JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1969, 12, 211-214 NUMBER 2 (MARCH)

TILTED LINES AS COMPLEX STIMULI[1]

PAUL E. TOUCHETTE

MASSACHUSETTS GENERAL HOSPITAL

Severely retarded boys were taught to respond differentially to lines tilted at 45° and 135°. While all subjects could perform the discrimination, the aspect of the stimulus that controlled responding was shown to differ among subjects.

Human subjects and a wide variety of animal species have been presented with tilted lines as training and test stimuli (Bloomfield, 1966, 1967, 1967*a*, 1967*b*; Butter, 1963; Hanson, 1959; Honig, 1966; Mello, 1965, 1966; Newman and Baron, 1965; Ray, 1967; Rudel and Teuber, 1963; Stoddard, 1968; Sutherland, 1957, 1957*a*, 1960, 1963; Zeigler and Schmerler, 1965).

The fact that tilt or orientation of lines has been used or referred to as a dimension in so many discrimination and generalization studies lends weight to the question of whether these data are comparable, or whether the subjects in the several experiments may have been using various aspects of the stimuli presented. It is now accepted that when several bases for a discrimination exist during training, the stimulus aspect which gains control cannot be predicted from the stimuli themselves (Lashley, 1938; Nissen and Jenkins, 1943; Reynolds, 1961; Ray, 1967). Stoddard (1968) suggested that tilted lines present more than one basis for discrimination.

Skinner reported in 1944 that pigeons may "attend" to only a small portion of a line. He found that pigeons with a history of responding to square stimuli ". . . tended to respond to the end of a rectangular bar, which might be regarded as at least three-quarters of a square". (Skinner, 1965, p. 200).

In the present experiment, subjects were taught to discriminate tilted lines by using a small portion of the lines as the initial training stimuli, then adding the remainder. This technique was applied to establish a uniform locus of control across subjects, rather than allowing control to develop from the accidental interaction of the subject's history and the training procedure.

METHOD

Subjects

Seven boys, residents of the same ward at the Walter E. Fernald State School, served as subjects. Ages ranged from 12 to 17 yr, duration of institutionalization from 11 to 14 yr, and most recent I.Q. scores from 28 to 38. All subjects had been diagnosed as severely retarded.

Apparatus

Subjects sat in a room approximately 9 by 8.5 by 7 ft, lit by indirect light. The wall in front of the subject contained a response and display matrix consisting of three 3.75-in. square Polacoat Plexiglas panels, mounted in an aluminum plate. The two outside panels (keys) were hinged at the top and were in contact with heavy-duty microswitches at their lower edges. The center panel was used only for display of stimuli and was fixed in place. Stimulus projection apparatus was a model 550 Kodak Carousel 35-mm slide projector, mounted behind the response panel. A motor-operated shutter interrupted light from the projector during the interval between trials. Each slide contained the display for a given

[1]The author wishes to thank Drs. Murray Sidman and Barbara Ray for their assistance, and to acknowledge the cooperation of the following personnel of the Walter E. Fernald State School: Malcolm J. Farrell, Superintendent; Hugo Moser, Director of Research. This research was supported by the Children's Bureau; Department of Health, Education and Welfare; and by P. H. S. Research Grant NB 03535 from the National Institute of Neurological Disease and Blindness. Reprints may be obtained from the author, Neurology Research, Massachusetts General Hospital, Burnham 802, Boston, Mass. 02114.

trial. Photocells below the panels were keyed by holes punched in the lower portion of the slides, and decoded the correct key position for each trial. A similar apparatus has been described by Sidman and Stoddard (1966).

Responses were recorded on a 20-channel Esterline-Angus operations recorder which provided a running account of the onset of trials, location of the correct key, and latency of all responses during and between trials. This recording apparatus was surrounded by sound-insulating material housed in a plywood container.

After each correct response, a dispenser, mounted to the right of the stimulus display, operated and chimes sounded. The candy or token (poker chip) dropped into a 3- by 5- by 1-in. tray at the base of the dispenser. During a session the room was dimly lit, but subjects had no difficulty locating the candy or token. Those children who received tokens could trade them for toys or privileges when they returned to their ward.

Procedure

A trial began when the display panel and the two keys were illuminated, and ended when the subject closed the switch behind the correct key. Reinforcement (candy, tokens, chimes, projector cycle . . .) followed responses on the correct key. If both keys were pressed simultaneously (within 0.5 sec of each other), the trial was terminated and reinitiated after 5 sec. An intertrial interval of 5 sec, during which the panels were dark, followed each correct response. Incorrect responses were only recorded. This correction procedure was used throughout the experiment.

The sequence of experimental stimuli is shown in Fig. 1. Initially, all subjects were taught to press the outside key closest to a 0.75-in. square, displayed on the center panel. The procedure used to establish this discrimination has been described earlier (Touchette, 1968). Training, criterion, and probe stimuli consisted of 0.75- by 4-in. lines tilted at 45° and 135°, and portions of these lines.

Having established differential responding to stimuli displayed on the center panel, the five experimental subjects (E1, E2, E3, E4, E5) were given 40 training trials with 0.75-in. squares in the lower left or right corner of the display panel. This procedure was designed to establish control by a stimulus which constituted a part of the tilted lines. As a control for position effects, two boys (C1 and C2) were given the 40 training trials with stimuli in the upper corners of the display panel.

During the next 40 trials, subjects were presented with the criterion stimuli, lines tilted at 45° and 135°. The one boy who did not respond differentially to the tilted lines (E5) was given a 25-trial programmed slide sequence during which the 45° and 135° lines were faded in over the training stimuli.

Subjects were given a series of 40 probe trials after having successfully completed 40 trials with the titled lines. Probe trials consisted of the upper and lower halves of the 45° and 135° lines, as shown in Fig. 1, presented in a mixed sequence. Reinforcers were delivered during the probe trials as if the entire 45° or 135° line were displayed.

RESULTS

All subjects responded to the dots, and portions of the line which constituted the training stimuli, at 90% or better accuracy (Fig. 1). Six of the seven maintained accurate responding when the completed 45° and 135° titled lines were presented. The one boy (E5) who did not make the transition directly, maintained appropriate responding when the complete lines were gradually faded in over the training stimuli.

Data from the probe trials alone are presented in the lower section of Fig. 1. Subjects E1 and C2 responded appropriately to both the upper and lower portions of the tilted lines. All other subjects responded appropriately to stimuli in the portion of the key where training stimuli had been. Of these, E4's responses to the other portion of the lines were 90% inaccurate. Four subjects (E2, E3, E5, C1) responded at a chance level to the other portion of the line.

DISCUSSION

The present results indicate that tilted lines did function as complex stimuli.

All subjects were taught to respond differentially, with a high degree of accuracy, to lines tilted at 45° and 135°. When these subjects were tested, all responded appropriately to the portion of the line which contained the training stimulus. The testing procedure, how-

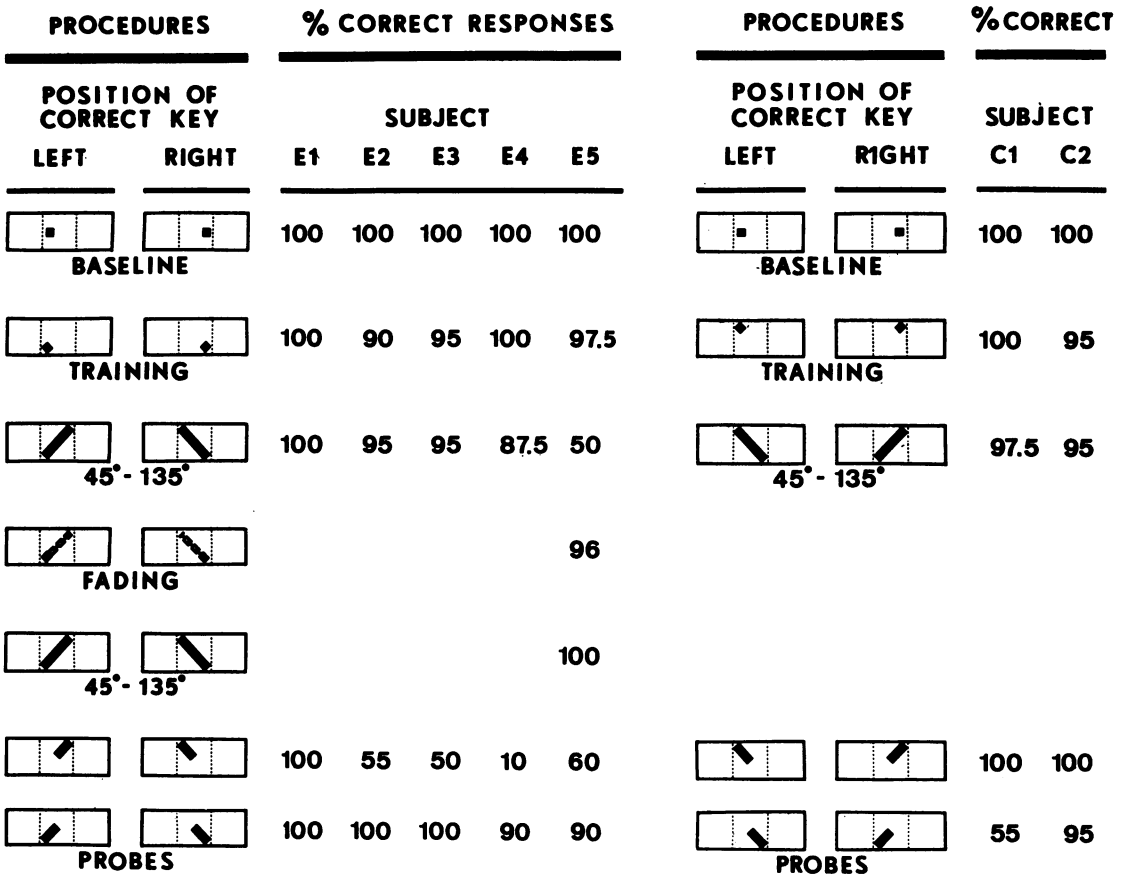

Fig. 1. The stimuli for each of the procedures are shown in sequence from top to bottom. Only one boy (E5) was presented with tilted lines fading in over the training stimuli. The percent of correct responses for each subject is given to the right of the corresponding stimuli.

ever, revealed three distinct patterns of responding to the portion of the line which did not include the training stimuli. Subjects E2, E3, E5, and C1 responded at chance level; Subjects E1 and C2 responded appropriately; and Subject E4 was wrong 90% of the time. If we suppose that the boys were responding to the trained and non-trained portions of the lines on the same basis, then it would appear that three different systems for discriminating the trained portions of the lines were in use. Alternatively, if we suppose that Subjects E2, E3, E4, E5, and C1 were displaying a conditional discrimination, they might have been responding on two different bases, one for the trained portion of the line, and another for the non-trained portion. In either case, it is clear that the forms of stimulus control revealed by the probe trials was neither simple nor uniform.

Customary discrimination training procedures display the entire positive stimulus (*e.g.*, tilted line) and apply differential reinforcement contingencies. When the subject successfully acquires the discrimination, responding may be under the control of any aspect of the stimuli displayed (Lashley, 1938; Reynolds, 1961). In this study, differing forms of stimulus control developed across subjects despite a procedure which initiated uniform control by one easily discriminable aspect of the lines and maintained correct responding throughout training. Whether one is designing the next step in a teaching program, or attempting to interpret the particular shape of a generalization gradient, any assumption that stimulus-response relations are identical across subjects performing the same "tilt" discrimination requires validation.

An effort was made to look into the effect of continued exposure to the tilted lines. Although it was not possible to collect sufficient

data to draw any formal conclusions, it was observed that all five subjects who responded appropriately to only some of the probe stimuli (E2, E3, E4, E5, C1) responded appropriately to all probes after an additional 200 trials with the criterion 45° and 135° lines. This suggests that additional aspects of the criterion stimuli come to control the subject's behavior with extended exposure. The tendency for additional elements of the positive stimulus to acquire stimulus control has been noted in other studies (*cf* Terrace, 1963).

REFERENCES

Bloomfield, T. M. Two types of behavioral contrast in discrimination learning. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 155-161.

Bloomfield, T. M. Behavioral contrast and relative reinforcement frequency in two multiple schedules. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 151-158.

Bloomfield, T. M. Some temporal properties of behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 159-164. (*a*)

Bloomfield, T. M. A peak shift on a line-tilt continuum. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 361-366. (*b*)

Butter, C. M. Stimulus generalization along one and two dimensions in pigeons. *Journal of Experimental Psychology*, 1963, **65**, 339-346.

Hanson, H. M. Effects of discrimination training on stimulus generalization. *Journal of Experimental Psychology*, 1959, **58**, 321-334.

Honig, W. K. The role of discrimination training in the generalization of punishment. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 377-384.

Lashley, K. S. The mechanism of vision: XV. Preliminary studies of the rat's capacity for detail vision. *Journal of Genetic Psychology*, 1938, **18**, 123-193.

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. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 11-16.

Newman, F. L. and Baron, M. R. Stimulus generalization along the dimension of angularity: a comparison of training procedures. *Journal of Comparative and Physiological Psychology*, 1965, **60**, 59-63.

Nissen, H. and Jenkins, W. Color and form discrimination in the chimpanzee. *Journal of Comparative Psychology*, 1943, **35**, 85-95.

Ray, B. A. The course of acquisition of a line-tilt discrimination by rhesus monkeys. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 17-33.

Reynolds, G. S. Attention in the pigeon. *Journal of the Experimental Analysis of Behavior*, 1961, **4**, 203-208.

Rudel, R. G. and Teuber, H. L. Discrimination of direction of line in children. *Journal of Comparative and Physiological Psychology*, 1963, **56**, 892-898.

Sidman, M. and Stoddard, L. T. The effectiveness of fading in programming a simultaneous form discrimination for retarded children. *Journal of the Experimental Analysis of Behavior*, 1967, **10**, 3-15.

Skinner, B. F. Stimulus generalization in an operant: A historical note. In D. I. Mostofsky (Ed.), *Stimulus Generalization*. Stanford, Calif.: Stanford University Press, 1965. Pp. 193-205.

Stoddard, L. T. An observation on stimulus control in a tilt discrimination by children. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 321-324.

Sutherland, N. S. Visual discrimination of orientation by octopus. *British Journal of Psychology*, 1957, **48**, 55-71.

Sutherland, N. S. Visual discrimination of orientation and shape by octopus. *Nature*, 1957, **179**, 11-13. (*a*)

Sutherland, N. S. Theories of shape discriminations in octopus. *Nature*, 1960, **186**, 840-844.

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

Terrace, H. S. Errorless transfer of a discrimination across two continua. *Journal of the Experimental Analysis of Behavior*, 1963, **6**, 223-232.

Touchette, P. E. The effect of graduated stimulus change on the acquisition of a simple discrimination in severely retarded boys. *Journal of the Experimental Analysis of Behavior*, 1968, **11**, 39-48.

Zeigler, H. P. and Schmerler, S. Visual discrimination of orientation by pigeon. *Animal Behavior*, 1965, **13**, 475-477.

Received 26 February 1968.