

Self-punitive behavior in the rat during successive-discrimination "extinction" trials*

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Self-punitive locomotor behavior was studied by means of a within-Ss design. Following shock-escape training, rats were shocked in the middle of the runway on only half their extinction trials. One tone was presented on shock trials and another on nonshock trials. In opposition to a discrimination hypothesis, starting speeds as well as running speeds in every runway section, both preceding and following shock, were faster on shock trials than on nonshock trials. The data support the notion that enhancing the distinctiveness of punishment conditions may augment rather than weaken self-punitive behavior.

Recent investigations support the conclusion that rats may persist in self-punitive locomotor behavior even when the discriminability of the punishment zone has been deliberately enhanced by the introduction of distinctive stimuli. In one study (Brown, 1970), rats for which the walls of the shock zone were marked off by black and white striped panels perseverated in high-speed running across shock as long as did rats for which no additional cues were presented. In another investigation (Brown, Beier, & Lewis, 1971), the tactual and visual distinctiveness of the shock section was increased during "extinction" by covering all other sections of the grid with smooth black panels. Yet this operation failed to obliterate or even significantly to diminish the self-punitive effect. Moreover, this result was obtained in spite of the fact that the shocked Ss showed clear evidence of differential reactivity to the covered and uncovered sections of the floor.

In the present experiment, the effect of distinctive shock-signaling cues on self-punitive behavior was studied by means of a within-Ss design instead of the previously used between-Ss design. Following shock-escape training, randomly intermixed punished and nonpunished extinction trials were administered. One distinctive auditory stimulus (CS_{sk}) was presented on shock trials and a different tone (CS_{nsk}) was introduced on nonshock trials. The tones were turned on before an animal was dropped from the upper part of

the two-level startbox. The procedure resembled the conventional successive-discrimination learning paradigm, save that it was superimposed on an extinction-like phase following shock-escape training. Presumably, these conditions were favorable for the development of a discrimination between those trials on which shock would be encountered in the runway and those on which it would not. A conventional discrimination hypothesis (Mowrer, 1960; Dreyer & Renner, 1971) would presumably generate the prediction that the rats would proceed much more hesitantly in the presence of a tone that was always followed by punishment than when stimulated by a tone that was never associated with shock. However, one conception (Brown, 1970) of the effect of distinctiveness on self-punitive running includes the possibility that under some conditions, stimuli that are perfectly correlated with impending shock may enhance rather than degrade self-punitive running.

SUBJECTS

The Ss were 16 naive female albino rats (Sprague-Dawley derivatives), about 90 days old, from Carworth Farms, Inc., Portage, Michigan.

APPARATUS

The apparatus, described in more detail elsewhere (Brown, Martin, & Morrow, 1964), consisted of a grid-floored runway (183 cm long, 11.4 cm wide, 20.3 cm deep, inside), a grid-floored starting section (42 cm long) that matched the runway and was surmounted by a trap-door-floored startbox (22 cm long, 10 cm wide, 28 cm deep), and a large goalbox (45.7 cm long, 30.5 cm wide, and 20.3 cm deep). The walls and floor of the goalbox were painted with black and white squares (2.54 cm on a side) in a checkerboard pattern, whereas the walls of the runway, the goalbox, and the subflooring beneath the grid were painted a medium gray. Hinged Plexiglas lids covered the entire

apparatus, and the grid was made of 2.4-mm stainless steel rods at 1.27-cm intervals. Photocells and infrared light sources, located at the beginning of the runway and at intervals of 61 cm thereafter, served in conjunction with ancillary devices to provide measures of starting speed and of running speeds in each of the three 61-cm runway segments. The 60-Hz shock was controlled by a variable-voltage autotransformer and was fed to the grid through a series resistance of 10 K ohms. The shock voltages were measured at the grid with a dummy load of 100 K ohms simulating a rat. The voltmeter, which remained in the circuit at all times, had a full-scale calibration of 150 V ac and a sensitivity of 2,000 ohms/V. The pure tones used as CS_{sk} and CS_{nsk} during the discrimination-extinction phase were generated by two audio oscillators driving a 4-in. wide-range speaker mounted on the wooden end panel of the upper compartment of the startbox. A star-shaped pattern of 36 holes was drilled in that panel with a 4.8-mm drill to permit the sound to enter the starting chamber without undue attenuation. Under the normal running conditions of the experiment, both the 7-kHz and the 4-kHz tone had intensities of 60 dB (re .0002 dynes/cm²) as measured on the A scale of a General Radio sound level meter (Model 1551-C). The ambient noise level measured in the absence of the tones was 45 dB. The microphone was located about 5 cm in front of the end panel and slightly above the center of the speaker holes for these measurements. Both the trapdoor floor and the Plexiglas lid were closed.

PROCEDURE

On the day after their arrival in the laboratory and on the following day, the animals were handled individually for 2 min, during which they were put down and picked up three times. These taming procedures were administered at the hour at which experimentation was scheduled to occur.

On the 3rd and 4th days, each rat was permitted to explore the goalbox for 2 min, being placed therein and removed therefrom every 30 sec. Each of the four placements was in a different corner of the box. The lid of the goalbox was closed after each placement on the 4th day but not on the 3rd. The relatively noisy recording apparatus was not turned on until the 4th day.

The 5th day marked the beginning of shock-escape training which consisted of a series of trials involving progressively longer segments of the runway. For the first two trials, the startbox was placed next to the goalbox so that the animals could

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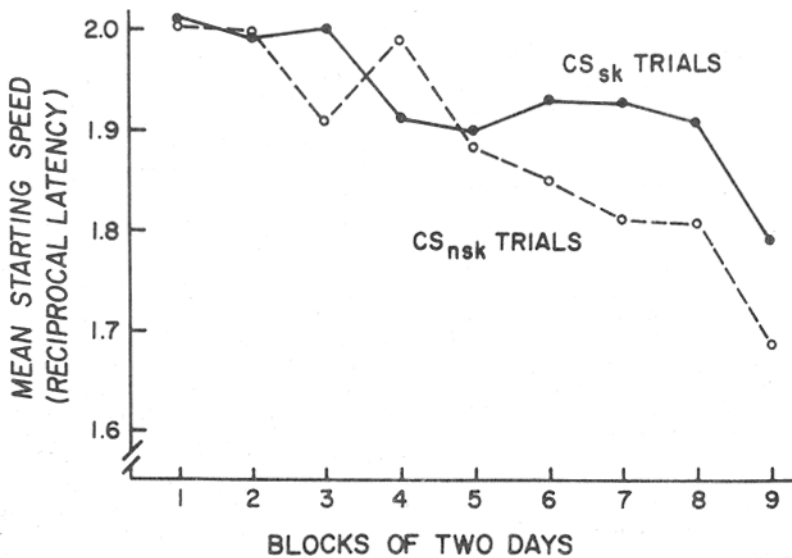


Fig. 1. Mean reciprocal starting times on trials when a tone (CS_{sk}) forewarned of shock in the middle of the runway and on trials when a different tone (CS_{nsk}) denoted no shock.

reach safety after traversing roughly 10 cm of electrified grid. Since the trapdoor floor of the startbox was hinged at the narrow end most remote from the goalbox, the animals tended, for the most part, to land about 10 cm from the nearest alley segment when dropped. On the third and fourth trials, the rats had to cross an additional 61 cm to reach the goalbox, and on the fifth and sixth trials, the length of the electrified segment was increased to 122 cm. Trials 7-10 involved the start section plus the entire 183-cm alley. The shock voltages were set at 40 V for Trials 1 and 2, at 45 V for Trials 3-6, and at 50 V for Trials 7-10. Ten additional shock-escape training trials exactly like Trials 7-10 were administered on the 6th day, followed by one more escape trial before the beginning of extinction on Day 7.

The successive-discrimination extinction procedure consisted of 10 daily trials on 5 of which shock was present in the middle 61-cm segment of the runway and on 5 of which no shock was administered anywhere. The following basic sequence was used to determine the order of shock (S) and nonshock (N) trials: SNSNNNSNSS. From this sequence, 10 different orders were generated by designating each of the ordinal positions of the sequence as a starting point. Each rat was assigned a different one of these 10 patterns each day for the first 10 extinction days, with 8 of the orders recurring over the last 8 days. Of the basic orders, 8 were assigned to the eight animals of each replication in such a manner that the number of shocked and nonshocked animals was

equal on each trial for every day. The experiment was run in two replications of eight Ss each by two Es.

For all animals, one tone was turned on when shock was to be presented in the middle segment of the runway and the other tone was turned on when no shock was scheduled to occur. For half the Ss, a 4-KHz tone signaled shock and a 7-KHz tone indicated no shock; for the other half, the higher tone was correlated with shock and

the lower with no shock. The tones were turned on 5 sec after a rat had been placed into the upper part of the startbox, and 10 sec later the trapdoor floor was released. The tones were terminated either when the animal intercepted the light beam at the goalward end of the middle 61-cm segment, or, if it did not reach that point, after 60 sec. Rats failing to enter the goalbox within 60 sec were removed from the runway. On the first such trial, the times, as recorded, for each completed segment (including start) were used as data unless they exceeded 15 sec, in which case a 15-sec score was assigned. Times for each segment not completed were computed by subtracting the total time of the completed segments from 60 sec and dividing the remainder equally among uncompleted segments. On all additional trials, a score of 15 sec was assigned to the start segment and to each of the three runway segments.

RESULTS

From the raw data, median starting times and median segment-running times for the five shock and five no-shock trials were computed for each rat for each day. Median starting times were transformed into simple reciprocals to provide starting speeds, whereas median segment times were converted into running speeds in cm/sec.

Starting Speeds

The means of the median starting speeds in the presence of the tones

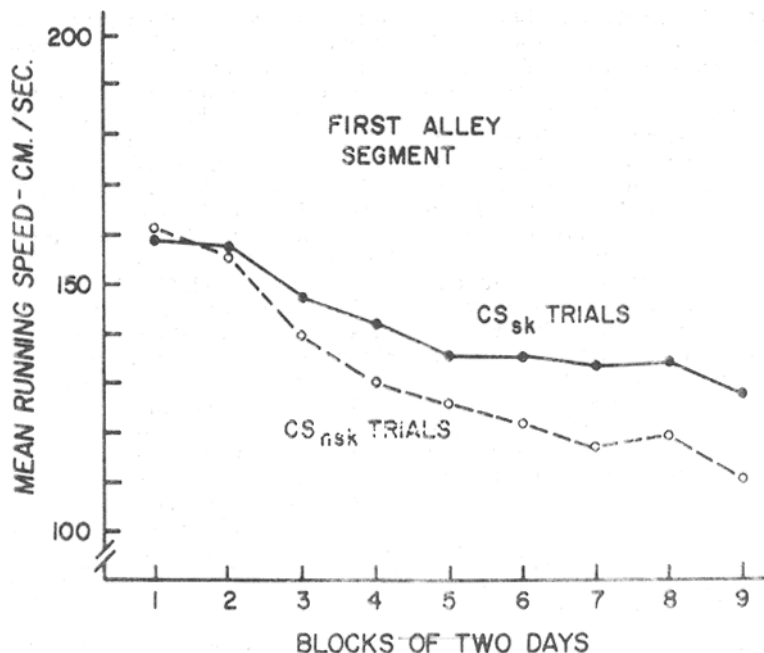


Fig. 2. Running speeds in the first 61-cm segment of the runway in the presence of shock-denoting (CS_{sk}) and nonshock-denoting (CS_{nsk}) tones. No shocks were present in the first segment on any of the trials plotted here.

that signaled either shock (CS_{sk}) or no shock (CS_{nsk}) are plotted over blocks of 2 days in Fig. 1. Though the starting speeds were about equal initially, they became unequal as training progressed, the terminal level being higher on CS_{sk} trials than on CS_{nsk} trials. Thus, the cue (CS_{sk}) that could be viewed as a "danger" signal led to faster starting than did the presumed "safety" signal. An analysis of variance of these data involving the factors of days, cues (CS_{sk} vs CS_{nsk}), and E yielded a significant effect for cues ($F = 6.41$, $df = 1/14$, $p = .024$) and a significant interaction of Days by E ($F = 2.22$, $df = 8/112$, $p = .031$). No other main effect or interaction approached significance. The interaction involving E is difficult to interpret. It is presumed to be of limited general significance, however, since none of the interactions with E in the analyses of running speeds (below) were significant.

Running Speeds

The mean, median running speeds in the first, second, and third alley segments are plotted in Figs. 2, 3, and 4, respectively. It is clear from these curves that in every segment and on nearly every block of days, the animals ran faster on CS_{sk} than on CS_{nsk} trials. The unusual nature of this differential reaction is underscored by the recollection that CS_{sk} always forewarned of shock, whereas CS_{nsk} always indicated the absence of shock. The data in these three figures were evaluated by an overall analysis of

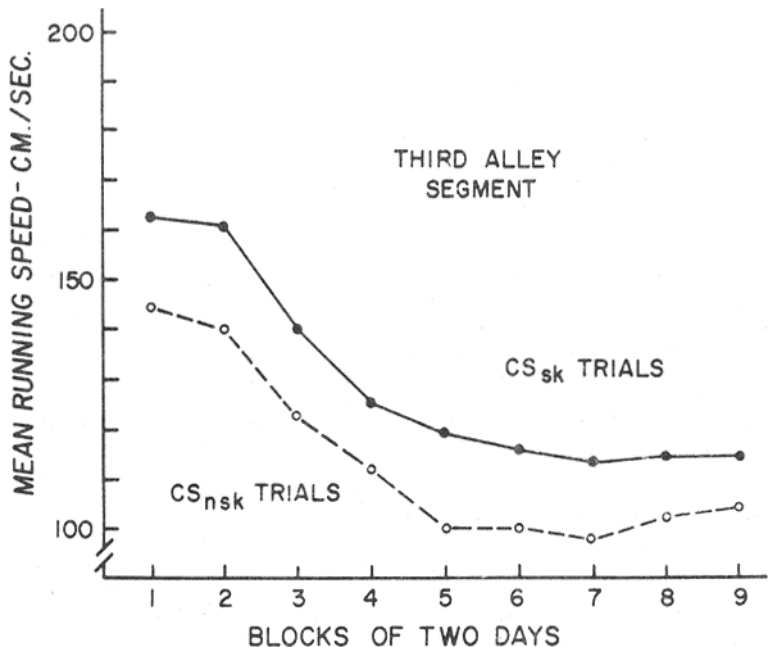


Fig. 4. Running speeds in the final runway segment on trials when either the CS_{sk} or the CS_{nsk} had been present throughout the first and second segments but were absent from the final segment.

variance involving the factors of cues, E, days, and alley segment. Days, cues, and alley segments emerged as highly significant sources of variance ($p < .001$ in each case), the respective F ratios and corresponding degrees of freedom being 10.17 (8/112), 49.32 (1/14), and 46.32 (2/28). In addition, the interactions of alley segment with

days, with cues, and with days and cues were all significant beyond the .001 level, the F ratios and degrees of freedom being 5.47 (16/222), 11.44 (2/28), and 5.91 (16/224), respectively. None of the other effects or their interactions reached conventionally accepted significance levels.

To illuminate the nature of these various interactions, the data from the three alley segments were analyzed separately. In each of them, the contributions of days, cues, E, and their interactions were evaluated. The following outcomes were obtained from the data of the first segment: days ($F = 5.26$, $df = 8/112$, $p < .001$); cues ($F = 13.13$, $df = 1/14$, $p < .005$); Days by Cues ($F = 4.87$, $df = 8/112$, $p < .001$). These outcomes coincide well with visual impressions provided by the curves plotted in Fig. 2. The speeds in the presence of the two CSs were about equal at first but soon diverged, with the rats running faster on CS_{sk} trials than on CS_{nsk} trials. Moreover, the development of the differential reaction over days was clearly superimposed upon a general decrease in speed. The highly significant Days by Cues interaction in the first segment data contrasts with the lack of a similar interaction in the data of the other segments (see below) and these outcomes, taken conjointly, provide the explanation for the triple Days by Cues by Segment found in the overall analysis.

The analysis of the second segment data, plotted in Fig. 3, produced a

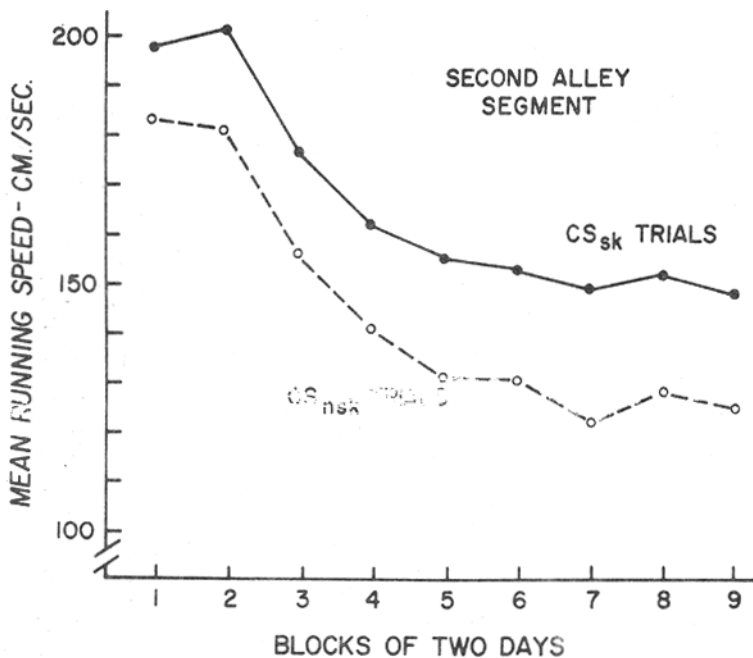


Fig. 3. Running speeds in the middle 61-cm section on trials when both the shock and the CS_{sk} were present and when only the CS_{nsk} was administered.

significant days effect ($F = 11.25$, $df = 8/112$, $p < .001$) and a significant cues effect ($F = 68.8$, $df = 1/14$, $p < .001$), but no other. The parallel nature of the curves in Fig. 3 is consistent with the lack of a Days by Cues interaction, the progressive decline of the curves is reflected in the days effect, and their separation is consonant with the significant cues outcome.

The analysis of the third segment data in Fig. 4 also yielded only two significant outcomes, one for days ($F = 14.10$, $df = 8/112$, $p < .001$) and the other for cues ($F = 33.11$, $df = 1/14$, $p < .001$). Again, the visually evident relations are consistent with these statistical results.

Comparisons of performance among the three segments revealed that running speed increased from the first to the second segment, both when shock was being administered on CS_{sk} trials and when it was not (on CS_{nsk} trials), and then decreased again in the final segment. The increase in speed from the first to the second segments on CS_{nsk} trials was significant ($t = 3.40$, $df = 15$, $p < .01$). Inasmuch as the tones terminated at the goalward end of the second section, differences in locomotor speeds in the third segment cannot be ascribed to the effects of the CSs, as such, but only to the aftereffects of their presence in the preceding two sections, coupled perhaps with aftereffects of shock.

Since the tones were counterbalanced in their relations to CS_{sk} and CS_{nsk} and since little theoretical interest attended the question of which tone was better, the contributions of tones, as such, were not partialled out in the above analyses. Analyses in which tone (high or low) was included as a separate factor were nevertheless carried out with the data from each segment. Only in one of these analyses was the tone a significant contributor to the variance and in only one did it interact significantly with another factor. Specifically, in the second segment, the interaction of tone with cues was accompanied by an F of 4.86, which, with 1 and 12 degrees of freedom, is significant at the .05 level. This reflects the fact that the high tone had a slightly greater tendency to elicit faster running when serving as the CS_{nsk} than did the low tone.

DISCUSSION

In the present experiment, preliminary shock-escape training was followed by both punished and nonpunished extinction trials administered in an intermixed order to the same rats. The middle third of the alley was electrified on half the trials but not on the other half. While the

animal was still in the startbox, one distinctive auditory stimulus was presented if shock was scheduled for that trial and a different tone was turned on if shock was not scheduled. Conditions suitable for the acquisition of differential reactions to the two auditory cues were thus present. Differential reactions were, in fact, acquired, but the animals started more quickly and ran more swiftly when forewarned of an impending encounter with shock than when provided with a CS that denoted the absence of shock. The results were thus consistent with the outcomes of previous studies (Brown, 1970; Brown, Beier, & Lewis, 1971), showing that increases in the distinctiveness of the shock zone failed to eliminate or even significantly to diminish the self-punitive effect.

One of the ways in which these seemingly counterintuitive results might be explained involves an appeal to an acquired-drive conception. Since the CS_{sk} consistently preceded shock, it should have acquired the capacity to evoke a classically conditioned emotional (fear) reaction having motivational properties. As a result, tendencies to run toward the goal elicited by apparatus cues could have been potentiated by the CS_{sk} . The CS_{nsk} , by contrast, having never been paired with shock, would have acquired no such facilitatory propensity and might even have acquired inhibitory power (cf. Rescorla, 1968). As a consequence, the CS_{nsk} should have been accompanied by slower starting and running speeds. This interpretation has much in common with Mowrer's (1947) original explanation of vicious-circle behavior and with subsequent extensions of his theory (e.g., Brown, 1969).

The acquired-drive notion is particularly appropriate as applied to starting speeds and to first segment running speeds. Shock was never present in the startbox or first segment to energize running, and any potentiation by postshock residual from prior trials is ruled out by the trial sequences used. These sequences were such that CS_{sk} and CS_{nsk} trials were preceded with very nearly equal frequency by shock on immediately antedating and on more remotely precedent trials. Running-speed differences in the second segment could, of course, have been due in part to the dynamogenic effects of shock on CS_{sk} trials. However, the animals also tended to speed up in the second section on shock-free trials, an effect that might be viewed as reflecting the power of the adjacent cues either to function as secondary motivators or to mediate the transfer of high-speed running from shock to nonshock trials.

An alternative explanation of these

results can be formulated that involves associative mechanisms but not the concept of acquired drive. On such a view, shock in the runway reinstates the tactual cues that were part of the conditioned stimulus complex during the preliminary shock-escape phase. These cues elicit vigorous forward-running reactions in the presence of the newly introduced CS_{sk} , and these reactions become conditioned to that stimulus with increasing strength as "extinction" continues. The CS_{sk} is also present in the startbox and first runway segment and serves to mediate the transfer of high-speed running to those segments in accord with the principle of stimulus generalization. Since shock is not present on CS_{nsk} trials, the vigorous forward movements are not conditioned to that stimulus and hence locomotion in its presence is slower. The net result is faster running in the early segments of the apparatus on CS_{sk} trials than on CS_{nsk} trials. The facilitation of running in the middle segment on CS_{sk} trials would be expected to appear at the outset of extinction because of the presence of shock, but should emerge gradually in the first segment as conditioning to the new stimulus compound progresses. This view can accommodate the facilitation of running in the third section if one assumes that the momentum gained in the presence of shock perseverates into the adjacent segment.

Dreyer & Renner (1971) have recently suggested that rats run self-punitively because they have failed to discern the fact that shock is no longer present in the startbox and first segment of the runway. For reasons that are not spelled out, shock in the runway is assumed to function not as punishment to deter running, but as an accelerator. That is, shock not only causes the rats to run quickly through the electrified segment, but it also causes them to run so rapidly through the nonshock segments on the following trial that they have insufficient time to note that shock is no longer there. Hence they continue, stupidly, to run from the safe region through shock to the safe goalbox. The nonpunished rats, having no shock to accelerate them, have more time to find out that shock is absent, and when they do, they stop running.

Perhaps the major weakness of the Dreyer-Renner conception is that they have failed to propose independent objective criteria for deciding when an animal has, in fact, acquired the requisite knowledge concerning the absence of shock. Such empirical referents as can be identified in their exposition make it trivially circular. Rats are said to run self-punitively

because they have failed to detect or discern the lack of shock in the initial sections of the runway. But *the only objective basis for the claim that the rats have failed to make the discrimination is the persistent self-punitive running that is itself attributed to the failure to discriminate.*

Dreyer and Renner have also failed to specify the details by which the acquisition of a "discrimination" becomes transformed into action. With human Ss, verbal reports are commonly used as the criterion for asserting that they "know" when a response will be followed by punishment. But paradoxically, the possession of such "knowledge" does not always lead to "rational" actions or to the abandonment of behaviors that eventuate in pain. Granting this, what possible reason can be adduced for supposing, as do Dreyer and Renner, that a rat will *necessarily* give up self-punitive running as soon as it gains insight into the response-punishment contingency? Clearly, Dreyer and Renner's theory is vulnerable to the same criticism that Guthrie (1935) leveled against Tolman for his neglect of the problem of how *realizations* (sign-Gestalt-expectations)

are translated into *action*. By likewise failing to bridge the gap between *knowing* and *doing* in the rat, Dreyer and Renner have left it, as did Tolman, interred in thought.

On the present view, to say that an organism is discriminating is to say that it is reacting differentially either to the presence and absence of a stimulus or to two different stimuli. Discriminating stands firmly in the position of a dependent variable. Rats that travel slowly through the initial shock-free segments of a runway and then accelerate in the shock zone are undeniably discriminating, by this definition, but they are also behaving self-punitively. The Ss of this experiment, by virtue of their differential reactions to the two CSs, were discriminating the set of shock-forewarning conditions from the set of safety-indicating conditions. Still they persisted for many trials in running from a safe region into, and across, shock. Moreover, in a dramatic reversal from predictions based on an overly simplistic human analogue, they started more quickly and ran more rapidly in the presence of the CS_{sk} than in the presence of the CS_{nsk}. These findings strengthen the suggestion (Brown, 1970) that

self-punitive behavior may even be enhanced, on occasion, by changes in the environment designed to make the contingent relation of shock to response patently unambiguous. Our findings also raise serious doubts as to the utility of purely ad hoc mentalistic interpretations of self-punitive behavior.

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BOSSOM, J. The effect of lesions in caudate nucleus and superior colliculus upon adaptation to prisms in monkey. *Psychonomic Science*, 1972, 26, 255-256. On page 255, col. 3, 7 lines from bottom—123 mm should read 12.3 mm; 6 lines from bottom—166 mm should read 16.6 mm. On page 256, col. 1, line 7—13 mm should read 1.3 mm; 11 lines from bottom—245 mm should read 24.5 mm; and 7 lines from bottom—87 mm should read 8.7 mm.