**STIMULUS-FOOD RELATIONS AND FREE-OPERANT
POSTPONEMENT OF TIMEOUT FROM
RESPONSE-INDEPENDENT FOOD PRESENTATION**

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Grain was briefly presented to food-deprived pigeons intermittently and response-independently except during signaled timeouts. During Experiment 1, key pecks postponed the next timeout for a specified interval. Rates of pecking during time in were inversely related to the length of time pecking postponed the next timeout. Response-independent presentation of temporal distributions of timeouts exactly matched to a preceding postponement condition decreased pecking rates during Experiment 2. These results indicate that key pecking of pigeons can be controlled by response-dependent postponement of timeout, but that responses elicited by stimulus-reinforcer relations inherent in timeout-postponement procedures may substantially modify rates and patterns of pecking.

Key words: free-operant avoidance, timeout from food, key pecking, negative reinforcement, stimulus-reinforcer relations, elicited behavior, pigeons

Thomas (1965) exposed food-deprived pigeons, previously magazine trained but otherwise experimentally naive, to the following experimental contingencies. A response key was transilluminated with red light for 300 sec, then with green light for 10 sec. Response-independent food was presented on the average once every 60 sec during the latter stimulus condition ("time in"), but never during the former ("timeout"). Pecks to the key when lit green postponed the next timeout until x sec elapsed without a response.

Thomas viewed this procedure as free-operant avoidance (Sidman, 1953) of timeout, with a timeout-timeout (TT) interval equal

to 10 sec and a response-timeout (RT) interval of x sec. When the RT interval was lengthened from 20 to 30, 60, then 120 sec, response rates monotonically decreased, similar to results obtained under analogous shock-postponement schedules (e.g., Clark & Hull, 1966; Sidman, 1953; Todorov, Ferrari, & de Souza, 1974; see Hineline, 1977, for a review).

This result appears to support Thomas's contention that pecking was controlled by response-dependent delay of timeout. An equally plausible interpretation of these data may be provided, however, through analysis of stimulus-reinforcer rather than response-reinforcer contingencies. ("Stimulus-reinforcer" in the present context refers to correlations between stimulus and food presentations, not between stimulus presentation and timeout delay.) Thomas's procedure involves alternation of two stimulus conditions, correlated with different keylight colors, one of which occasions intermittent brief presentations of food independent of responding. Pecking directed at a stimulus can be "autoshaped" (Brown & Jenkins, 1968) in experimentally naive, food-deprived pigeons, provided the rate of food presentation during the stimulus is greater than the rate of food presentation across the entire session. Specifically, the reliability of acquisition, and to a lesser degree the rate of pecking, varies directly as a function of the frequency of food presentation during the stimulus expressed relative to the overall frequency of

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food presentation (cf. Gibbon, 1981; Gibbon & Balsam, 1981; Jenkins, Barnes, & Barrera, 1981). Generally, stimulus-directed pecking is elicited whenever food is presented more than twice as frequently during the stimulus as during the session overall. Thomas's procedure, prior to the first peck, provides food 31 times more frequently during time in than during the session overall (one food presentation per six 10-sec time-in periods vs. one per six 310-sec time-in-timeout cycles) and thus provides contingencies conducive to the development of elicited pecking.

This contingency between stimulus- and session-rates of food presentation is reduced by pecking under Thomas's procedure, because pecking postpones timeout. The frequency of food presentation during the session would increase as a result of lengthening the duration of time in; however, the rate of food presentation during time in would remain unchanged. The disparity between rates of food presentation during the stimulus and during the session thus would decrease. The degree of disparity remaining would be related directly to the frequency of timeout presentation. At one extreme, if no timeouts are delivered, the rates of food presentation during the stimulus and during the session are identical, in that the session is comprised entirely of time in. The other extreme, where no pecking occurs and timeout is not postponed, results in the 31:1 ratio between stimulus- and session-rates of food presentation outlined above. Frequencies of timeout intermediate to these two extremes would generate stimulus-reinforcer contingencies equally intermediate.

Timeout frequency itself depends on the RT interval and the temporal spacing of responding. It is conceivable, however, that timeout frequency decreases as a function of RT-interval duration, much as shock frequency decreases under shock-postponement procedures when the response-produced delay is lengthened (cf. Hineline, 1977). Thus, the monotonic decreases in response rate Thomas obtained as the RT interval was lengthened might reflect decreases in the rate of elicited pecking, resulting from progressively weaker stimulus-reinforcer contingencies as timeout frequency decreases, and not changes in operant pecking controlled by timeout delay.

The above interpretation of Thomas's results emphasizes the frequency of timeout pre-

sensation, not reported by Thomas, as an important controlling variable. Our first experiment, a systematic replication (Sidman, 1960) of Thomas's study, was conducted to obtain a more detailed analysis of pecking under free-operant postponement of timeout. Rates of responding during both time in and timeout, as well as the frequency of timeout delivery, were recorded across a range of RT intervals. Temporal patterns of responding during time in and transitions in responding between successive RT-interval values also are reported.

EXPERIMENT 1

METHOD

Subjects

Three adult male White Carneaux (*Columba livia*) pigeons, used previously in an undergraduate laboratory course, were reduced to 80% of their free-feeding body weights (475, 400, and 415 g for P-7820, P-9275, and P-6441, respectively). They were maintained subsequently on a 23-hr deprivation regimen, with postsession feeding of mixed grain restricted to maintain the 80% body weight. Between experimental sessions, subjects were housed individually, with continuous access to water and health grit, in a colony.

Apparatus

Experimental sessions were conducted in a pigeon conditioning unit measuring 30 cm wide by 31 cm long by 31 cm deep. All walls were painted flat black except the front, which was an aluminum sheet containing three 2-cm diameter response keys (Gerbrands) 22 cm above the grid floor. A static force of .15 N applied to the center key, located 15.5 cm from either side edge of the front wall, briefly operated a feedback relay mounted behind the front wall and was recorded as a response. Located behind the key were two 1.1-W, 28-V dc lamps covered with either a white or red translucent cap. A Plexiglas extension mounted on the key protruded .15 cm beyond the front wall of the chamber. Such extensions have been reported (e.g., Rachlin, 1969) to facilitate autoshaping of key pecking. The two side keys did not extend beyond the front wall and remained dark and inoperative throughout the experiment. Mixed grain could be presented, dependent on the operation of a solenoid-

driven grain feeder, through a 6-cm by 5-cm aperture located directly beneath the center key. A 1.1-W, 28-V dc lamp, located above and behind the aperture, was lit during grain presentations. General chamber illumination was provided by 1.1-W, 28-V dc lamps located in both upper corners of the front wall and mounted behind reflectors that prevented direct downward illumination. The chamber was located in a room where white noise was continuously present; noise from a ventilation fan mounted on the chamber ceiling also helped mask extraneous sounds. A PDP-8/f minicomputer, located in an adjacent room and operating under the SKED (Snapper, Stephens, & Lee, 1974) or SuperSKED (Snapper & Inglis, 1978) software systems, programmed stimuli and recorded data. Cumulative records of responding during each session also were generated by a Gerbrands Model C-3 cumulative recorder located in the same room as the computer.

Procedure

During daily 1-hour sessions, the key could be lit either white or red. When the keylight was white (time in), mixed grain was presented independent of responding for 2 sec at random intervals averaging 30 sec. The intervals were determined by a probability generator set equal to .033 and sampled every sec. When the keylight was red (timeout) grain was never presented. Grain was also never presented within 3 sec of timeout termination. To maintain the frequency of food presentation relatively constant in the presence of large changes in response rate, food presentation was not delayed after responses. Responses during time in produced a click from the feedback relay and postponed the next 20-sec timeout for the amount of time specified by the RT interval. In the absence of responding, timeouts followed one another at 5-sec intervals (i.e., TT interval = 5 sec). Timeout termination was signaled by a brief (.25 sec) darkening of the houselights as well as reillumination of the white keylight. The houselights were not extinguished at any other time during experimental sessions. Sessions began with the RT interval in effect, and neither the TT nor RT interval operated during food presentations.

The RT-interval duration was manipulated across phases in successive order from 20 to 10 to 40 to 5 sec, while maintaining the TT in-

terval equal to 5 sec. Each condition remained in effect until response rates during time in and timeout, as well as numbers of timeouts presented, showed minimal variability and no ascending or descending trends for 20 consecutive daily sessions as determined by visual examination of these measures. The number of sessions each subject was exposed to the different RT-interval values is presented in Table 1.

Because all subjects had histories involving magazine training and key pecking, little preliminary training was necessary. One subject (P-7820) was exposed to a variety of preliminary conditions, during which a number of variables (e.g., session length, stimulus conditions, feeder cycle length, etc.) were manipulated unsystematically. The other subjects were exposed directly to the first experimental condition, with two exceptions. First, the feeder cycle initially was set at 4 sec. This value remained in effect until each subject ate readily from the magazine, at which point the cycle duration was reduced and subsequently maintained at 2 sec. Second, the probability of food presentation was adjusted such that grain was presented during approximately half of the initial time-in periods. Following the first key peck, the probability of grain presentation was reduced to the value used subsequently throughout the experiment (i.e., .033).

RESULTS

Both subjects initially exposed directly to the experimental procedure pecked the response key within 15 min of the beginning of the first session. For all subjects, pecking occurred first during time in and always occurred more frequently during time in than during timeout. Informal visual observations suggested that pecks during timeout generally occurred during the first few seconds of a timeout, and often were initiated prior to timeout presentation.

Table 1 presents the means and ranges of summary measures obtained across the last 20 sessions of each condition for each subject. Response rates during time in, graphically depicted in Figure 1, generally were linearly decreasing functions of RT-interval duration when plotted on double-logarithmic axes. In contrast, response rates during timeout were not reliably different under the different conditions (see Table 1). Although the mean

Table 1

List of conditions and values of summary measures obtained in individual subjects during Experiment 1.

Subject	RT Interval (sec)	Sessions (Order)	Response Rate (R/min) ^a		
			Time in	Timeout	Timeouts ^a
P-7820	5	72	43.62	0.71	41.7
		(4)	(36.00-53.10)	(0.24-1.54)	(33-53)
	10	96	20.82	0.38	46.3
		(2)	(16.50-25.32)	(0.10-0.78)	(35-65)
	20	171	12.18	0.24	25.0
		(1)	(10.50-15.36)	(0.00-0.86)	(9-39)
	40	71	7.80	0.10	13.0
		(3)	(6.42-11.16)	(0.00-0.58)	(5-32)
P-9275	5	42	21.72	0.27	105.2
		(4)	(17.34-26.10)	(0.14-0.49)	(95-114)
	10	100	17.58	0.19	41.0
		(2)	(15.06-19.86)	(0.00-0.44)	(30-72)
	20	74	8.94	0.14	31.5
		(1)	(7.14-10.44)	(0.00-0.44)	(24-47)
	40	30	5.28	0.10	27.5
		(3)	(4.20-6.36)	(0.00-0.25)	(17-35)
P-6441	5	69	39.16	2.53	25.0
		(4)	(32.70-42.60)	(1.29-3.95)	(13-42)
	10	45	20.88	1.25	11.3
		(2)	(16.80-26.92)	(0.17-2.71)	(5-18)
	20	103	12.30	1.79	19.8
		(1)	(10.44-16.20)	(0.40-3.88)	(7-33)
	40	49	9.60	0.68	5.0
		(3)	(5.40-13.22)	(0.00-3.67)	(0-14)

^aValues shown are the means of values observed during the last 20 sessions under each RT interval. Ranges of values observed during this period are shown in parentheses.

Fig. 1. Response rates during time in for each subject as a function of the RT interval. Points and vertical bars represent means and ranges of values observed, respectively, during the last 20 days exposure to each RT interval. Points have been slightly displaced to increase clarity. Note the logarithmic axes.

response rate during timeout in some cases decreased systematically with increases in RT-interval duration, the ranges of values under all RT intervals showed considerable overlap.

The relationship between RT interval and the number of timeouts per session (see Figure 2) was less consistent across subjects than that between RT interval and time-in response rate. There was a general tendency for timeout frequency to decrease with longer RT intervals. Note, however, the large differences in individual subject response rate between RT intervals under which similar frequencies of timeout were presented (for example, response and timeout rates for P-7820 under RT interval = 5 and 10 sec, and for P-6441 under RT interval = 5 and 20 sec).

Cumulative response records obtained under the different RT-interval values are presented for each subject in Figure 3. Response rates were fairly constant within sessions, with occasional negative acceleration following timeout

Fig. 2. Numbers of timeouts delivered to each subject as a function of the RT interval. Figure characteristics are the same as those for Figure 1.

(some examples of this have been noted in the figure by arrows).

The development of steady-state performance required a large number of sessions under some RT-interval values, due more to short-term oscillations in response rate than to gradual transitions between experimental phases. Indeed, these transitions generally were very rapid. Data depicting such transitions for P-6441, a representative subject, are presented in Figure 4 in the form of cumulative response records. The left record in each row depicts responding during the last session under a particular RT interval. The right record depicts responding during the immediately following session, when a new RT-interval value was programmed. Hence, records from the first and last session under a particular RT interval correspond to the last record in one row and the first record in the row immediately below. Response rates approximating those obtained after extended exposure were generally ob-

Fig. 3. Representative cumulative records for each subject under the different RT intervals. In each record, time reads from left to right. The upper (response) pen stepped vertically with each response during time in, reset to baseline after 550 responses, and was deflected during timeout (and the motor stopped). Deflections of the lower (event) pen denote food presentations. Arrows denote some post-timeout increases in response rate. Records were selected from sessions that most closely approximated both the median response rate and number of timeouts delivered at each RT interval.

Fig. 4. Cumulative records depicting transitions in key pecking of P-6441 between different RT intervals. Records on the left show responding during the last session at a specific RT-interval value, those on the right during the first session of the subsequent value. The first and last day of exposure to a particular RT interval is shown, respectively, in a record on the right and the one immediately beneath it on the left. Event pen tracings have been removed from each record; otherwise recording characteristics are the same as those for Figure 3.

tained by the last third of the first session under the new RT-interval value.

DISCUSSION

The monotonic decreases in response rate as the RT interval was increased and the temporal patterns of pecking observed during this experiment were similar to those previously reported under free-operant postponement of timeout or shock (cf. Hineline, 1977). They are thus completely consistent with analyses emphasizing response-reinforcer relationships in the control of pecking by timeout delay. They are not, however, entirely consistent with an analysis emphasizing inherent stimulus-rein-

forcer relationships in timeout-postponement procedures. Although there was a general tendency for timeout frequency to decrease with response rate as the RT interval was increased, there were also exceptions to this relationship. Nearly identical timeout frequencies were delivered to P-7820 under RT intervals of 5 and 10 sec and to P-6441 under RT intervals of 5 and 20 sec, yet response rates maintained under the shorter RT interval were double or triple, respectively, those under the longer RT interval. Thus, response rates were not controlled solely by changes in the overall frequency of timeout presentation under the different RT intervals.

A stimulus-reinforcer interpretation of these data might point to changes in the local frequency of timeout presentation to account for these results. Although the overall frequency of timeout presentation under two RT intervals might be nearly equal, temporal distributions of timeout presentation might differ sufficiently to maintain different rates of elicited pecking. The next experiment examined this possibility by comparing pecking under timeout postponement with that maintained when exactly equal temporal distributions of timeouts were presented independent of responding. Stimulus-reinforcer relationships do not differ under these two procedures. Hence, if responding under the timeout-postponement procedure involves only elicited pecking, this manipulation should have little effect. Alternatively, presentation of timeout independent of responding constitutes an operant extinction procedure, analogous to ones shown to decrease rates of responding previously maintained by shock postponement (e.g., Coulson, Coulson, & Gardner, 1970; Smith, 1973). If pecking under timeout postponement is controlled (if only partially) by response-dependent delay of timeout, temporary suspension of this dependency should reduce response rates, even in the presence of occasional response-independent timeout presentation.

EXPERIMENT 2

METHOD

Subjects and Apparatus

As in Experiment 1.

Table 2

List of conditions and values of summary measures obtained in individual subjects during Experiment 2.

Subject	Condition	Sessions	Response Rate (R/min) ^a		Timeouts ^a
			Time in	Timeout	
P-7820	RT interval = 10 sec	101	26.56 (22.92-29.22)	0.63 (0.08-1.48)	33.5 (25-46)
	Yoked-VT:timeout	20	17.69 (14.10-22.56)	0.39 (0.07-1.12)	—
P-6441	RT interval = 20 sec	118	14.16 (10.20-18.42)	0.41 (0.00-1.01)	16.3 (7-31)
	Yoked-VT:timeout	20	5.62 (4.29- 7.32)	0.39 (0.20-0.48)	—
P-9275	RT interval = 40 sec	32	4.25 (3.36- 5.64)	0.08 (0.00-0.25)	27.8 (18-41)
	Yoked-VT:timeout	20	2.54 (1.92- 3.90)	0.06 (0.00-0.18)	—

^aValues are the means of the last 20 (delay conditions) or 5 (yoked-VT) sessions under each procedure. Ranges are shown in parentheses.

Procedure

Directly following Experiment 1, P-7820, P-6441, and P-9275 were exposed to RT intervals of 10, 20, and 40 sec, respectively. These values were not determined randomly. Subject P-6441 finished Experiment 1 first and was re-exposed to the first RT interval studied (i.e., RT interval = 20 sec). In an attempt to minimize between-subject differences in timeout frequencies, P-9275 was exposed to an RT interval of 40 sec. Finally, to collect data (albeit between subjects) under each of the three longer RT intervals, P-7820 was exposed to an RT interval of 10 sec. The timeout-postponement procedure remained in effect until responding stabilized according to the stability criterion outlined for Experiment 1. Table 2 presents the number of sessions the postponement contingency was in effect for each subject.

During each daily 1-hr session, the inter-timeout intervals were recorded in sequence. Once responding stabilized, sequences of inter-timeout intervals from the final 20 sessions under the postponement procedure were used to program response-independent timeout presentation in a "yoked" fashion. Specifically, timeout presentation in any particular session was governed by the sequence of intertimeout intervals from the 20th preceding session. Because timeouts were presented at varying times and were response-independent, this condition

was termed "yoked variable time" (yoked-VT). The yoked-VT schedule remained in effect for 20 sessions, during which responses had no effect on the presentation of timeout. Following this condition, the timeout-postponement contingency was reinstated at the RT-interval value prevailing prior to the yoked-VT condition. All other parameters of the experimental procedure were the same as in Experiment 1.

RESULTS

Overall response rates during time in and numbers of timeouts delivered under the timeout-postponement schedule (see Table 2) were comparable for each subject to those obtained under initial exposure to that RT-interval value during Experiment 1.

As shown in Figure 5, suspension of the delay contingency decreased time-in response rates to less than 50% of the mean time-in response rate under the postponement procedure in every subject within the 20 sessions the yoked-VT schedule was in effect. No systematic differences were observed between subjects in the relative degree or speed of response-rate reduction. Absolute response rates, in contrast, were inversely related to the previous RT-interval length after 20 sessions exposure to the yoked-VT schedule (see Table 2). Reinstatement of the postponement procedure resulted in response rates above the mean rate observed prior to the yoked-VT procedure after 10, 25,

Fig. 5. Daily session time-in response rates for each subject during the final 20 sessions of initial re-exposure to the postponement contingency (left panel), the 20 sessions of the yoked-VT contingency (middle panel), and 30 sessions subsequent re-exposure to the postponement procedure (right panel). (Subject P-7820 was subsequently re-exposed to the postponement contingency for only 25 sessions.) Response rates are expressed as a percentage of the mean rate obtained during the final 20 sessions of initial exposure during Experiment 2 to the postponement contingency.

or 1 session for P-7820, P-6441, or P-9275, respectively.

Cumulative response records in Figure 6 depict within-session patterns of responding under the postponement and yoked-VT procedures. The records presented are the 1st, 11th, and 20th session of the last 20 sessions under the postponement schedule and the 1st, 11th, and 20th session under the yoked-VT procedure. (The record from the "11th" yoked-VT session for P-9275 is actually the 12th session, as the same sequence of timeouts was inadvertently programmed during the 8th and 9th sessions. To compensate for this repetition, the sequence of intertimeout intervals from the 14th session, selected at random from the remaining distributions, was not presented.) The

records have been overlaid to highlight the correspondence of intertimeout intervals within each pair. Patterns of responding under the postponement procedure were comparable to those observed during Experiment 1. No systematic pattern of responding emerged during the 20 sessions exposure to the yoked-VT procedure.

DISCUSSION

These results demonstrated that response and timeout rates obtained under re-exposure to an RT-interval value were comparable to those obtained under initial exposure to that value during Experiment 1 and that response-dependent delay of timeout was essential in maintaining the rates of responding observed under the postponement procedure. The decreases in response rate observed following presentation of identical distributions of response-independent timeout argue against the notion that key pecking under free-operant timeout postponement was governed solely by stimulus-reinforcer contingencies.

Although the delay contingency was crucial in determining response rates, the possibility remains that elicited key pecking directed at the time-in stimulus occurred under the postponement procedure and thus contributed to the overall rate of responding. Suspending the postponement contingency reduced rates of pecking but did not eliminate it altogether in any subject within the 20-session period the yoked-VT procedure was in effect. Response rates appeared stable for P-9275 and P-6441 after 11 and 12 sessions, respectively, under this condition. Response rates for P-7820 were not stable after 20 sessions and likely would have decreased further with extended exposure to this condition. The other subjects' results, however, suggest that responding would not totally have ceased.

To the extent that responding maintained under the yoked-VT procedure involves pecking elicited by stimulus-reinforcer relations, comparable contingencies present during timeout postponement may also elicit pecking that contributes to the overall rate of responding. Further, systematic decreases in the rate of elicited pecking resulting from less frequent timeout delivery as the RT interval is lengthened may partially or wholly determine the slope of the function relating response rate to RT-interval duration under timeout postpone-

Fig. 6. Cumulative records from selected sessions under the delay contingency and under the corresponding yoked-VT session. Records were taken from the 1st, 11th, or 20th session of the last 20 sessions the delay contingency was in effect and of the yoked-VT procedure. Records from sessions under the delay contingency (labeled "R" in the figure) have been overlapped with records from corresponding sessions under the yoked-VT procedure (labeled "Y"). Recording characteristics are the same as those for Figure 4. (Occasional extended deflections of the response pen were the result of an infrequent mechanical failure that did not stop the motor during timeout.)

ment. The results of the present study demonstrate only that pecking is controlled by the presence versus absence of response-dependent timeout delay, not necessarily by the duration of the consequent delay. Pecking may vary systematically as a function of RT-interval duration because pecking is controlled by the consequent delay duration, by systematic changes in stimulus-reinforcer contingency, or by some combination thereof. The slopes of the functions relating time-in response rate to RT interval obtained during Experiment 1 may thus be greater than they would be in the absence of elicited pecking. Functions relating response rate under a range of RT intervals and under their yoked-VT counterparts might even be parallel, the former simply elevated by some constant amount. Such results would suggest that pecking is modified by the presence versus absence of response-dependent timeout delay but is not affected differentially by the length of the consequent delay. This supposition, of course, awaits experimental test.

GENERAL DISCUSSION

Although the present analysis has emphasized "negative reinforcement" (i.e., timeout delay), an equally precise interpretation of the present results may be provided by emphasizing correlations between rates of pecking and food delivery (cf. Baum, 1973). Emphasis on "feedback functions" relating these two measures suggests that responding decreases as the RT interval is increased (i.e., Experiment 1) because the rate of responding required to maintain a particular rate of food presentation is reduced, and that removal of the response dependency (i.e., Experiment 2) abolishes the correlation between response and food rates, decreasing response rates. Indeed, any manipulation of the present paradigm may be presented in terms of either positive or negative reinforcement, depending on whether prolonging time in or delaying timeout is viewed as the consequent event. Dual interpretation of "negative-reinforcement" procedures is not re-

stricted to timeout postponement, as evidenced by interpretations of shock postponement in terms of response-produced "safety" (cf. Dinsmoor, 1977). Avoidance of light (e.g., Keller, 1941), noise (e.g., Azrin, 1958) and extreme temperatures (e.g., Matthews, Morin, & Church, 1971; Weiss & Laties, 1961) equally are subject to such dual interpretation.

The particular mode of analysis adopted may reflect variables controlling the verbal behavior of researchers more than those controlling the behavior of experimental subjects. Timeout postponement appears especially to invite interpretation with respect to positive reinforcement contingencies because (a) food presentation, by far the most frequently employed positive reinforcer, is one component of the procedure, and (b) the duration of the "aversive stimulus" is much longer than that typically used with shock postponement. These characteristics only distinguish positive and negative reinforcers historically, however; they do not otherwise define the two classes of consequent events. Positive and negative reinforcers are specified functionally by the increase in response rate engendered either by response-dependent presentation or postponement of the consequent event. This functional definition expressly ignores physical characteristics of consequent stimuli, but these may increasingly control researchers' verbal behavior if only limited, and largely mutually exclusive, sets of events are investigated under the rubrics of "positive" and "negative" reinforcement. Timeout postponement is not historically biased towards either mode of analysis. As such, it may help decrease any artificial limitations imposed on areas of research by tradition, facilitating integration of positive and negative reinforcement contingencies.

One possible result of such integration is reassessment of the control exerted by phylogenetic variables over response acquisition under negative reinforcement. For example, Bolles (1970, 1972) has suggested that genetic variables determine the acquisition rate of a particular avoidance response in the natural habitat, arguing that response shaping by differential environmental contingencies progresses much too slowly, exposing the organism to numerous occasions during which it may fall prey. Instead, Bolles proposes that "species-specific-defense-reactions" (SSDRs), responses elicited by aversive stimulation, vary in acqui-

sition rate because low-probability SSDRs emerge only after repeated punishment of unsuccessful, higher-probability SSDRs. Experimental results offered to support this notion primarily involve differences in the rate with which experimentally specified responses are acquired under a shock-postponement procedure. For example, pigeons acquire pecking under shock-postponement procedures only with extended training (cf. Hineline, 1977). Whether this results, however, from pecking being a low-probability SSDR or from competition between the required operant response and neck contraction elicited by shock presentation (cf. Smith, Gustavson, & Gregor, 1972) is not readily apparent in the absence of a comparative database involving a variety of species, responses, and aversive stimuli. Pecking under timeout postponement is of interest in this regard because it provides one such comparative analysis of species and response generality (Sidman, 1960) and utilizes an aversive stimulus other than electric shock. The rapid and reliable acquisition of pecking under timeout postponement argues against a general conceptualization of pecking as a low-probability SSDR in deference to a more detailed analysis of particular interactions between species, response classes, and aversive stimuli. The presence of differential stimulus-reinforcer relations in timeout-postponement procedures, for example, no doubt facilitates key-peck acquisition, but it is precisely such situation-specific additional sources of control that SSDR analyses typically overlook.

Also generally overlooked by such analyses, but illustrated by behavior controlled under timeout delay, is the nonlethal nature of a number of "natural" aversive stimuli. Although predators may not allow the gradual shaping of a response, other aversive stimuli need not act immediately on an organism's survival. Poikilotherms learn responses that facilitate thermoregulation within a temperature range that is neither fatally hypo- nor hyperthermic. More relevant to the present experiments, organisms may learn, in foraging for food, to avoid areas void of nutritional resources (i.e., geographically defined "time-outs") without succumbing to the lethal effects of extended stay in such areas. Aversive stimuli such as these may be presented repeatedly without harm to the organism, gradually shaping responding through negative-reinforcement

contingencies. It is, thus, not unproductive to analyze environmental contingencies modulating response acquisition in the laboratory, as principles obtained therein may indeed be directly applicable to more "natural" negative-reinforcement contingencies.

REFERENCES

- Azrin, N. H. Some effects of noise on human behavior. *Journal of the Experimental Analysis of Behavior*, 1958, 1, 183-200.
- Baum, W. M. The correlation-based law of effect. *Journal of the Experimental Analysis of Behavior*, 1973, 20, 137-153.
- Bolles, R. C. Species-specific defense reactions and avoidance learning. *Psychological Review*, 1970, 77, 32-48.
- Bolles, R. C. The avoidance learning problem. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 6). New York: Academic Press, 1972.
- Brown, P. L., & Jenkins, H. M. Auto-shaping of the pigeon's key-peck. *Journal of the Experimental Analysis of Behavior*, 1968, 11, 1-8.
- Clark, F. C., & Hull, L. D. Free operant avoidance as a function of the response-shock = shock-shock interval. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 641-647.
- Coulson, G., Coulson, V., & Gardner, L. The effect of two extinction procedures after acquisition on a Sidman avoidance contingency. *Psychonomic Science*, 1970, 18, 309-310.
- Dinsmoor, J. A. Escape, avoidance, punishment: Where do we stand? *Journal of the Experimental Analysis of Behavior*, 1977, 28, 83-95.
- Gibbon, J. The contingency problem in autoshaping. In C. M. Locurto, H. S. Terrace, & J. Gibbon (Eds.), *Autoshaping and conditioning theory*. New York: Academic Press, 1981.
- Gibbon, J., & Balsam, P. Spreading association in time. In C. M. Locurto, H. S. Terrace, & J. Gibbon (Eds.), *Autoshaping and conditioning theory*. New York: Academic Press, 1981.
- Hineline, P. N. Negative reinforcement and avoidance. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior*. Englewood Cliffs, N. J.: Prentice-Hall, 1977.
- Jenkins, H. M., Barnes, R. A., & Barrera, F. J. Why autoshaping depends on trial spacing. In C. M. Locurto, H. S. Terrace, & J. Gibbon (Eds.), *Autoshaping and conditioning theory*. New York: Academic Press, 1981.
- Keller, F. S. Light-aversion in the white rat. *Psychological Record*, 1941, 4, 235-250.
- Matthews, T. J., Morin, L. P., & Church, R. M. Avoidance of thermal stimuli in the rat. *Psychonomic Science*, 1971, 22, 59-60.
- Rachlin, H. Autoshaping of key pecking in pigeons with negative reinforcement. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 521-531.
- Sidman, M. Two temporal parameters of the maintenance of avoidance behavior by the white rat. *Journal of Comparative and Physiological Psychology*, 1953, 46, 253-261.
- Sidman, M. *Tactics of scientific research: Evaluating experimental data in psychology*. New York: Basic Books, 1960.
- Smith, G. D. *Extinction of free-operant avoidance in rats*. Unpublished doctoral dissertation, Temple University, 1973.
- Smith, R. F., Gustavson, C. R., & Gregor, G. L. Incompatibility between the pigeons' unconditioned response to shock and the conditioned key-peck response. *Journal of the Experimental Analysis of Behavior*, 1972, 18, 147-153.
- Snapper, A. G., & Inglis, G. *The SKED software system: Time-shared SUPERSKED*. Kalamazoo, Mich.: State Systems, 1978.
- Snapper, A. G., Stephens, K. R., & Lee, D. M. *The SKED software system*. Kalamazoo, Mich.: State Systems, 1974.
- Thomas, J. R. Time-out avoidance from a behavior-independent contingency. *Psychonomic Science*, 1965, 3, 217-218.
- Todorov, J. C., Ferrari, E. A. M., & de Souza, D. G. Key pecking as a function of response-shock and shock-shock intervals in unsignalled avoidance. *Journal of the Experimental Analysis of Behavior*, 1974, 22, 215-218.
- Weiss, B., & Laties, V. G. Behavioral thermoregulation. *Science*, 1961, 133, 1338-1344.

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