mg Noyes pellets which were in a cup in the center of the table.

Following prehandling, the rats were given acquisition training on a simultaneous discrimination problem as described above. During acquisition, a modified correction procedure (cf. Warren & McGonigle, 1969) was used such that, if the rat made an error, the position (right or left) of the positive cue was not changed. If the rat made a correct response, whether or not the position of the positive cue was changed was varied according to randomly selected Gellerman series (Hilgard, 1951); i.e., following a correct response, the probability was 0.5 that the positive cue was moved. Acquisition training continued each day until the rat made a total of 10 correct responses. Each rat was trained to a criterion of 15 correct responses in 16 consecutive trials. During acquisition, the within-day intertrial interval was approximately 10 sec; reward for a correct response was five .045-g pellets; the rat was confined in the goalbox for 10 sec following an incorrect response or until he ate the pellets following a correct response; the empty foodcup was always present in the unbaited goalbox, and the order of running the rats was reversed daily. Transfer to the brightness discrimination began on the day after each rat reached acquisition criterion. During transfer, all procedures were the same as in acquisition.

RESULTS AND DISCUSSION

Mean errors to criterion during acquisition and transfer are shown in Table 1 for the three treatment groups. Analysis of variance indicated that acquisition performance was not significantly different for the irrelevant-cue conditions in transfer ($F = 1.34$, $df = 2/42$) and was not affected by which cue was positive during acquisition ($F = 3.46$, $df = 1/42$, $.05 < p < .10$) or by the interaction of positive cue with treatment group ($F < 1.0$). During transfer, Group CI learned the brightness discrimination fastest, followed by Groups VBI and VWI. Analysis of variance of errors to criterion indicated that the effect of irrelevant cues was significant ($F = 5.48$, $df = 2/42$, $p < .01$), but neither the effect of positive cue nor the interaction of irrelevant cues with positive cue was significant (all $F < 1.00$). Individual comparisons, using the Newman-Keuls procedure (Winer, 1962), showed that Group CI learned the transfer task significantly faster than Group VBI or Group VWI and that Group VBI learned faster than Group VWI (MS error = 9.68). The superiority of Group VWI to Group VBI, following acquisition training with CI cues, agrees with similar results following acquisition training with VWI cues (Dickerson, 1967; Shepp & Gray, 1971) or with VBI cues (Shepp & Gray,

1971) with humans. The superiority of Group CI to Group VBI also agrees with previous results with moderately retarded children (Zeaman & Denegre, 1967).

Presumably, training on the texture discrimination increased the strength of the mediating response to the texture dimension. During subsequent transfer to the brightness discrimination, Groups VBI and VWI continued to attend to the then-irrelevant texture dimension and performed worse than Group CI. An alternative interpretation of the superiority of Group CI to Groups VBI and VWI contains the assumption that the animals learned the original discrimination on the basis of a compound-cue dimension (e.g., approach the smooth-gray cue and avoid the rough-gray cue). If so, the shift discrimination essentially was an ID, rather than an ED, shift and Group CI had to learn only one discrimination (e.g., approach WI and avoid BI), whereas Groups VBI and VWI had to learn two separate discriminations (cf. Shepp & Gray, 1971; Zeaman & House, 1963). From Experiment I, it is impossible to test the compound-cues explanation; an appropriate test is included in Experiment II.

Concerning the superiority of Group VBI to Group VWI, both groups had equivalent acquisition training on texture cues, so the difference between the two groups cannot be attributed to differences in: (a) strengths of the mediating response to texture or brightness cues at the end of acquisition, (b) strengths of instrumental responses to texture or brightness cues at the end of acquisition, or (c) novelty (cf. Slamecka, 1968) of the brightness cues at the beginning of transfer (black and white were novel cues for all groups). Further, the compound-cues hypothesis discussed above is inadequate to account for this effect. Since both groups had equivalent compounds to be discriminated during transfer, there should have been no difference between the two groups. A reasonable interpretation of the superiority of Group VBI to Group VWI is that the negative transfer of the mediating response to the irrelevant texture dimension was greater if the cues on the dimension varied within trials than if they were constant within trials and varied only between trials. The assumption is that an organism is more likely to observe or attend to an irrelevant dimension if two values are present at once (VWI) than if only one value is present at a given time (VBI) and comparisons between trials are necessary to detect the variability. It is obvious that rats can respond differentially to values of a dimension separated by time—rats can learn successive discriminations (cf. Sutherland & Mackintosh, 1971) where only one cue from a relevant dimension is present at any specific time.

There is an alternative interpretation, based on a methodological inadequacy, of the inferiority of Group VWI to the other groups—there was instrumental cue conflict for Group VWI, but not for the other two

groups. On half of the transfer trials, the positive texture cue from acquisition was in opposition to the positive brightness cue from transfer. For example, on half the trials, some rats were required to choose between WR and BS when R and S previously were negative and positive, respectively. The cue conflict did not occur with VBI cues because only one value of texture was present on any transfer trial. The cue-conflict hypothesis, which cannot be adequately eliminated by the data of Experiment I, can be eliminated if new stimulus values are chosen for the irrelevant transfer dimension. Experiment II included such a test. Yet, a final possibility is that the inferiority of Group VWI was due to differential habit strength to the two texture cues (cf. Lovejoy, 1968; Campione & Wentworth, 1969). Again, this problem was eliminated in Experiment II.

EXPERIMENT II

The first purpose of Experiment II was to repeat the basic design of Experiment I, with appropriate methodological modifications to test for compound-cue learning and to eliminate the cue-conflict situation in the VWI transfer condition. Thus, rats were first trained on a stripe orientation (left or right oblique) discrimination with CI width cues (i.e., all stripes were of medium width). Then, different groups were given an ED shift to a discrimination with width cues (wide or narrow) relevant and orientation cues (horizontal or vertical) CI, VBI, or VWI. The change in orientation cues (from left-right to horizontal-vertical) eliminated the cue-conflict during transfer in the VWI condition. To assess the degree of learning about stimulus compounds, all animals were given test trials that were alternated with retraining trials (cf. Sutherland & Mackintosh, 1971; Waller, 1971) after learning the transfer discrimination. On the test trials, the irrelevant component of the shift discrimination was changed, but the relevant component was not. If the animal learned the discrimination on the basis of compound cues, then performance should be disrupted on the test with a changed irrelevant component.

A second and important purpose of Experiment II was to compare ID and ED shifts under CI, VBI, or VWI conditions in transfer following acquisition training with CI cues. Previous research (Turrissi, Shepp, & Eimas, 1969; Dickerson et al, 1970; Shepp & Gray, 1971) reported no significant ED-ID shift differences under VBI conditions but clear superiority on ID shifts under VWI conditions. However, in Experiment I, Group CI learned faster than Group VBI. The inferior performance with VBI cues pointed to the possibility of negative transfer of dimensional mediating responses, even though the irrelevant transfer cues were VBI; i.e., possibly an animal attends to the previously relevant cue even though it is VBI and not VWI. If an animal attends to the VBI cue during an ED shift, resulting in negative

Table 2
Experimental Design of Experiment II

Shift Condition	Irrelevant Cue Condition	Discrimination		Test Cues
		Acquisition	Transfer	
Intra-dimensional	Constant	LI-RI	VW-HW	VN-HN
	Variable	LI-RI	VW-HW	VI-HI
	Between		VN-HN	
	Variable Within	LI-RI	VW-HN	VI-HI
Extra-dimensional	Constant	LI-RI	WV-NV	WH-NH
	Variable		WV-NV	WL-NL
	Between	LI-RI	WH-NH	WR-NR
	Variable Within	LI-RI	WV-NH	WL-NL
			WH-NV	WR-NR

transfer, then ED shifts should be learned more slowly than ID shifts with VBI cues, as well as with VWI cues. In order to compare ID and ED shifts under each of the three irrelevant-cue conditions, three additional groups were trained on the orientation discrimination (left vs right) with CI (medium) width cues and then given an ID shift. On the ID shift, orientation continued to be relevant with new values (left and right) on the orientation dimension and width (wide or narrow) CI, VBI, or VWI.

Method

Design. To facilitate communication of the design, Table 2 shows an example of the treatments for each of six groups of eight rats. During acquisition, all animals were trained to discriminate left-intermediate stripes (LI) from right-intermediate stripes (RI), with appropriate counterbalancing for S+ (but with no counterbalancing for relevant dimension). Then the rats were shifted to one of six transfer treatments in a 2 x 3 factorial design with two shift conditions (ID and ED shifts) and three irrelevant cue conditions (CI, VBI, or VWI). All transfer cues were a combination of wide (W) or narrow (N) stripes that were oriented vertically (V) or horizontally (H). Animals in Group ED-CI were trained on one pair from WV-NV, WH-NH, NV-WV, or NH-WH, with the first cue being S+. Those in Group ED-VBI were trained either on WV-NV and WH-NH or on NV-WV and NH-WH. Those in Group ED-VWI were trained either on WV-NH and WH-NV or on NH-WV and NV-WH. In the ID shift conditions, the transfer cues were one pair from VW-HW, VN-HN, HW-VW or HN-VN for Group ID-CI; either HW-VW and HN-VN or VW-HW and VN-HN for Group CI, VBI; and either HW-VN and HN-VW or VW-HN and VN-HW for Group ID-VWI.

Following training on the transfer discrimination, each rat was given a series of test trials, alternated with retraining trials on the transfer cues. On test trials, the irrelevant component from the transfer cues was changed but the relevant cues were unchanged. Examples of the test cues are shown in Table 2.

Subjects. The Ss were 48 experimentally naive male albino rats of the same type as in Experiment I. Upon arrival, the rats were reported to be approximately 90 days old and they weighed approximately 290-330 g.

Apparatus. In order to have four cues on one dimension (in this case, orientation), it was preferable to use a different apparatus from that in Experiment I. The apparatus, described in Waller (1970), was a gray, wooden, Plexiglas-covered

discrimination box with start, choice, and goal areas separated by horizontally sliding wooden doors. The start section led into a triangular-shaped choice area which opened into two adjacent goalboxes. The floor of the goalboxes was 6.4 cm below the floor of the choice area. In the rear wall of each goalbox was a 3.8-cm round hole, centered 4.1 cm above the floor of the goalboxes. Food pellets were placed in foodwells located behind swinging doors which covered the holes. To get the reward pellets, S had to put his head through the hole, pushing open the hinged door. The hinged doors in either goalbox could be locked from the outside.

Stimulus inserts for the rear walls of the goalboxes were cut from Masonite and were 15.2 x 24.8 cm with a 3.8-cm hole to match the hole in the rear wall of the goalboxes. The stimulus inserts were covered with alternating black and white stripes which were oriented in one of four orientations (vertical, 45 deg to the left of vertical, 45 deg to the right of vertical, or horizontal) in combination with one of three widths (1.91, 3.18, or 5.08 cm). The stripes were produced by placing strips of black cloth tape over inserts which had been painted flat-white.

Procedure. Upon arrival, each animal was housed individually and given ad lib access to food and water for 3 days. Then each animal was weighed and put on a once-daily ration to maintain constant body weight as in Experiment I. On the next 5 days, each rat received two prehandling sessions, each lasting 2 min, as described in Experiment I. Following prehandling, each rat was trained on a stripe orientation discrimination. There were 2 trials on the first training day, 3 on the second, 5 on the third, and 10 on each day thereafter. All other training procedures (amount of reward, intertrial intervals, training criterion, goal confinement) were the same as in Experiment I. After reaching criterion on the orientation discrimination, each rat received training either on an ED shift (width relevant) or on an ID shift (orientation relevant), with the irrelevant cues (orientation in the ED shift and width in the ID shift) being CI, VBI, or VWI. Training procedures were the same during transfer as during acquisition. After reaching the transfer criterion, each rat received 6 days of testing. On each test day there were 10 trials, 5 test trials, and 5 trials of retraining on the transfer cues, with the first trial of any day always a retraining trial. On test trials, the values on the irrelevant dimension were changed as indicated in Table 2. On test trials, the animal was rewarded regardless of which goalbox was entered but, on retraining trials, the rat was rewarded only for choosing the S+ from the transfer cues.

RESULTS AND DISCUSSION

Table 3 shows mean errors made during: (a) acquisition of the original discrimination, (b) transfer to the shift discrimination, (c) 30 retraining trials on the transfer problem, and (d) 30 tests on the transfer cues with the changed irrelevant values. In acquisition, there

Table 3
Mean Errors During Each Experimental Phase of Experiment II

Shift Condition	Irrelevant Cue Condition	Acquisition	Transfer	Retraining	Test
Intra-dimensional	CI	46.50	12.50	6.43	6.15
	VBI	56.12	11.37	6.25	6.50
	VWI	58.00	11.63	6.50	5.75
Extra-dimensional	CI	47.00	11.50	8.50	9.38
	VBI	45.50	14.12	8.25	8.62
	VWI	50.62	20.00	8.00	8.62

were no differences among the six treatment groups as indicated by analysis of variance of errors to acquisition criterion ($F_s = 1.50, < 1.00, < 1.00$, $dfs = 1/42, 2/42, 1/42$, for the effects of shift condition, irrelevant-cue condition, and interaction, respectively).

Analysis of variance of errors to transfer criterion indicated a significant effect of shift condition ($F = 4.98$, $df = 1/42$, $p < .05$) and a significant interaction of shift condition with irrelevant-cue condition ($F = 3.44$, $df = 2/42$, $p < .05$), but the effect of cue condition was not significant ($F = 2.38$, $df = 2/42$). Subsequent analyses of simple effects and Newman-Keuls comparisons (Winer, 1962) of the groups indicated (with MS error = 27.44) that there was no effect of irrelevant-cue conditions on the ID shift. On the ED shift groups, CI and VBI did not differ but both learned faster than Group VWI. Further, the ID shift was learned significantly faster than the ED shift when the irrelevant cues were VWI but not when the irrelevant cues were CI or VBI. In effect, the results from the ED shift are in the same relationship as in Experiment I. However, Group CI learned the ED shift significantly faster than Group VBI in Experiment I but not in Experiment II. The insignificant difference in Experiment II perhaps should be attributed to less power, associated with fewer Ss. As in Experiment I, Group VBI learned faster than Group VWI. The inferior performance of Group VWI in Experiment II cannot be attributed to cue conflict, because new stimulus values were used on both the relevant and irrelevant dimension. The comparisons between ID and ED shifts agree with previous reports of ID superiority when transfer training includes VWI cues (cf. Shepp & Eimas, 1964; Dickerson, et al, 1970) and, further, indicate no difference when transfer training includes CI cues only. It must be pointed out that straight ID-ED comparisons are confounded in that ID groups learned an orientation discrimination and ED groups learned a width discrimination. That is, the relevant dimension during transfer was not counter-balanced. Thus, a comparison requires the assumption that the two dimensions are equally salient. The assumption is supported, to some extent, in that there was no ED-ID difference in the CI condition. The two discrimination problems also differed in that, in the ID shift, the novel dimension (width) was irrelevant, while in the ED shift, it was relevant. If the novelty of the new dimension attracted attention, the ED performance should have been facilitated. All the specific transfer cues (V, H, etc.) were novel to all groups.

Analysis of variance of errors made on retraining trials indicated that animals trained on the ED shift performed worse than those trained on the ID shift ($F = 5.05$, $df = 1/42$, $p < .05$). Mean errors for ID and ED shifts were 6.38 and 8.25, respectively. Neither the effect of cue conditions nor the interaction of shift with cue conditions was significant (both $F_s < 1.0$). Analysis of variance of errors on test trials (with the changed cues

on the irrelevant dimension) indicated, as with errors on retraining trials, that animals trained on the ED shift made more errors than did animals trained on the ID shift ($F = 9.93$, $df = 1/42$, $p < .01$). Mean test errors for animals trained on ID and ED shifts were 6.13 and 8.88, respectively. Neither the effect of cue conditions nor the interaction was significant (both $F_s < 1.0$), nor was there a significant change in performance over three blocks of 10 best trials ($F = 1.16$). The relatively poor performance by the ED groups during retraining and test trials is somewhat surprising, as is the difference between the ED and ID groups. There is no obviously plausible explanation. Although all groups were trained to the same transfer criterion (15/16 correct), it is obvious (from the retraining trials) that the ED groups were less likely to maintain the high performance level. Perhaps it is the case that ED animals were more likely to learn about compounds and, therefore, were more susceptible to disruption of performance by the changed cues presented on the test trials. However, the evidence presented below does not provide strong support for this hypothesis. Further, even if the ED condition did, in general, promote compound learning, it was not affected by the irrelevant cue condition.

To determine if the change in the irrelevant cues on test trials did cause a disruption in performance on test trials, a difference score was computed based on the number of errors during retraining minus the number of errors during tests. Presumably, if the rats learned the transfer problem solely on the basis of stimulus compounds, then a change in the value of the irrelevant dimension should have disrupted performance and there should have been an increase in errors during tests as compared to retraining trials. Any differences in compound-cue learning, as a function of experimental conditions, also would be revealed by the difference scores. Analysis of variance of the difference scores indicated no significant effects attributable to any treatment condition ($F_s = 1.10, < 1.0$, and < 1.0). Further, it cannot be concluded that any of the mean differences were significantly different from zero (SE mean = 1.01, $df = 42$). Since the analysis provided no evidence of compound-cue learning in any of the six treatment groups, the superior performance of Group CI in Experiment I should not be attributed solely to the compound-cues hypothesis.

GENERAL DISCUSSION

The major results of the two studies taken together are: (a) Following criterion training with CI cues, an ED shift was learned faster with CI cues than with VBI cues and faster with VBI cues than with VWI cues; (b) following training with CI cues, performance on an ID shift was not affected by the arrangement of the irrelevant shift cues; (c) with CI cues in transfer, there was no ID-ED shift difference, but with VWI cues in transfer,

there was a clear superiority on an ID, as compared to an ED, shift; and (d) there was no evidence of learning solely on the basis of compound cues.

There are several possible interpretations of the data presented here: a nonmediational single-link hypothesis, a compound-cues hypothesis, and several versions of a mediational (i.e., observing response or attention) hypothesis. A nonmediational, single-link hypothesis (Spence, 1936; Wolford & Bower, 1969) generally predicts no differences between ED and ID shifts (regardless of cue conditions), predicts that performance should be better with CI than with VBI or VWI cues, and predicts that performance with VBI and VWI cues should not differ. Clearly, the results offer little support for a nonmediational account.

A simple compound-cue hypothesis (cf. Zeaman & House, 1963; Shepp & Gray, 1971) predicts no ED-ID shift differences and no difference between VBI and VWI conditions. The transfer results clearly do not support a compound-cue interpretation. As further evidence against the compound-cue hypothesis, there was no evidence of learning about compounds on test trials following acquisition of the transfer discrimination. If the animals attended only to compounds, then performance should have been disrupted by changes in the irrelevant element of the compound. The fact that disruption did not occur is strong evidence against a compound-cues hypothesis and evidence for a hypothesis based on mediation to a single dimension. Further, these results do not support previous suggestions (cf. Shepp & Gray, 1971) that attention to compounds accounts for the lack of difference between ID and ED shifts when irrelevant cues are VBI.

The mediational hypotheses (Zeaman & House, 1963; Sutherland & Mackintosh, 1971; Lovejoy, 1968) are variations on the basic assumption that, during acquisition of the orientation discrimination with constant width cues, attention to the relevant orientation dimension was strengthened while attention to the CI width cues was unchanged. Further, there was positive transfer of the mediating response to the ID shift and negative transfer to the ED shift. If the difference between ID and ED shifts is based on negative transfer of the previously relevant mediator to the ED shift, and if attention occurs only when cues are variable (either between or within trials), then there should be no ID-ED difference with CI cues. However, if attention occurs only to cues that are variable within trials (the VWI groups), then there should be ID superiority only in the VWI condition and no ID-ED difference in the VBI condition. Further, within the ED shift treatment, learning should be faster with CI and VBI than with VWI cues, and there should be no difference between CI and VBI conditions. From the study reported here, the best conclusion is that learning is faster with CI than with VBI cues and is faster with VBI than with VWI cues. Inferior performance with VBI cues suggests that nega-

tive transfer of the mediator occurs even though cues are variable only between trials but are constant within trials. If the mediating response occurs even with VBI cues, then performance on ED shifts should be better under CI than under VBI, and there should be a difference between ID and ED shifts even under VBI conditions. Presumably, mediation would be less likely to occur in the VBI condition than in the VWI condition, since the organism would have to rely on memory to detect the variability across trials. The hypothesis of negative transfer in the VBI condition encounters difficulty in that there was no ID-ED difference in the VBI condition even though the data indicated that learning was faster under CI than under VBI. However, including the present data, there are at least four independent demonstrations that under VBI conditions, ID shifts are learned insignificantly faster than ED shifts (cf. Turrisi et al, 1969; Dickerson et al, 1970; Shepp & Gray, 1971). That is, four independent experiments have found no significant difference between ID and ED shifts with VBI cues in transfer, but all four experiments showed slightly superior performance in the ID condition. The probability of four such occurrences assuming no ID-ED difference is 0.0625. Considering the consistency of the published research, it seems safe to conclude that there is a small and consistent, but theoretically important, superiority on ID shifts under VBI conditions. The alleged superiority on ID shifts in the VBI condition and the observed superiority with CI, as compared to VBI cues on the ED shift, do not offer support to previous suggestions (cf. Eimas, 1965; Dickerson, et al, 1970) that negative transfer of the mediating response occurs only if originally relevant cues become irrelevant and vary *within* trials. While the explanation offered here seems to complicate the mediation account of discrimination learning, when all the data are taken together, the interpretation actually is simple. The superiority of CI to VBI on the ED shift is due to negative transfer of the mediating response, even though the irrelevant cues are constant within (but variable between) trials. If there is negative transfer, however slight, in the ED-shift condition, then there should be a slight superiority on ID, as opposed to ED, shifts.

The mediating-response hypothesis also includes the suggestion that there is positive transfer of the mediating response (to orientation) in the ID shift, as well as negative transfer in the ED shift. If there was any positive transfer of the mediating response from acquisition, then transfer performance should be better on ID than on ED shifts, even with CI cues (i.e., with CI cues there would be positive transfer to the ID shift and no transfer to the ED shift). The absence of difference between ID and ED shifts in the CI condition points to the possibility that positive transfer of the mediating response is not important and that ID-ED differences are attributable only to negative transfer. A precise test of

this possibility would have to include control groups not included here.

In summary, the hypothesis offered to account for these data assumes that the organism learns a mediating response to the relevant dimension during acquisition and that attention to a constant irrelevant dimension is unaffected by acquisition training. In transfer, there is negative transfer if the irrelevant cues vary either within or between trials. The negative transfer is greater if the previously relevant cue is variable within trials than if it is only variable between trials.

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(Received for publication February 25, 1974;
accepted June 29, 1974.)