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An analysis of two extinction procedures for leverpress escape behavior

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Following leverpress escape training, 12 rats were exposed to one of two extinction procedures. For half of the subjects, the contingency between response and shock termination was broken and shocks were presented and terminated in a response-independent (RIT) manner. Each RIT subject's median escape latency obtained during training determined the duration of shock during extinction. For the second group of subjects, extinction consisted of withholding shock altogether. All subjects in the no-shock group and four of six RIT subjects ceased all lever contact by the end of the second extinction session. The remaining two RIT subjects continued to respond contiguously with shock for the maximum of 12 extinction sessions. Continuous recording of the force of all lever contact, however, revealed the uniform elimination of intertrial lever contact for all subjects, regardless of extinction condition. It is suggested that the response which terminates shock may depend upon intertrial lever contact, and that lever contact during this period, rather than contiguously with shock, is maintained by shock termination.

The purpose of this experiment is to evaluate the behavioral effects of two operationally different procedures for the extinction of leverpress excape behavior.

In previous studies dealing with the extinction of leverpress escape, extinction has variously been defined as the total withholding of shock (e.g., Boren, Sidman, & Herrnstein, 1959), or the continuous presentation of shock irrespective of the subject's behavior (e.g., Campbell, 1959). Although both of these procedures have been successful in eliminating the escape response, it is reasonable to question whether either constitutes an operationally appropriate extinction procedure (e.g., Coulson, Coulson & Gardner, 1970; Davis, Iriye, & Hubbard, 1973). For instance, Rescorla and Skucy (1969) have demonstrated a situation involving appetitive conditioning in which responding was more affected by the removal of food per se, than by the removal of the contingency between food and the response. The authors argued that the greater reduction of responding in the absence of food was not due to its superiority as an extinction procedure, but rather to the simultaneous removal of discriminative properties for responding which had been associated with food. In similar manner, the rate of extinction under a "traditional" procedure for escape extinction in which shock is withheld altogether may be related to the removal of a key discriminative stimulus (S^D) which previously occasioned escape responding.

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Since reinforcement for escape behavior is termination of shock, more of the original experimental conditions would be retained if extinction consisted of first presenting shock and then terminating it in a nonresponse contingent manner. As Rescorla and Skucy (1969) have suggested, when the contingency between behavior and reinforcement is broken, the specific response that is eliminated can reasonably be inferred to have been originally dependent upon the reinforcement contingency. The use of response-independent shock termination as an extinction procedure is therefore of value not only because it may reduce escape behavior, but also because of its heuristic advantage in identifying the previously reinforced component of the escape sequence. Several previous studies have employed such a procedure (e.g., Domjan & Rowell, 1969a, 1969b; Migler, 1963), but have not equated shock duration or intertrial interval values between conditioning and extinction phases.

In the present experiment, the effects of two extinction procedures, withholding shock altogether and terminating shock automatically according to the subject's previously determined median escape latency, are assessed. Because of the vast number of underlying differences inherent in these operations (e.g., presence vs. absence of cue properties of shock, arousal properties of shock, etc.) no direct comparison of their effects is implied. Rather, both procedures will be examined in order to determine their respective behavioral effects, as well as to allow each to elucidate something of the conditions which were previously effective in maintaining escape behavior.

METHOD

Subjects

Twelve experimentally naive male Wistar rats served as

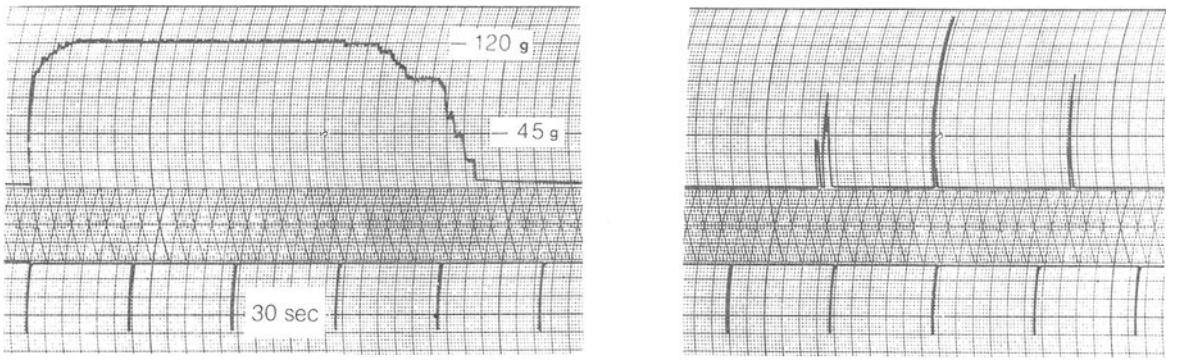

Figure 1. Response force record obtained for Subject NS-1 during extinction procedure in which all shocks were withheld following shock escape training. Each heavy ruling on vertical axis represents 15 g increment. In record at left, subject maintained lever contact at 120-g force for approximately 100 sec, then systematically decreased force of contact to 0-g over next 30 sec. This sustained contact was followed later in session by several brief spikes of lever contact (record at right) ranging in force from 40 to 143 g.

subjects. They were individually housed with food and water freely available in their home cages. At the beginning of the experiment, subjects were approximately 110 days old, with a mean weight of 365 g.

Apparatus

Subjects were tested in a Lehigh Valley grid shock chamber of dimensions 12 in. (30.5 cm) x 8 in. (20.3 cm) x 7.5 in. (19.0 cm) (length x width x height). The floor consisted of 15 stainless steel grids 3/16 in. (.64 cm) in diam spaced 3/4 in. (1.9 cm) apart. A constant current shock generator and scrambler (Campden Inst. Company) delivered a .4-mA shock to the grid floor, cage walls and lever of the chamber. A 1/2 in. (1.3 cm) x 2 in. (5.1 cm) response lever protruded 7/8 in. (2.2 cm) from the front cage wall, 2 in. (5.1 cm) above the grid floor.

In order to complement measurement of response frequency, a continuous record was made of the force exerted by the subject during contact with the lever. The amount of downward force was run through a transducer circuit (described in detail in Davis & Burton, 1974) and expressed as a pen deflection on a Beckman physiograph (Type RS). A schmitt trigger was calibrated to require a minimum downward exertion of 15-g force in order for a "discrete" response to activate programming and recording equipment.

Procedure

Phase I-conditioning. Prior to the first experimental session, subjects were trained to press the lever to terminate (escape) shocks of .4-mA intensity, which occurred 30 sec apart from offset to onset. This shaping session lasted 50 trials, by which time all subjects had reached the training criterion of 10 consecutive low latency (2 sec or less) escape responses. In order to establish stable escape behavior, all subjects were run for 12 daily escape sessions of 50 trials per session. The intertrial interval (ITI) remained at 30 sec and shock intensity was maintained at .4 mA.

Phase II-extinction. Following the final escape conditioning session, subjects were randomly divided into two groups of six. All subjects were comparable in terms of escape latencies, frequency of contact with the lever, and mean force of lever contact during the ITI. At the start of the first extinction session, both groups were given 10 regular escape trials.

After termination of the tenth shock, each group was exposed to a different extinction procedure. For Group RIT (response-independent termination), shock was programmed to occur every 30 sec. with its duration fixed at a value corresponding to the median escape latency which had been recorded for each subject during the final six conditioning sessions. These values ranged between .3 and .7 sec in duration. The second group (NS) received no shock deliveries during extinction. Response frequency and the force and duration of all lever contacts were recorded for subjects in both groups. Each extinction session for Group RIT lasted for a total of 50 shock deliveries. Extinction sessions for Group NS were carried out for a comparable period of time, approximately 25 min. All subjects were run for a minimum of two extinction sessions.

Because of the difference in extinction procedures, it was expected that persistence of escape behavior would be evidenced differently for the RIT and NS groups. Since subjects in the RIT group were regularly presented with shock, it was considered that any response contiguous with shock would represent a persistence of escape behavior. Accordingly, the criterion for Group RIT consisted of a maximum of three lever contacts contiguous with shock delivery over the final 20 trials. Since no shocks were presented for Group NS, resistance to extinction of escape behavior would be reflected in sustained responding during the latter portion of the session. Therefore, the extinction criterion for Group NS required the subject spend less than 10% of the second half of the session in contact with the lever. Subjects in both groups which failed to meet criterion were given a maximum of 12 extinction sessions.

RESULTS

Extinction Under the NS (no-shock) Condition

Extinction session 1. Prior to extinction, subjects in the NS condition spent an average of 77% of the session in contact with the lever. Lever contact was reduced during the first extinction session to 34%, and was confined almost exclusively to the first half of the session. The mean force of lever contact was 52 g, an increase of 9 g from that recorded during training sessions.

Seventy-nine percent of the total lever contact exerted by NS subjects was essentially stable, showing little fluctuation in force from moment to moment. For the purpose of classification, lever contacts were regarded either as stable (an average of less than one 10 g fluctuation in force per 5-sec period) or erratic (an

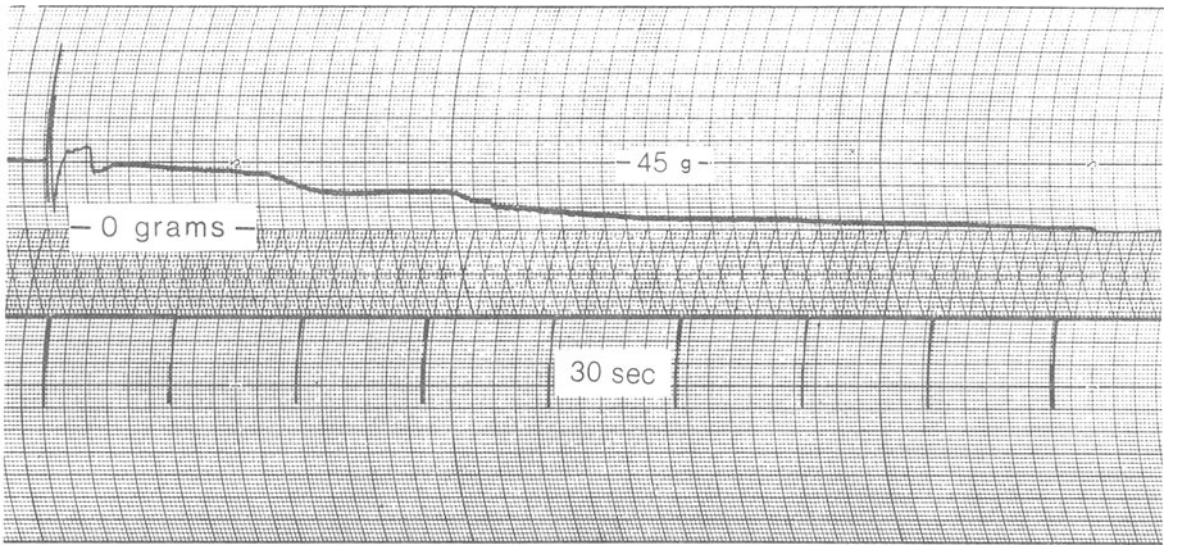

Figure 2. Response force record obtained for second subject (NS-4) under no-shock extinction procedure. The monotonic decline in force of lever contact from approximately 45 to 0 g took slightly more than 4 min.

average exceeding one 10 g fluctuation per 5-sec period).

Extinction session 2. During Extinction Session 2, two subjects in the NS condition made no lever contact whatsoever. The total lever contact for the remaining four subjects was reduced to a mean of 8% of total session time. The pattern of responding, however, remained largely unchanged. Lever contact again occurred during the first half of the session, with a mean force of 47 g. A preponderance (86%) of lever contact was classified as stable. By the end of Session 2, all subjects had reached the criterion for extinction.

The course of extinction. Subjects in the NS group showed two distinct patterns of lever contact during extinction: (1) sustained contact of fairly consistent force and (2) a systematic decline in response force from some initial value to 0 g. Four of six subjects gave both behavior patterns (e.g., Figure 1), showing stable contact for between 90 and 570 sec, and a decline in force for between 45 and 120 sec. A fifth subject (see Figure 2) showed only Pattern 2; i.e., a fairly systematic decline in response force over a period of approximately 270 sec. The remaining NS subject made several brief contacts with the lever totalling 390 sec, but showed no systematic decline in force over time. For all subjects, several brief spikes of contact with the lever were noted later in the course of extinction (e.g., Figure 1.).

Extinction Under the RIT (response-independent shock termination) Condition

Extinction session 1. As in the NS condition, the average amount of session time RIT subjects spent in contact with the lever was reduced from 81% during training to 35% during Extinction Session 1. Seventy-one percent of this contact was classified as stable. The mean force of lever contact was 39.5 g, which was lower than the force exerted by subjects in the NS condition ($p = .07$, randomization test).

Extinction session 2. During the second extinction session, one RIT subject made no contact whatsoever with the lever. The remaining five subjects reduced lever contact to a mean of 7% of total session time. Eighty-three percent of this contact was categorized as stable. The mean force of contact exerted on the lever was 38 g, which was not significantly different from the force recorded for subjects in the NS condition. By the end of the second extinction session, three additional RIT subjects had met the criterion for extinction. The remaining two subjects failed to reach the extinction criterion within the maximum of 12 sessions, although intertrial lever contact was eliminated for these subjects.

The course of extinction. The course of extinction for RIT subjects differed markedly from that of subjects in the NS condition. Rather than being confined to any one portion at the session, lever contact was evenly distributed throughout. As its frequency declined, lever contact was typically eliminated first during the intertrial intervals, and tended to persist for brief periods ($\bar{X} < 5$-sec) immediately following shock (see Figure 3).

The average duration of the longest single sustained lever contact was significantly shorter for RIT subjects[1] compared to subjects in the NS condition (65 sec vs 229 sec during extinction session one; 31 sec vs 137 sec during extinction Session 2) ($p < .05$, randomization test).

DISCUSSION

The present experiment has analyzed the effects of two different extinction procedures for leverpress escape behavior. Despite considerable operational differences (viz presence vs. absence of shock), the results indicated that both techniques are successful in reducing escape behavior.

The comparatively longer sustained lever contact recorded for NS subjects is reasonable in terms of the discriminative conditions which maintained escape behavior. An analysis of the S^D previously associated with intertrial lever contact reveals that

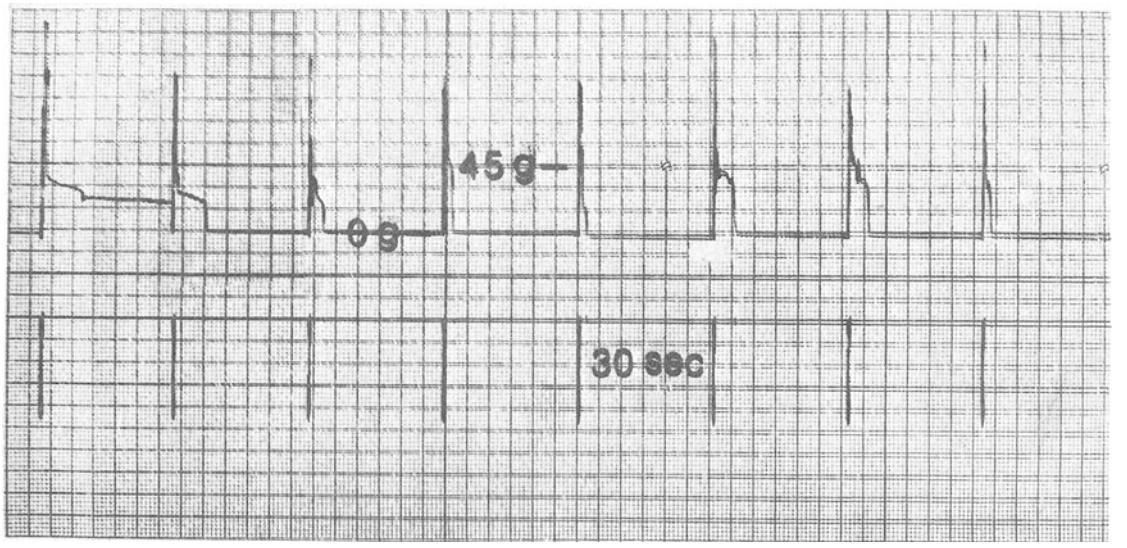

Figure 3. Illustrative record of lever contact observed under response independent shock termination (RIT) extinction procedure following leverpress escape training. Initial trial (at left) shows lever contact throughout intertrial interval, typical of performance during escape conditioning. Subsequent trials, more typical of effects of RIT extinction procedure, show virtual elimination of lever contact during intertrial interval and persistence of brief period of shock-contiguous responding. Each heavy ruling on vertical axis represents 15-g increment in force. Downward marks on lower record indicate shock deliveries separated by 30 sec.

this behavior was occasioned by "absence of shock", the very condition which was maintained throughout extinction for the NS group. Because "absence of shock" only remains a meaningful S^D within the context of occasional shock presentation (as during conditioning), the S^D properties of "absence of shock" were eventually eroded during NS extinction and lever contact was eliminated.

As previously noted, the RIT extinction procedure may be of value not only in eliminating escape responding, but also in identifying those components of the escape sequence which were specifically maintained by the shock termination contingency (Rescorla & Skucy, 1969). An analysis of which behavior was affected under the present RIT procedure reveals this to be intertrial lever contact, and not the "discrete" leverpress response which terminated shock. When the focus of extinction is therefore changed to intertrial lever contact, virtually all between-subject differences found under the RIT procedure are eliminated; i.e., behavioral variability appears primarily in terms of shock-contiguous responding.

Emphasis on intertrial lever contact during escape is not unique in the literature; in fact, this behavior has received growing emphasis in recent years. An analysis by Bolles and McGillis (1968) has suggested that what is actually reinforced during escape conditioning is freezing on the lever during the intertrial interval, and that a shock-induced lurch from the lever results in a "discrete" escape response. Documentation of this view of escape dynamics has been provided by Davis and Burton (1974), and Campbell (1962) has provided empirical support by demonstrating that trials on which a subject is in contact with the lever yield lower escape latencies than when the subject is off-lever at the moment of shock onset. It is therefore, not unreasonable to find that the RIT procedure in the present experiment directly affected intertrial lever contact insofar as this behavior may be functionally related to the response which terminates shock.

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NOTE

1. To allow comparison with data obtained under the NS (no shock) condition, the duration of lever contact by RIT subjects was adjusted to compensate for the brief "reflexive" break in sustained contact resulting from shock delivery (see Davis & Burton, 1974). For example, a sequence of continuous lever contact for three full 30-sec intertrial intervals, interrupted only by shock onset, would be categorized as a 90-sec contact.

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