EFFECTS OF FIXED-TIME SHOCKS AND BRIEF STIMULI ON FOOD-MAINTAINED BEHAVIOR OF RATS

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When a fixed-time schedule of shocks was presented to rats lever pressing for food on a random-interval schedule, a pattern of behavior developed with a high rate of pressing after shock declining to near zero before the next shock was delivered. Once this pattern had stabilized, one-quarter of the shocks were replaced with brief auditory stimuli (tones) in a random sequence. Tone maintained behavior similar to shock, although tone was never paired with shock. Both tone and shocks elicited responding when presented at various times as probe stimuli, and responding was usually totally suppressed if neither stimulus occurred at the beginning of the fixed-time interval. When other stimuli were paired with tone and shock, only those paired with tone gained discriminative control and elicited responding. These findings suggest that stimuli that signal a shock-free, or safe, period will maintain the pattern of behavior generated by shock on a fixed-time schedule. There is a parallel between this phenomenon and the control of behavior on second-order schedules of positive reinforcement with nonpaired brief stimuli.

Key words: random-interval schedule, fixed-time shock, brief stimuli, second-order schedules, lever press, rats

Early investigations of the conditions under which a previously neutral stimulus can acquire reinforcing properties relied heavily on experimental paradigms in which the stimulus was first paired with a primary reinforcer and then tested for reinforcing effects. Procedures of this type proved unsatisfactory because the association between stimulus and primary reinforcer was broken in the test phase, and any acquired effects of the stimulus rapidly diminished. One solution to this problem is to maintain the association between the putative conditioned reinforcer and the primary reinforcer, but to take other steps to control or minimize the direct effect of primary reinforcement on the operant behavior under study (Mackintosh, 1974).

To this end, second-order schedules have been investigated. Kelleher (1966) has defined a second-order schedule as one in which "a pattern of behavior engendered by a schedule contingency is treated as a unitary response that is itself reinforced according to some

schedule of primary reinforcement" (p. 476). For example, the schedule might comprise fixed-interval (FI) components each of which ends with a response-produced brief stimulus, and performance under this unit schedule might be reinforced with food on a fixed-ratio (FR) schedule. On these schedules, either every unit schedule ends with the brief stimulus which is thus paired with the reinforcer occasionally, or else the brief stimulus is only presented following units which are not reinforced (nonpaired procedure). Both types of schedule have been found to maintain performances appropriate to the unit schedule following reinforcement or brief stimulus presentation, although some studies found that the nonpaired brief stimulus procedure is less effective than the paired brief stimulus procedure (see Gollub, 1977, for a review). Corfield-Sumner and Blackman (1976) showed that control by nonpaired brief stimuli was better when the overall schedule was variable rather than fixed.

If second-order schedules involving nonpaired brief stimuli successfully maintain behavior appropriate to the unit schedule, we might conclude that the nonpaired brief stimuli have acquired positive reinforcing properties. This would be surprising, however, as it is generally believed that stimuli become

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conditioned reinforcers through some form of positive association with primary reinforcers. Reviewing evidence from many types of studies, Fantino (1977) concluded that stimuli signaling reductions in time to primary reinforcement become conditioned reinforcers. If, on a second-order schedule, the unit schedule is reinforced on a variable ratio (VR), then nonpaired brief stimulus presentation does not have this function. An alternative view would be that the brief stimulus acquires purely discriminative properties. If the unit schedule is FI or FR, responses occurring shortly after the brief stimulus will never be reinforced and so responding should be suppressed. This process would account for the effective control of behavior by brief stimuli observed within second-order schedules. Convincing evidence that nonpaired brief stimuli have other properties appropriate to conditioned reinforcers is lacking (Fantino, 1977).

Most studies of second-order schedules have maintained behavior with positive reinforcement and used auditory or visual brief stimuli, but related procedures involving aversive stimuli have been devised. For example, Stubbs and Silverman (1972) used electric shock as the brief stimulus in a second-order schedule with pigeons. In a more radical departure, Byrd (1969, 1972) showed that in cats and monkeys responding could be maintained solely by second-order schedules of response-produced shock. Finally, Hake and Azrin (1965) demonstrated conditioned punishment of food-reinforced key pecking of pigeons by a stimulus that was occasionally paired with shock.

The present study addressed various issues concerning second-order schedules and aversive control by superimposing response-independent shocks and brief stimuli on a schedule of food reinforcement. The preliminary training was similar to that of LaBarbera and Church (1974). They trained rats to lever press for food on a random interval (RI) 1-min schedule and subsequently superimposed brief noncontingent shocks at regular intervals of 1 min or 2 min (fixed time, FT, 1 min and 2 min schedules), or at irregular intervals averaging 1 min. Under either FT schedule, but not the irregular schedule, responding was rapid immediately after shock and declined through the interval, producing a "reversed scallop" (compared with positively reinforced FI behavior). In the present study rats were trained

on an RI 64-sec schedule of food reinforcement upon which FT 3-min response-independent shock was superimposed. Subsequently, a quarter of the scheduled shocks were replaced by tone presentations. The schedule thus produced can be described as an FT percentage shock schedule with nonpaired brief stimuli, that is FT 3-min (75% shock, 25% brief stimulus). It resembled a second-order schedule except that there were no contingencies between operant responses and either shock or tone presentations.

As the RI food reinforcement schedule remained in effect, the procedure of adding the FT shock or FT percentage shock schedules generated conditioned suppression. Normally, conditioned suppression is studied by presenting shock during or at the termination of an exteroceptive stimulus (see Blackman, 1977, for a review), but here as in the previous studies of LaBarbera and Church (1974) and Hendry, Yarczower, and Switalski (1969) the shocks were delivered at fixed time intervals. Neither of those studies, however, investigated the effects of replacing some of the shocks with another stimulus.

The main purpose of the present experiment was to see whether behavior was maintained in a similar fashion following the brief stimulus as following shock on the FT percentage shock schedule. Later in the study, the schedule was modified in several ways to see whether the brief stimulus, which had never been paired with shock, had acquired the same properties as shock.

METHOD

Subjects

Five experimentally naive adult male hooded rats were used. They were caged singly with water freely available and maintained at approximately 80% of their free-feeding body weights by feeding after experimental sessions. One subject (R14) died part way through the experiment.

Apparatus

Two rat test chambers (Campden Instruments Model CI 410) were used. Each chamber (24 cm long, 22 cm wide, 20 cm high) was illuminated by a 2.8-W bulb located in the center of the roof and was encased in a ventilated metal chest to mask extraneous noise.

Ventilating fans gave a background noise level of 72 dB in each chamber. Two stainless steel levers protruded 2 cm from the front walls, 3.2 cm above the grid floor, and 11 cm apart. The levers required a downward force of about .1 N to operate. Only the left levers were used in this study. Two 2.8-W stimulus lights were situated 12 cm above the levers, and a third was midway between the levers, 15 cm above the floor. A 5-cm, 35-ohm speaker was mounted above the chamber roof and could present a 5-Hz clicker stimulus or a 500-Hz 92-dB tone. Scrambled shock could be delivered to the grid floor, made of stainless steel rods 1.3 cm apart, from a constant current shock source (Campden Instruments Model 521C). Liquid food was delivered by a motor-driven dipper into a recessed tray situated between the two levers at floor level. The tray was covered by a lightly hinged clear plastic flap and was illuminated by a 2.8-W bulb during reinforcer delivery. A Nova 2 digital computer programmed contingencies and collected data.

Procedure

The sequence of conditions and numbers of sessions are given in Table 1. The lever press response was shaped using 3-sec access to .1 ml of 5% sucrose solution (by weight) as the reinforcer. Interreinforcement intervals were then increased in a series of steps to the RI

64-sec schedule used in the experiment. When response rates had stabilized, FT 3-min brief shocks were superimposed on the food reinforcement schedule. Shock intensity was increased from .1 to .5 mA over a number of sessions and remained at .5 mA thereafter; shock duration was .5 sec throughout. Each session comprised 20 3-min periods, or cycles, terminating in shock; a 3-min timeout period separated the first 10 cycles and the last 10 cycles. During timeout the houselight was switched off, and no reinforcements were available for lever pressing. Over the last 10 sessions in this condition, shock was omitted at the end of randomly selected cycles on four or five occasions in total for each rat.

When behavior had stabilized, the FT shock schedule was changed so that 75% of cycles ended with shock, and the other 25% ended with a .5-sec tone. All nonprobe conditions were continued to stability, which was deemed to have occurred when no rat showed an increasing or decreasing trend in overall response rate or in response patterning over five sessions.

The combination of the RI 64-sec food-reinforcement schedule and the schedule of shock and tones then formed the baseline for various subsequent conditions. After extended training on the baseline, there were several conditions in which probe stimuli were presented occasionally. In the 1-min probe condition either a shock or a tone was occasionally presented 1 min after the beginning of a 3-min cycle. Over a period of five sessions there were 16 probes in randomly selected cycles. A shock probe occurred five times in a cycle beginning with a shock and five times in a cycle beginning with a tone, and a tone probe occurred three times in a cycle beginning with a shock and three times in a cycle beginning with a tone. The procedure in the 2-min probe condition was identical except that the probes occurred 2 min after the beginning of a 3-min cycle. In the 1- and 2-min probe condition, the same probe (shock or tone) occurred twice, at 1 min and 2 min within the same 3-min cycle. The tone probes were presented less often than the shock probes, and the total number of probes was low, to minimize disruption of the baseline behavior.

In the remaining conditions, stimuli were paired with shock or tone presentations and then occasionally presented alone. In the first

Table 1

Sequence of experimental conditions and numbers of sessions in each.

Condition	Subject				
	11	13	14	25	26
RI 64-sec food reinforcement	20	20	20	20	20
RI 64-sec food reinforcement + FT 3-min shock	40	30	30	30	30
Baseline: RI 64-sec food reinforcement + FT 3-min (75% shock, 25% brief stimulus)	50	35	35	40	40
1-min probes	5	5	5	5	5
Baseline	3	3	3	3	3
2-min probes	5	5	5	5	5
Baseline	3	3	3	3	3
1- and 2-min probes	5	5	5	5	5
Baseline	10	12	12	10	10
Stimulus-shock pairings	12	12		13	13
Probe stimuli	3	3		3	3
Baseline	5	5		5	5
Stimulus-tone pairings	20	20		20	20
Probe stimuli	3	3		3	3
Baseline	25	25		25	25

of these conditions a 4-sec stimulus (clicker for R11 and R13, flashing light for R25 and R26) preceded half of shock presentations. On those occasions there was a 2-sec interval between stimulus offset and shock onset. A probe condition followed. On five occasions, distributed across three sessions, the stimulus was presented alone at the end of a cycle scheduled to end with the stimulus and shock. In the next condition, a 4-sec stimulus preceded 75% of the tones, presented in the same fashion as before. The stimulus for each rat (flashing light or clicker) was the one not used previously. Following this was another probe condition. On five occasions, distributed across three sessions, tone was omitted and the stimulus was presented alone at the end of a cycle scheduled to end with stimulus and tone.

Sessions on the baseline schedule were interspersed between conditions, and the four remaining rats were returned to baseline for 25 sessions in the final condition of the experiment. The fifth rat (R14) died before the stimulus-shock condition.

RESULTS

Typical cumulative records from the second condition, in which FT 3-min shock was superimposed on the RI 64-sec food reinforcement

schedule, are shown in Figure 1. The recorder pen stepped when a lever press occurred, reset when a shock was delivered, and deflected downwards briefly during sucrose delivery. The records are each of a complete session of 20 cycles with timeout in the middle, as shown in the figure. Arrows indicate where shock was omitted at the end of a cycle; on those occasions the recorder pen did not reset.

The records show negatively accelerated response patterns on most cycles, with high response rates after shock and suppression of responding before shock. When shock did not occur at the beginning of a cycle, responding was usually suppressed until the next shock. This can be seen in two ways in Figure 1: very little responding occurs in the first cycle of the session, and no responding occurs following omission of shock. Following timeout the effect is less clear cut, but R11 shows complete suppression until the first shock.

Figure 2 gives responses in 30-sec segments of the 3-min shock cycle and shows that behavior was highly consistent across subjects with a pronounced deceleration in rate through the cycle. The data presented are the means of the last three sessions. (In other phases of the experiment, means are based on the last five sessions in a condition, but in this

Fig. 1. Cumulative records for three rats with FT 3-min shock superimposed on RI 64-sec food reinforcement. Each record is for a whole session consisting of 10 3-min cycles, 3-min timeout, then 10 3-min cycles. The pen reset when shock was delivered and hatch marks indicate food reinforcements. On the bottom record, shock was omitted at the arrowed points.

Fig. 2. Rate of responding of each rat in successive 30-sec periods of the 3-min interval between shocks. Bars indicate standard deviations for the three sessions that were averaged.

condition partial loss of data on some sessions prevented this.) The bars indicate standard deviations of the session means.

When the percentage shock and tone schedule was introduced, the tone initially had the same effect as omission of shock had previously. That is, responding remained suppressed throughout the next 3 min until shock occurred. Over the first five sessions, however, during which there were a total of approximately 25 tone presentations, the tone came to acquire properties similar to those of the shock. Figure 3, upper panels, shows the eventual performance for all subjects. Data are the means and standard deviations of the last five sessions in this condition. The tone (dashed lines) maintained similar patterns of behavior to the shock (solid lines), and there were no differences between responding after shock and after tone that were consistent across subjects. The lower panels of Figure 3 show similar data for the baseline condition at the very end of the experiment. Comparing the upper and lower panels shows little change in response patterns, although approximately 100 sessions separate the two sets of data. Comparison of Figure 2, in which every cycle ended with shock, with Figure 3 shows that FT response patterns were consistent for individual rats across the whole experiment.

The results of the probes with tones and shocks are shown in Figure 4. Because there were no systematic effects of whether the probe

was tone or shock, or of whether the cycle started with tone or shock, data presented are the average of the 16 3-min cycles in each condition that included a probe stimulus, with bars indicating standard deviations. Arrows indicate the points at which probe stimuli occurred. Although only a small number of probes were presented to avoid disrupting the negatively accelerated patterns of responding, variability did tend to increase (e.g., R14 in final probe condition and R25 in 2-min probe condition). However, clear effects of probes can be seen by comparing performances in Figure 4 with those before the probes were introduced (upper panel, Figure 3). At the point where the 1-min probe occurred, between the second and third sixths of the 3-min cycle, response rate declined in nine out of 10 of the curves shown for the baseline condition, but in only five out of 10 curves when the 1-min probe was presented. At the point where the 2-min probe occurred, between the fourth and fifth sixths of the cycle, response rate declined in 10 out of 10 cases in the baseline condition, and increased in 10 out of 10 cases when the 2-min probe was presented. We may therefore conclude that probe stimuli increased the low rate of responding when presented after 2 min of the cycle and tended to delay the decline in response rate when presented after 1 min of the cycle.

The effects of stimulus-tone and stimulus-shock pairing procedures are shown in Figure

Fig. 3. Upper panels: performance following shock (solid lines) or tone (dashed lines) after initial training on the FT percentage shock schedule (baseline condition). Bars indicate standard deviations for five sessions, except where numerical values are given. Lower panels: equivalent data from final training on the second-order schedule.

Fig. 4. Performance on cycles in which probes were presented. Arrows indicate where probes occurred. Standard deviations for all 16 probes are indicated by bars. In the lowest panels probes were presented at both 1 min and 2 min.

5. When a stimulus was paired with tone (lower panel), the response pattern was well maintained following stimulus and tone presentation or following the stimulus alone. When a stimulus was paired with shock, however, the response pattern appeared following stimulus and shock, but not when the stimulus was presented alone. In the latter case, responding was greatly suppressed during the next 3 min. This effect resembles that found when shock was omitted in the FT shock condition (Figure 1) or when the tone was first introduced. To confirm that the stimulus paired with shock did affect the rats' behavior (although it did not change response rate), videorecordings were made of some sessions in which stimuli paired with shock were presented. All rats showed clear behavioral changes at stimulus onset, and the behavior observed often included freezing.

Within-session performances on the base-

line schedule were analyzed in closer detail. A possible contributing factor to the peak in responding at the beginning of a cycle was that the suppression at the end of the previous cycle makes it very likely that a reinforcement had been set up on the RI 64-sec food schedule. To determine whether local rate of food reinforcement was controlling local response rate, the number of reinforcements and the number of responses in 10-sec intervals over the first minute of the cycle were compared. It was consistently found that following both tone and shock the local reinforcement rate was highest in the first 10 sec and then roughly constant, whereas the local response rate was lowest in the first 10 sec and then roughly constant. There was, therefore, no positive correlation between local response rate and reinforcement rate, and it is unlikely that a local increase in reinforcement rate caused the peak in responding at the beginning of cycles.

Fig. 5. Upper panels: performance following stimulus and shock presentation (solid lines) or stimulus alone (dashed lines). Lower panels: performance following stimulus and tone presentation (solid lines) or stimulus alone (dashed lines).

Every session comprised 20 3-min cycles ending in tone or shock, with a 3-min timeout period occurring half way through the session. This meant that the first cycle of the session and the first cycle of the second half of the session differed from the others in that they were not initiated by a tone or shock. As illustrated in Figure 1, responding in the first cycle of the session was more or less totally suppressed, whereas responding in the first cycle of the second half showed the usual pattern. This phenomenon was investigated by occasionally beginning a session with a shock rather than simply houselight onset. This procedure increased the response rates in the first cycle of the session to approximately half that typically seen in the first cycle of the second half. Initiating the session with a tone had less consistent effects. For two rats (R11 and R13) rate increases were similar to those produced by shock; for the other two (R25 and R26), response rate remained near zero.

DISCUSSION

A brief auditory stimulus that was sometimes presented on an FT shock schedule in place of the shock came to maintain negatively accelerated response patterns closely resembling those occurring after shock. This behavior developed although the stimulus was never paired with shock. There is a parallel between this phenomenon and the control of behavior on second-order schedules in which the unit schedule is reinforced on a VR schedule and nonreinforced units end with a nonpaired brief stimulus (e.g., Corfield-Sumner & Blackman, 1976). In both cases brief stimulus presentation occurs unpredictably and signals that another time interval must elapse, or unit schedule be completed, before the next occasion at which shock, or the reinforcer, may be received. These conditions appear to be sufficient for the brief stimulus to maintain a similar pattern of behavior to the FT shock or positive reinforcement schedule.

After a number of sessions, control by the brief stimulus, a tone, and shock was almost identical (see Figure 3). This powerful effect was obtained with a nonpaired brief stimulus that is very short (.5 sec) relative to the values found to be most effective in second-order schedules of positive reinforcement. Cohen, Hughes, and Stubbs (1973) found that control

by a brief stimulus improved considerably as its length increased from .5 sec to 8 sec, and Stubbs, Vautin, Reid, and Delehanty (1978) reported similar findings with nonpaired brief stimuli. The tone acquired control very quickly in the present study, although it was presented an average of only five times each session.

Negatively accelerated response patterns have previously been reported when FT shock has been presented to rats lever pressing for food (Hendry, Yarczower, & Switalski, 1969; LaBarbera & Church, 1974) and when FI punishment with shock has been presented to pigeons key pecking for food (Azrin, 1956; Silverman, 1971). In all these studies, the patterns of behavior could have been generated by suppression of responding when shock was imminent, or by facilitation during safe periods. However, Hendry et al., using clock stimuli, and Silverman, using multiple or chained schedules, introduced stimuli associated with preshock and safe periods and found that responding was mainly facilitated during safe periods. Similarly, in variants of conditioned suppression procedures in which the conditioned stimulus (CS) or the shock itself signaled a shock-free period, responding was most frequent during the CS or following the shock, respectively (Davis & McIntire, 1969; Davis, Memmott, & Hurwitz, 1976).

The present study demonstrated the response-facilitating effects of signals of shock-free periods in several further ways. Prior to the introduction of brief stimuli, the shock on the FT schedule was occasionally omitted and responding was suppressed until the next scheduled shock. When brief stimuli were first introduced there was no responding in the period following a brief stimulus, but after a few sessions the negatively accelerated response pattern began to appear. Finally, shock or brief stimulus could elicit responding if presented as a probe at times when responding was suppressed. All these findings are consonant with the view that responding was facilitated by stimuli (including shock) that signaled shock-free periods, then gradually declined to zero and remained suppressed until another such stimulus occurred.

At first sight, the results of pairing new stimuli, clicker and flashing light, with tone and shock do not fit with this analysis. Stimulus-shock and stimulus-tone presented on the

FT schedule both produced typical negatively accelerated response patterns, but only the stimulus that had been paired with tone elicited responding when presented alone. After the stimulus that had been paired with shock, responding remained suppressed. Conditioning to that stimulus had occurred, however, because freezing and other types of behavior typically elicited by stimuli preceding shock were observed during the stimulus (cf. Hunt & Otis, 1953). This difficulty is resolved by noting that the preshock stimulus did not in fact signal a shock-free period. Except on a small number of test trials, it was immediately followed by shock and would not therefore be expected to acquire the response-facilitating effect of the other stimuli.

In second-order schedules of reinforcement, Cohen, Calisto, and Lentz (1979) found that brief stimuli that maintained patterns of responding only had reinforcing effects when they had been paired with the reinforcer. In parallel, one would expect that the tone in the present study would not have acquired aversive properties because it was not paired with shock. There was some evidence for this, in that the preshock and pretone stimuli had different effects on behavior, and the preshock stimulus was clearly aversive. Furthermore, the pretone stimulus would not have elicited responding when presented alone if the tone had been aversive as, according to the above analysis, only signals of safe periods elicited responding. It appears that scheduling a brief stimulus in place of some shocks on an FT schedule is sufficient for that stimulus to maintain responding in a similar fashion to the shock, but the brief stimulus does not become aversive.

REFERENCES

- Azzin, N. H. Some effects of two intermittent schedules of immediate and non-immediate punishment. *Journal of Psychology*, 1956, **42**, 3-21.
- Blackman, D. Conditioned suppression and the effects of classical conditioning on operant behavior. In W. K. Honig & J. E. R. Staddon (Eds.) *Handbook of operant behavior*. Englewood Cliffs, N.J.: Prentice-Hall, 1977.
- Byrd, L. D. Responding in the cat maintained under response-independent electric shock and response-produced electric shock. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 1-10.
- Byrd, L. D. Responding in the squirrel monkey under second-order schedules of shock delivery. *Journal of the Experimental Analysis of Behavior*, 1972, **18**, 155-167.
- Cohen, S. L., Calisto, G., & Lentz, B. E. Separating the reinforcing and discriminative properties of brief-stimulus presentations in second-order schedules. *Journal of the Experimental Analysis of Behavior*, 1979, **32**, 149-156.
- Cohen, S. L., Hughes, J. E., & Stubbs, D. A. Second-order schedules: Manipulation of brief-stimulus duration at component completion. *Animal Learning and Behavior*, 1973, **1**, 121-124.
- Corfield-Sumner, P. K., & Blackman, D. E. Fixed versus variable sequences of food and stimulus presentation in second-order schedules. *Journal of the Experimental Analysis of Behavior*, 1976, **26**, 405-413.
- Davis, H., & McIntire, R. W. Conditioned suppression under positive, negative, and no contingency between conditioned and unconditioned stimuli. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 633-640.
- Davis, H., Memmott, J., & Hurwitz, H. M. B. Effects of signals preceding and following shock on baseline responding during a conditioned-suppression procedure. *Journal of the Experimental Analysis of Behavior*, 1976, **25**, 263-277.
- Fantino, E. Conditioned reinforcement: Choice and information. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior*. Englewood Cliffs, N.J.: Prentice-Hall, 1977.
- Gollub, L. Conditioned reinforcement: Schedule effects. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior*. Englewood Cliffs, N.J.: Prentice-Hall, 1977.
- Hake, D. F., & Azrin, N. H. Conditioned punishment. *Journal of the Experimental Analysis of Behavior*, 1965, **8**, 279-293.
- Hendry, D. P., Yarczower, M., & Switalski, R. C. Periodic shock with added clock. *Journal of the Experimental Analysis of Behavior*, 1969, **12**, 159-166.
- Hunt, H. F., & Otis, L. S. Conditioned and unconditioned emotional defecation in the rat. *Journal of Comparative and Physiological Psychology*, 1953, **46**, 378-382.
- Kelleher, R. T. Conditioned reinforcement in second-order schedules. *Journal of the Experimental Analysis of Behavior*, 1966, **9**, 475-485.
- LaBarbera, J. D., & Church, R. M. Magnitude of fear as a function of expected time to an aversive event. *Animal Learning and Behavior*, 1974, **2**, 199-202.
- Mackintosh, N. J. *The psychology of animal learning*. London: Academic Press, 1974.
- Silverman, P. J. Chained and tandem fixed-interval schedules of punishment. *Journal of the Experimental Analysis of Behavior*, 1971, **16**, 1-13.
- Stubbs, D. A., & Silverman, P. J. Second-order schedules: Brief shock at the completion of each component. *Journal of the Experimental Analysis of Behavior*, 1972, **17**, 201-212.
- Stubbs, D. A., Vautin, S. J., Reid, H. M., & Delehanty, D. L. Discriminative functions of schedule stimuli and memory: A combination of schedule and choice procedures. *Journal of the Experimental Analysis of Behavior*, 1978, **29**, 167-180.

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