The effects of dimensional naming upon children's performance in a modified optional shift problem*

EVA L. KOBAYASHI and JOAN H. CANTOR

Institute of Child Behavior and Development, University of Iowa, Iowa City, Iowa 52242

In a modified optional shift paradigm, shift and test tasks were administered concurrently to 120 second-grade children. Ss required, during shift learning, to verbalize the values of the previously relevant dimension showed an increase in reversal responding in the test task, whereas those required to verbalize the values of the previously irrelevant dimension showed an increase in nonreversal responding. The results are in good agreement with predictions made from an extension of Hull-Spence discrimination learning theory.

The optional shift paradigm has provided a very useful technique for studying the development of dimension-specific responses in children. In problems of this type, two simultaneous discrimination tasks are administered in succession. In the original task, one dimension (e.g., form) is relevant and a second dimension (e.g., brightness) is irrelevant and variable within settings. In the second (shift) task, both dimensions are made relevant and the reinforcement contingencies are reversed on the formerly relevant dimension (form in the example). Thus, the shift task can be solved on the basis of either or both of the dimensions. Finally, a test task is presented to determine which dimension served as a primary basis for S's learning in the shift task. Those Ss who choose during the test phase on the basis of the originally relevant dimension (form) are classified as reversal-shift Ss, and those who choose on the basis of the originally irrelevant dimension (brightness) are classified as nonreversal-shift Ss.

Using this paradigm, a number of investigators (e.g., Kendler, Kendler, & Learnard, 1962; Kendler & Kendler, 1970; Tighe & Tighe, 1970; Kendler & Ward, 1972) have demonstrated that the tendency to make optional reversal shifts increases with age over a wide range from 3 years to adulthood. Furthermore, it has been demonstrated that various types of dimension-specific training, including perceptual pretraining, perceptual and verbal pretraining combined, and overt verbal labeling of values on the originally relevant dimension, all increase the frequency of optional reversal shifts (Kendler, 1964; Tighe & Tighe, 1970). Most investigators have concluded

that the age effect is in some way attributable to an increasing specificity of responding to the dimension that is relevant in original learning.

The purpose of the present experiment was to see if optional nonreversal shifts, as well as optional reversal shifts, could be brought under experimental control through the use of overt verbal labeling. Therefore, half of the Ss (second-graders) were required, during shift learning, to label the values of the previously relevant dimension (form in the example) prior to making a choice response, and the other half were required to label the values of the previously irrelevant dimension (brightness). It was expected that the former type of verbalization would increase the tendency to make reversal shifts, whereas the latter type of verbalization would increase the tendency to make nonreversal shifts.

The tasks used included the following modifications of the conventional optional shift paradigm. First, the shift and test tasks were administered concurrently to allow the study of any changes in optional shift behavior over the course of learning in the shift task. Second, an additional irrelevant dimension was used to produce more gradual learning in the shift task. Finally, in order to produce rapid learning in the original task, both irrelevant dimensions were made variable between settings in this task.

The tasks used for one counterbalancing subgroup (Group FBS) are shown in Fig. 1. The nonspatial dimensions that varied were form, brightness, and size. In the figure, Task 1 is an eight-setting problem with form relevant (circle positive) and with brightness and size both irrelevant and variable between settings. Task 2 consists of a four-setting shift task and a four-setting test task. In the shift task, the reinforcement contingencies are reversed on the form dimension (triangle now positive), brightness is also made relevant (white positive), and size remains irrelevant though now variable within settings. In the test settings, the positive values of the relevant dimensions in the shift task (triangle and white) are unconfounded and no reinforcement is given. Shift and test settings are

*This paper is based upon a thesis submitted by the first author (Eva Lundback) in partial fulfillment of the requirements for the MA degree at the University of Iowa. The writers are indebted to Charles C. Spiker for many valuable suggestions in the preparation of the manuscript. Sincere appreciation is expressed to James D. Blank, Director of Elementary Education, and many other of the personnel of the Iowa City Community School District for their fine cooperation in making Ss available. Thanks are also due to the Graduate College of the University of Iowa for funds to purchase computer time. Requests for reprints should be sent to the second author at the following address: Department of Psychology, University of Iowa, Iowa City, Iowa 52242.

Fig. 1. Illustration of the discrimination learning tasks for Group FBS.

presented on alternate trials throughout Task 2. A second counterbalancing group (Group BSF) had brightness relevant throughout, size changed from irrelevant in original learning to relevant in shift learning, and form irrelevant throughout. A third group (Group SFB) had size relevant throughout, form changed from irrelevant to relevant, and brightness irrelevant throughout. Each of the six dimensional values served as the positive cue for an equal number of Ss.

Each of the above groups was divided into two naming conditions. In the relevant-label condition, Ss were instructed, prior to the first trial of Task 2, to name the stimulus chosen on each trial by its value on the dimension relevant in both tasks. In the irrelevant-label condition, Ss were instructed to name the value on the dimension previously irrelevant, now relevant. No overt verbalization was required during original learning.

Spiker and Cantor (1973) have analyzed the present paradigm in terms of a modified version of Hull-Spence discrimination learning theory (Spiker, 1970, 1971). According to this analysis, Ss make dimension-specific responses which add distinctive response-produced stimuli to the stimulus complexes produced by the external discriminanda, thereby adding new response-produced dimensions to the learning task. Specifically, in the relevant-label groups, a reversal dimension is added that is expected to produce an increase in reversal choices in the test task during shift learning, whereas in the irrelevant-label groups, a

nonreversal dimension is added that is expected to produce an increase in nonreversal choices. Whether the labels are irrelevant or relevant is not expected to affect performance in either the first task or the shift task.

METHOD

Subjects

The Ss were 120 second-grade children in the Iowa City Public School System who were assigned randomly in equal numbers to the 12 groups resulting from the factorial combination of verbal condition, dimensional counterbalancing, and positive cue. The data for 27 additional Ss were replaced because they failed to meet criterion in Task 1.

Stimuli

The stimuli were eight Plexiglas blocks differing in form (circle and triangle), brightness (black and white), and size (large and small). The large and small circles were 10.2 and 7.9 cm in diam, respectively; the equilateral triangles were 10.6 and 8.0 cm on a side, respectively. Each block was halved and joined on the back with a hinge. A marble well located inside the block was used to bait the correct block on each learning trial.

Apparatus

A modified Wisconsin General Testing Apparatus was used to present the stimuli. The entire apparatus was painted blue. On each trial, two blocks were exposed to S on a sliding wooden drawer. A clear sheet of Plexiglas was used to cover both blocks on test trials. The marbles won by S were saved in a container placed next to the apparatus.

Procedure

Each S was seen individually in a mobile research trailer. Task 1 was presented to the child as a marble game, and the procedures for finding and saving marbles were explained by E on a step-by-step basis in the first two trials. Thereafter, the child was told that he should try to learn how to find a marble on every turn. All Ss were given two blocks of eight trials in Task 1, using a noncorrection procedure. Every stimulus setting was presented once in each trial block. If S made an incorrect response on Trial 7 or 8, he was told to try to find out how to get the marble on every turn. Those Ss who did not meet a criterion of seven correct responses in the last eight trials were replaced.

Task 2 was introduced with no interruption in procedure except for the verbalization instructions. In this task, the shift and test settings were presented on alternate trials, beginning with a shift trial. Before the first trial, S was instructed to tell which block he thought had the marble inside before he opened the block, using the appropriate dimensional labels. For test trials, the blocks were covered with the clear Plexiglas with no reinforcement being given, and S was asked to give his choice using the appropriate label. A total of 40 trials was given, with each eight-trial block consisting of one presentation of the four shift settings and the four test settings. The order of presentation was the same for all Ss and was predetermined to prevent the development of inappropriate response strategies.

RESULTS

Performance in Task 1

The procedures in Task 1 differed among groups only in terms of the dimension that was relevant—form, brightness, or size. Mean proportions of correct responses in the two eight-trial blocks were entered into an analysis of variance with trial blocks as a within-Ss

Table 1
Means and Standard Deviations of Proportions of Correct Responses in the Shift Task and Reversal Choices in the Test Task

Group	Shift Task				Test Task			
	R Label		I Label		R Label		I Label	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FBS	.863	.241	.878	.225	.785	.339	.305	.416
BSF	.903	.173	.928	.163	.875	.277	.123	.290
SFB	.905	.183	.898	.212	.843	.314	.163	.311
Combined	.890	.202	.901	.203	.834	.313	.197	.352

factor and verbal condition (relevant-label vs irrelevant-label), relevant dimension (form vs brightness vs size), and positive cue as between-Ss factors. The verbal-label factor was included to check for any differences that may have existed prior to verbal-labeling instructions. The only significant effect in this analysis was trial blocks ($\bar{X}_{TB1} = .756$, $\bar{X}_{TB2} = .994$). Thus, there were no significant performance differences for problems differing in relevant dimension, nor did the verbal groups differ in Task 1.

Performance in Task 2

Table 1 presents the means and standard deviations of proportions of correct responses in shift learning, and reversal choices in the test task, combined over trial blocks for the six major groups. It is evident that the groups differed very little in shift performance. In the test task, however, the relevant-label groups showed a strong tendency to make reversal choices, whereas the irrelevant-label groups showed a strong tendency to make nonreversal choices (low probabilities of reversal choices). The proportions for four-trial blocks were entered into an analysis of variance with trial blocks (1-5) and task (shift vs test) as within-Ss factors and verbal condition (relevant-label vs irrelevant-label), dimensional counterbalancing, and positive cue as between-Ss factors. Significant main effects were obtained for verbal condition, task, and trial blocks, as expected. Major interest, however, is in the significant Verbal Condition by Task interaction [$F(1,108) = 129.99$, $p < .0001$]. The means contributing to this interaction are presented in the final row of Table 1, where the strong effect of type of label on test performance is evident.

In a follow-up analysis of test performance only, the verbal groups differ significantly [$F(1,108) = 127.80$, $p < .0001$] and the Trials by Verbal Condition interaction is also significant [$F(4,432) = 8.04$, $p < .001$]. This interaction with trials is produced by an increasing tendency to make reversal choices in the relevant-label groups and an increasing tendency to make nonreversal choices in the irrelevant-label groups. No other effects are significant in this analysis.

A second follow-up analysis involving the shift task only indicates that the verbal groups do not differ in shift performance [$F(1,108) = .59$], nor are there any interactions involving verbal condition.

DISCUSSION

The primary purpose of this experiment was to investigate the effects of dimensional naming on Task 2 performance. In Task 1, no differential performance was expected for the six major groups, and none was found. In Task 2, dimensional naming was required on the reversal dimension for the relevant-label groups and on the nonreversal dimension for the irrelevant-label groups. These verbal conditions were not expected to produce differential shift performance, and no significant effects involving verbal condition were obtained. Choice responses in the test task, on the other hand, were expected to be affected by the type of dimensional naming. For the relevant-label groups, the tendency to make a reversal choice was predicted to increase over shift learning, whereas for the irrelevant-label groups, the tendency to make a nonreversal choice was expected to increase. These expectations were confirmed by the significant difference between the verbal groups in test performance and by the significant Trial Blocks by Verbal Condition interaction.

Comparison of the present results with the existing optional shift literature can be made by computing the percentage of Ss in each verbal condition who consistently performed reversal or nonreversal shifts, using the conventional criterion of eight consistent choices in the final 10 test trials. These percentages are presented in Table 2, where it can be seen that 82% of the relevant-label Ss made reversal shifts and 78% of the irrelevant-label Ss made nonreversal shifts. Comparable percentages obtained by Kendler (1964) and by Kendler and Kendler (1970) are also presented in Table 2. Kendler used kindergarten children in the first of these studies and included a condition similar to the present relevant-label condition. The second study is included for comparison at various age levels when no overt dimensional naming is used. The percentages for these studies were calculated by averaging the published values over stimulus counterbalancing groups and also over experiments in the earlier report.

Since the stimuli and procedures differed in many ways, comparisons in Table 2 must be made with caution. Nevertheless, it is interesting to note that overt naming on the reversal dimension produced 81% reversal shifts at 5 years of age and 82% reversal shifts at 7 years. Thus, this type of verbalization increased the proportion

Table 2
Percentage of Reversal and Nonreversal Shifts in the
Present and Related Experiments

	Age	Overt Naming	RS	NRS
Kobayashi & Cantor	7	R Label	82	8
	7	I Label	15	78
Kendler (1964)	5	R Label	81	12
	5	None	48	38
Kendler & Kendler (1970)	5	None	53	30
	7	None	60	28
	11	None	74	19
	Adult	None	85	12

of reversal shifts to a level comparable to that of uninstructed college students (85%). The effects of overt naming on the nonreversal dimension appear to be even stronger, with 78% nonreversal shifts in the present study and only 28% nonreversal shifts for uninstructed 7-year-olds in the Kendler and Kendler study.

According to the values in Table 2 for 7-year-olds, the difference between overt naming and uninstructed conditions was 22% for reversal shifts and 50% for nonreversal shifts. The larger difference for nonreversal shifts is, of course, due to the fact that, although verbal labeling produced high levels of both types of shifts in this experiment, *uninstructed* 7-year-olds have a stronger tendency to make reversal shifts (60%) than nonreversal shifts (28%). In the more general context of other optional shift studies, the tendency to make optional reversal shifts as opposed to nonreversal shifts has been shown to be a function not only of age, but also of several experimental variables in addition to verbal labeling, including dimensional salience (Smiley & Weir, 1966; Tighe & Tighe, 1966b, 1970), perceptual pretraining (Tighe & Tighe, 1970), and novelty of the nonreversal dimension during shift learning (Eimas, 1967). In this context, the present study not only replicates the earlier findings regarding labeling on the reversal dimension, but also goes a step further in showing that labeling of values on the nonreversal dimension produces a high percentage of nonreversal shifts. The latter results are consistent with the suggestion (Eimas, 1967) that age differences may be due, at least in part, to the nature of the dimensional responding, rather than just to the presence or absence of responding on the reversal dimension. Perhaps, for example, the younger child makes more nonreversal shifts because he has a stronger tendency to shift dimensional responses from the reversal to the nonreversal dimension in the face of nonreinforcement at the beginning of the shift task. Relatively little attention has been given to such a possibility, probably because most theories, including the modified Hull-Spence theory, can predict the occurrence of nonreversal shifts in the absence of any dimensional responding.

The present results are consistent with the theoretical

predictions that have been derived for this paradigm (Spiker & Cantor, 1973). As noted earlier, dimension-specific responses are assumed to produce stimuli that constitute an additional reversal dimension for the relevant-label groups and an additional nonreversal dimension for the irrelevant-label groups. Several other theoretical accounts of the function of dimension-specific responses have been suggested. Kendler and Kendler (1962, 1970) have suggested that reversal shifts are produced by a symbolic mediating process specific to the reversal dimension. Other explanations are based on the supposed learning of observing or perceptual identifying responses (Zeaman & House, 1963; Tighe & Tighe, 1966a). Differential rates for the extinction of mediating and instrumental responses have also been postulated to account for RS-NRS differences (Dickerson, Wagner, & Campione, 1970). These alternative explanations are not necessarily incompatible with each other or with the present theory. Indeed, the functional properties thus far hypothesized for the different covert processes are so similar that it would be difficult at present, if not impossible, to design crucial experiments that would permit definitive choice among them.

Until important differences in function are specified for the different explanatory mechanisms, it would appear to be more fruitful to concentrate on assessing the relative contributions of experimental variables known to affect shift performance. The theory within which the present study was formulated (Spiker & Cantor, 1973), together with procedures for parameter estimation (Spiker, 1970), offers a quantitative method of studying the separate and combined effects of such variables as verbal labeling, perceptual pretraining, stimulus similarity, novelty of irrelevant dimensions, and dimensional salience. Spiker and Cantor have also shown that an attention hypothesis can be incorporated into the theory in the same manner as response-produced cues, with identical mathematical consequences. Thus, estimates can be obtained for parameters that are expected to vary with attentional variables as well as for those that vary with verbal labeling and stimulus similarity. For example, in a properly designed experiment in which both perceptual pretraining and overt verbal labeling are varied, the relative effects of these two variables would be reflected in the numerical values estimated for different parameters. Such a strategy appears to hold considerable promise for gaining an eventual understanding of all the processes contributing to shift performance.

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(Received for publication August 22, 1973;
revision received October 30, 1973.)