Generalization gradients around S Δ following errorless discrimination learning*

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Four pigeons were shaped by an errorless procedure to discriminate a blank key as S Δ and a key lit by 576 nm as S Δ , and then discrimination training continued on a MULT RI 1 min, EXT schedule before generalization tests were conducted on wavelength and intensity dimensions. Generalization gradients along wavelength were flat at zero response rate, while intensity generalization gradients were sloped to high response rates at low intensities. Implications for defining generalization of inhibition were drawn.

Brown & Jenkins (1967) demonstrated conditions of operant discrimination learning with pigeons in which S Δ controlled behavior (R $_2$) which was antagonistic to the S Δ -controlled key-peck (R $_1$). It is in this sense that Jenkins (1965) identified inhibitory stimulus control, and based upon this idea, Jenkins suggested a way to observe generalization of inhibitory stimulus control. The rationale requires choosing S Δ and S Δ from different stimulus dimensions and observing changes in R $_2$ for variations in the S Δ dimension as in a standard generalization test. Decreases in R $_2$ strength occur with a decrease in strength of the behaviors R $_1$ $\bar{U}$ R $_2$ and is thus observed as an increase in R $_1$.

Terrace (1966) suggested that S Δ exercised inhibitory stimulus control only when R $_1$ occurs and goes unreinforced in the presence of S Δ (errors). He found that generalization gradients around S Δ were flat at zero response rate when discriminations were acquired without errors, while gradients about S Δ following discrimination learning with errors took the more familiar, shallow U shape, showing increases in R $_1$ (Jenkins & Harrison, 1962; Honig, Boneau, Burstein, & Pennypacker, 1963).

The present experiment replicated the essential conditions of the Terrace experiment in that pigeons were trained to discriminate without errors a dark achromatic key as S Δ and a key lit by 576 nm as S Δ . Successive generalization tests were subsequently conducted along two dimensions, wavelength and intensity, of S Δ .

SUBJECTS

Four naive White King cock pigeons

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were maintained at 80% of their free-feeding weights and were run daily, provided that running weights were within 15 g of 80% weights.

APPARATUS

A standard operant-conditioning chamber (LVE 1519C) contained a single pecking key, 2.54 cm in diam, centered on a front panel 25.4 cm from the floor. A 5.1-cm square hole, centered below the key 12.5 cm from the floor, provided access to an automatic grain magazine, where reinforcement grain (50% kaffir, 40% vetch, 10% hempseed) was occasionally made available for 3-sec periods as reinforcement.

A 3-W lamp houselight above the key provided general illumination, a speaker presented masking white noise at 86 dB re: SPL, and a fan provided chamber ventilation.

Light was collimated and passed through Wratten narrow-band monochromatic

filters and neutral density filters to transilluminate the pecking key. Five narrow-band filters had fundamental wavelengths of 490, 538, 576, 605, and 678 nm; halfwidths were about 50 nm.

PROCEDURE

All birds were fed their daily ration at the chamber magazine location for 3 successive days; this was followed on 3 successive days with magazine training during which the magazine was presented occasionally for 60 3-sec periods. Each S was then shaped by approximation methods to peck the key.

Shaping was carried out to a dark, unlit key with the houselight on. When the 10th reinforcement was delivered, the Ss were placed directly on a random-interval 1-min schedule of reinforcement (Farmer, 1963; T = 3.75 sec, p = 1/16) for 90 sec. At the end of this 90 sec, a 5-sec blackout, during which all chamber illumination was extinguished and responses were never reinforced, occurred and was followed by a 2-sec presentation of 576-nm light at 0.76 log mL, with houselight on. During the lighted key periods responses were never reinforced. Thus, the unlit key was S Δ and the 576-nm lit key was S Δ .

From this point S Δ and S Δ periods were alternated with intervening 5-sec blackouts. S Δ periods varied between 30 and 90 sec and S Δ periods gradually increased in duration according to the series 2, 2, 5, 10, 15, 20, 25, 30 until S Δ was presented at 30 sec duration for three S Δ periods. During the second training session, S Δ again varied between 30 and 90 sec and S Δ began at 5 sec and increased to 10 sec and

Fig. 1. Generalization gradients across wavelength for four individual pigeons. Blank indicates the blank-key, positive-training stimulus condition.

Fig. 2. Generalization gradients across intensity for four individual pigeons. B indicates the blank-key, positive-training stimulus.

then in 10-sec increments to 60 sec over successive S^{Δ} periods until five S^{Δ} periods of 60 sec were presented. In the third session S^D duration was stable at 60 sec, and S^{Δ} was presented initially at 30 sec and then at 60 sec when S^D and S^{Δ} periods alternated in a quasirandom sequence assuring equal exposure time to each.

There followed seven standard discrimination training sessions in which 60-sec S^D and S^{Δ} components alternated in a quasirandom sequence with an intervening 5-sec blackout until each had appeared for 20 presentations. During S^D responses were reinforced on a R_1 1-min schedule. On the 11th day a generalization test was conducted in extinction by presenting the five wavelengths and the unlit key for 50-sec periods with intervening 10-sec blackouts, in mixed orders, until each stimulus was presented 10 times.

All Ss were then returned to discrimination training for three sessions. After this, a generalization test was conducted in extinction by presenting five intensities of the 576-nm light in addition to the unlit key. This test was identical in all other respects to wavelength generalization tests. Here, Ss 47 and 50 were exposed to five values over a wide range of intensities including -1.64 , -1.24 , $-.64$, 0.16 , and 0.76 log mL, while Ss 48 and 49 were exposed to a narrow range of intensities including -1.54 ,

-1.24 , $-.94$, $-.64$, and $-.44$ log mL.

RESULTS

Birds 47, 48, and 49 were considered to have learned the discrimination without errors, and responses to S^{Δ} made by these Ss in the first and all discrimination sessions, respectively, were: 47-6.6; 48-1.14; and 49-0.1. In fact, most errors after the initial session by these birds appeared to be "spill-over" from responding during blackout. Bird 50, on the other hand, responded regularly to S^{Δ} at the low rate of about eight responses per hour after making nine errors in the initial training session.

The first generalization test varied wavelength of the lighted key, and the obtained gradients are presented in Fig. 1. Gradients for the three birds that acquired the discrimination without errors are flat at essentially a zero response rate; virtually all responding occurred to the blank key. Bird 50 responded to other stimuli than the blank key, but, paradoxically, nearly all that responding occurred to the S^{Δ} value, 576 nm. Bird 50's test responding would be understandable had errors been maintained in a superstitious fashion during training, but no such behavior was apparent in the records.

In the second generalization test, intensity of the 576-nm light was varied within two ranges for two groups of birds and the obtained gradients are presented in Fig. 2. All gradients were about equally steeply sloped from high rates at low

intensities, similar to the blank-key rates, to essentially zero rate at higher intensities. In fact, slopes compare well with intensity gradients obtained about S^D by Blough (1959). Gradients appear no different, depending upon the wide or narrow range of intensity values. Further, there is no apparent relation to number of errors committed during discrimination training.

DISCUSSION

If Jenkins's (1965) definition of generalization of inhibition were followed strictly, one would conclude, as Terrace (1966) did, that no inhibitory stimulus control was exercised by wavelength for those Ss which acquired without errors, since those generalization gradients were flat at zero response rate. Bird 50 is anomalous; while responding occurred (that is, the tendency for R_2 decreased) these data do not seem to form an inhibitory gradient since that responding occurred primarily to the S^{Δ} value.

There are several possible descriptions for the intensity generalization gradients. First it may be said that the intensity dimension did exercise inhibitory stimulus control since R_2 strength clearly decreased away from S^{Δ} , seen as an increase in R_1 .

A second thought would simply disallow these gradients as unambiguous evidence since the test violates the requirement that test stimuli be equidistant from S^D . However, one may argue that the absence of energy is on no physical dimension with the presence of any energy, parallel to Jenkins's argument that "absence of a tone or white noise are stimuli without a sensible dimension of tonal frequency [p. 57]." Any argument otherwise derives from the behavioral observation in pigeon and man that no light energy is generalized to certain low values of light energy present, with the response, "I do not see the light." But this evidence has the same form as the present data, and for that matter, as all experiments purporting to display gradients of inhibitory stimulus control, namely, that a response occurs with some strength in different stimulus situations.

Thus, the third possibility is anticipated, that excitatory stimulus control, or generalization around S^D was observed here. The fact that the E could match the blank key with a luminance of about -1.45 log mL and that intensity gradients changed most drastically near that value makes this description seem more reasonable. This is a sensible conclusion only with data, as in the present case for intensity generalization gradients, where generalization of a response to values on different physical dimensions is well established, as by psychophysical data.

Describing any increase of R_1 strength

in "inhibitory" generalization gradients instead as generalization around S^D is clearly more parsimonious. R_2 is never directly observed unless all stimuli except S^D set the occasion for R_1 , e.g., Brown & Jenkins (1967), Johnson, Kinder, & Scarboro (1969), otherwise absence of R_1 may mean the presence of either R_2 or $\bar{R}_1 \cup \bar{R}_2$. Maintenance of the excitatory-inhibitory gradient distinction in Jenkins's sense derives from identifying different physical specifications for a white vertical line and a field of 490-nm light (as in Terrace, 1966) or unlit, black vertical line on a white lit background and a fully white lit key (as in Honig et al, 1963). But behavioral equivalence is an empirical matter, and Lashley (1938) observed generalization of R_1 between many stimulus pairs of different physical specifications. If orthogonal physical dimensions guaranteed stimulus control independence, it would be impossible to understand how Jenkins & Harrison (1960), who first found flat generalization gradients for pigeons across tonal frequency, later found peaked gradients across frequency following discrimination training between tone and no tone! Generalization of inhibition must be observed in the same circumstances in which inhibition is unequivocally identified.

The foregoing suggests that errorless discrimination training makes S^D control quite independent of S^A dimensions except those on which generalization may have been previously trained, such as brightness, by natural or experimental conditions.

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Prey selection in naive *Elaphe obsoleta* (Squamata: serpentes) — A reappraisal*

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Naive hatchling *Elaphe obsoleta* were exposed to extracts prepared from prey eaten by young (lizard, frog) and adults (mouse, bird, rat). A preference was shown for the frog (*Hyla*) extract, a favorite food of young of this species. Young will also accept adult prey species provided they are cut into small pieces. This suggests that prey size is an important determinant of the feeding response in this species.

A body of literature is growing which indicates that newborn snakes of various species demonstrate clearcut preferences for extracts prepared from natural prey species over nonprey species (Burghardt, 1966, 1967, 1969). These studies are all based on relatively prey-specific species or, at least, species which eat the same prey throughout their lives. A recent study (Morris & Loop, 1969), utilizing *Elaphe obsoleta*, a species which varies its prey as growth proceeds, suggests that naive young of such species are less specific in their response to animal extracts. The data Morris and Loop presented indicate feeding habits for the species at variance with the experience of herpetologists familiar with *Elaphe obsoleta* and suggest a more complex picture of the stimulus controls of prey attack in naive snakes than that indicated in the studies by Burghardt. The present data were gathered incidentally to a study of the role of experience in shaping the food preference in this species and suggest an interpretation different from that presented by Morris and Loop.

METHOD

Fourteen Ss were obtained from eggs from a female *Elaphe obsoleta* collected in

Butler Co., Pennsylvania. They were normal in size, color, pattern, and morphology for the species. The stimulus items were extracts, prepared by Burghardt's (1966) method, of laboratory rat and laboratory mouse (strains uncertain), fish (whiting), domestic chick (*Gallus*), earthworm (*Lumbricus*), lizard (*Anolis carolinensis*), and frog (*Hyla squirella*). Distilled water served as control.

The Ss were housed in individual gallon jars with cheesecloth covers at a temperature of 24°C to 28°C and were tested initially 1 month after hatching. Each extract was presented once only in a random order, different for each S, with the constraint that the control be presented first and last always. Extracts were introduced into the jar at 2-min intervals on a standard 15-cm cotton swab and brought to within 2 cm of the snake's snout. After 30 sec, if no attack occurred, the swab was slowly moved forward until it touched the snout, then withdrawn 2 cm. The scoring method devised by Burghardt (1966) was used, except that attack latency was measured to the nearest 1 sec rather than to the nearest 0.01 min.

RESULTS

Considerable individual variation was evident in the responses of the Ss. These, in general, reflected the overall response of the Ss to the experimental situation; some

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