Sensory interaction: Control of auditory discrimination by visual stimulation in the pigeon

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Two pigeons were trained to peck at different keys, each associated with a different tone intensity. Although the test tones were of the same intensity as those used during training, simultaneous presentation of a light with the tone altered the probability of correct key choice in the same manner as increasing the intensity of the tone.

Over the past several decades numerous Russian investigators have reported that the minimum amount of energy required for a subject to detect the presence of a stimulus in one modality can be modified by stimulating a second sensory modality (London, 1954). Such findings have also been reported by Western investigators (Thompson, Voss, & Brogden, 1958; Gregg & Brogden, 1952; Hartmann, 1934; Harris, 1950, pp. 41-47). However, some experimenters have been unable to replicate certain specific sensory interaction phenomena (Chapanis, Rouse, & Schachter, 1949).

A demonstration of sensory interaction requires an experimental procedure in which subjects are made to respond differentially to different intensities of a stimulus, either through the use of instructions or by means of reinforcement for correct responses. When discriminative control is established for stimuli in this first sensory modality, sensory interaction is demonstrated by presenting, simultaneously with the discriminative stimulus, a stimulus in another modality (accessory stimulus) which produces an effect equivalent to increasing the intensity of the discriminative stimulus.² Most sensory interaction experiments are designed to show that an accessory stimulus can lower sensory thresholds, but more recent experiments (Zajonc & Dorfman, 1964; Dorfman, 1961) have demonstrated the effect when initial behavioral control is established for stimuli well above threshold.

The design of the experiment may be understood more clearly by reference to Fig. 1. A subject is trained to make one response (S_1 response) in the presence of one stimulus (S_1) and to make another response (S_2 response) in the presence of a second stimulus (S_2) of greater intensity. In training situations of this kind the upper portion of Fig. 1 shows that the probability of a response may be expected to decrease as the stimulus intensity is changed from the original training intensity to the intensity used to set the occasion for the other response. The shape of these theoretical gradients of stimulus generalization shown in the upper portion of Fig. 1 is supported by data from human subjects (Cross & Lane, 1962; Lane & Kopp, 1964).

Suppose that the original training stimuli are two tones

differing only in intensity. According to the sensory interaction hypothesis the probability of either response not only depends on the intensity of the tone on a given trial, but should also depend on non-auditory aspects of the stimulus conditions. For example, suppose that the original training is carried out in the presence of a dim light (L_1). When the tone of low intensity (S_1) is presented under dim light conditions (L_1S_1), the predicted probability for the S_1 response is found by measuring the height of the S_1 curve at S_1 on the abscissa in the upper half of Fig. 1. Similarly, when tone S_2 is presented under dim light conditions (L_1S_2) the predicted probability of the correct choice (the S_2 response) is found by measuring the height of the S_2 curve at S_2 on the abscissa. These two values serve as the baseline in assessing the sensory interaction effects and are shown by the height of the open bars of the histogram in the lower half of Fig. 1.

The test for sensory interaction involves probing the baseline with a bright light (accessory stimulus, L_2) on trials in which reinforcement is not given. In the present study correct choices under the baseline condition are still reinforced. If a sensory interaction effect

Fig. 1. Theoretical generalization gradients in the test for sensory interaction (upper portion) and the resulting predictions when a bright accessory stimulus light is presented during the testing session (lower portion). See text for explanation.

occurs under such conditions, i.e., if increasing the intensity of the light has the same effect as increasing the intensity of the auditory stimuli by some increment, the probability of choice for each response will be altered. For purposes of illustration, suppose that the increment of auditory intensity is equal to three stimulus units on the abscissa in the upper half of Fig. 1. When tone S_1 is presented with the bright light (L_2S_1) the predicted probability of the S_1 response is found by measuring the height of the S_1 curve three units to the right of S_1 . This value shows a decrease from the baseline. When tone S_2 is presented with the bright light (L_2S_2) the predicted probability of the S_2 response is found by measuring the height of the S_2 curve three units to the right of S_2 . This value shows an increase from the baseline. The predictions for the sensory interaction hypothesis are shown by the cross-hatched bars at the bottom of Fig. 1.

METHOD

Subjects

Two male White Carneaux pigeons were maintained at 80% of their free-feeding body weight. Both birds were experimentally naive.

Apparatus

All sessions were carried out in a Grason-Stadler pigeon box containing three translucent plastic keys and a solenoid-operated food hopper beneath the center key. Standard relay apparatus automatically programmed the reinforcement contingencies and presentation of the stimuli (Salive & Carter, 1966). A sound-insulated cubicle reduced extraneous noise in the experimental chamber.

Procedure

The birds were trained to peck at the left key in the presence of a loud tone (98 db re: 0.0002 dynes/cm²) and to peck at the right key in the presence of a soft tone (68 db re: 0.0002 dynes/cm²). Both were 1000 cps tones. Each correct response produced access to mixed grain in the food hopper for a period of 3 sec. A single peck on the center key was required to turn on the tone and the lights behind the side keys. A 15-sec. blackout separated each trial, after which the center key light came on signaling the start of another trial. If a response was not made to either side key within 3 sec. following tone onset, a blackout occurred and the same trial was repeated. Whenever a bird made an incorrect choice between the side keys the trial was repeated until the correct choice was made. However, correct responses were recorded only when they occurred on the initial presentation of each tone which was terminated by a side-key response rather than by the 3-sec. time requirement. The two tones were alternated randomly.

After the discrimination training had established stable control in the presence of each tone, the soft tone was increased in 5-db steps re-establishing stable

Table 1. Proportion of Correct Responses in the Presence of Each of the Four Possible Stimulus Combinations as a Function of Blocks of 40 Trials

	Baseline			Test	
	Trials	L_1S_1	L_1S_2	L_2S_1	L_2S_2
Bird 15	1-40	0.50	1.00	0.10	1.00
	41-80	0.70	1.00	0.20	1.00
	81-120	0.50	1.00	0.20	1.00
	121-160	0.90	0.90	0.00	1.00
	161-200	0.60	1.00	0.00	0.90
	201-240	0.70	1.00	0.00	1.00
	241-280	0.80	1.00	0.10	1.00
	281-320	0.70	1.00	0.00	1.00
	321-360	0.90	1.00	0.00	1.00
	361-400	0.90	1.00	0.00	1.00
	401-440	0.90	1.00	0.00	1.00
	441-480	0.80	1.00	0.00	1.00
	481-520	0.70	1.00	0.00	1.00
	521-560	0.70	1.00	0.00	1.00
	561-600	0.70	1.00	0.10	1.00
Bird 19	1-40	1.00	0.60	0.40	0.90
	41-80	1.00	0.80	0.60	0.90
	81-120	1.00	0.40	0.20	1.00
	121-160	0.90	0.70	0.10	0.90

stimulus control each time. When a difference of 10 db was reached, reinforcement was given on the average for every 10th correct response. During the testing session half of the trials were chosen as test trials. Reinforcement was never programmed on a test trial and the apparatus advanced to the next trial regardless of whether or not the bird made the correct choice. Each center-key response turned on a 45-watt incandescent bulb in the back of the experimental chamber. This accessory light remained on until a side-key response was made or until 3 sec. had elapsed, after which a blackout occurred and the same trial was repeated. Trials not designated as test trials were identical to training trials except that on the average every 5th correct response produced food reinforcement.

RESULTS AND DISCUSSION

The results of the sensory interaction tests for both birds are shown in Table 1. The hypothesis predicts that the probability of the S_1 response will decrease under increased visual stimulation. Comparison of the L_1S_1 column with the L_2S_1 column in Table 1 reveals that the prediction is confirmed for both subjects. There is no overlap between the two distributions for either bird. Bird 19 was removed from the experimental chamber before the completion of 600 trials because of power failure.

The hypothesis also predicts that the probability of the S_2 response will increase under the accessory stimulus condition. Comparison of the L_1S_2 column with the L_2S_2 column in Table 1 shows that the predicted increase does not occur for bird 15 whose baseline accuracy is already close to 100%. However, the baseline accuracy for bird 19 is low enough to be sensitive to the sensory inter-

action effect and the predicted increase does occur. Again there is no overlap between the two distributions for bird 19.

Since the only difference between training and testing consisted of altered accessory stimulation, response changes observed in the present experiment may be interpreted as sensory interaction effects. Under the baseline condition bird 15 shows a left key preference which is the same as the sensory interaction prediction. However, the magnitude of the difference in response probabilities under the test condition suggests that the bird has not simply reverted to his baseline key preference under conditions of nonreinforcement. In addition, the effect of the accessory light on the discriminative behavior of bird 19 is in a direction opposite to that exhibited under baseline conditions. The data of both subjects are consistent with the sensory interaction hypothesis. Moreover, because the effects were observed for each subject, the possibility of a statistical artifact suggested by some authors (e.g., Burnham, 1941) in accounting for sensory interaction results, is ruled out.

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Notes

1. The research reported in this paper was carried out under grant AF-49(638)-367 from the Air Force Office of Scientific Research to the third author during the period while the first author was a graduate student at the University of Michigan. The assistance of Dr. Harlan L. Lane is gratefully acknowledged. Reprints are available from David E. Carter, 470 Schermerhorn Hall, Columbia University, New York, N. Y. 10027.
2. When an accessory stimulus produces the same effect as increasing the intensity of the stimulus in the first modality, the change in behavior is called facilitation. Accessory stimuli may also produce inhibition, but a review of the literature shows that increases in the intensity of an accessory light usually produce auditory facilitation (Carter, 1962).

(Received in the Editorial Office June 14, 1966.)