NOTE ON RESPONSE DIFFERENTIATION DURING A SIMPLE DISCRIMINATION¹

J. M. NOTTERMAN and A. H. BLOCK

PRINCETON UNIVERSITY

Apart from other requirements set by the experimenter, bar-pressing situations have at least one characteristic in common: the animal must learn how hard to press the bar if it is to procure reinforcement. (Notterman, 1959, has described the emission of forces over the course of operant level, CRF, and extinction.) This requirement is to be distinguished from additional demands placed upon the organism in the typical experiment involving discrimination of exteroceptive stimuli. In the latter instance, and in addition to the intensive requirements, the animal must learn when to press and when not to press. The eventual disparity in S^D - S^A rate of responding has been used as an indicator of the extent of the discrimination thus established (Frick, 1949; Dinsmoor, 1951; Smith & Hoy, 1954).

Since the organism is not reinforced in S^D unless it presses hard enough, and since it goes unreinforced in S^A no matter how hard it presses, experiments concerned with the establishment of a discrimination to exteroceptive stimuli inevitably and concomitantly involve the possibility of interaction between the "when-to-press" and "how-hard-to-press" aspects of bar-pressing behavior. This report is a preliminary attempt to describe the relation between response differentiation and stimulus discrimination during the development of stimulus discrimination.

METHOD

By means of a pair of strain gauges used as a force pick-off, the force-related voltages characteristic of successive bar-pressing responses during the establishment of a discrimination were passed through the amplifiers of an analog computer, and the peak force of each response noted. (Apparatus details are available in Notterman, 1959.) A total of 15 discrimination sessions was given, preceded by two unreinforced basal or operant-level sessions. In order to preclude any temporal conditioning, each of the daily sessions consisted of periods of S^D and S^A having the following irregular sequence: 80 seconds of S^D ; 80 of S^A ; 40, S^D ; 20, S^A ; 20, S^D ; 160, S^A ; 10, S^D ; 40, S^A ; 160, S^D ; and 10, S^A . This sequence was programmed on a continuous tape such that daily sessions could begin at any point in the schedule and run either forward or backward. A daily experimental session consisted of two entire sequences, making for a total time of 20 minutes and 40 seconds. A CRF schedule was maintained during S^D , with a required force of 3.0 grams minimum for both reinforcement and recording, and with The P. J. Noyes Company 0.45-milligram pellets as reinforcements.

RESULTS AND DISCUSSION

Figures 1 and 2 represent the data for the first Wistar rat exposed to this procedure; they are typical of data obtained from some 20 additional animals during a related parametric study currently underway as a dissertation by the junior author.

The first figure reveals the customary S^D - S^A separation in number of responses emitted during each session as a function of successive discrimination sessions. The S^D responding is

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Figure 1. Number of responses emitted during operant-level and discrimination training.

characterized by a rapidly increasing rate until an asymptotic level is reached; there, the rate, which is limited by the subject's eating behavior, remains fairly stable. The S^A responding decreases. This decrease is directly attributable to the extinction process characteristic of S^A behavior. The second figure gives the mean peak force per session for the very same responses tallied in Fig. 1. The S^D-S^A separation is again observed; but, in this case, the S^A data lie *above* the S^D data. Therefore, the animal pressed harder (albeit less often)

Figure 2. Mean peak forces emitted during operant-level and discrimination training.

during S^A than during S^D . A rational interpretation of these observed higher S^A force levels probably lies jointly in the extinction operations characteristic of discrimination training, and in the induction effects due to continued S^D reinforcement. The latter explains why the animal continues to press during S^A ; the former (extinction during S^A) accounts for the high S^A force levels.

In general, the data are taken to indicate the following. 1) As expected, response differentiation does develop during the formation of a simple discrimination. 2) The disparity between S^D and S^A mean peak-force emission occurs shortly after discrimination training begins, and may actually precede the development of S^D - S^A rate disparity. (Further evidence on this point is currently being accumulated.) 3) The disparity between S^D and S^A forces seems to be invariant with continued discrimination trials. This invariance is not due to a lack of apparatus sensitivity, since the system is sufficiently sensitive to detect 0.1-gram variations. We believe the phenomenon of force invariance to be a real one, and that it reflects the very rapid discrimination of the force required to obtain reinforcement (Notterman, 1959). In short, the animal learns much sooner how hard to press, rather than when to press and when not to press. The apparent contradiction to this, namely, the consistently high forces during S^A , must be explained on other grounds. Although other explanations are possible, we are at present speculating that a process of "incidental directional reinforcement" is operating. This interpretation rests upon the fact that should an animal *not* press hard enough to reach the required force criterion during periods of CRF, it will of course go unreinforced. If, on the subsequent response, the organism presses with lower force, it will still go unreinforced; but if it presses in a higher direction, it *will* receive reinforcement, assuming that the criterion has been reached. In short, the higher force levels characteristic of periods of nonreinforcement (e.g., extinction or S^A) may be the result of the organism-administered "incidental directional reinforcement" obtained during periods of reinforcement (or S^D). 4) The fact that S^D - S^A force disparity is invariant with continued discrimination trials suggests that force measures have limited usefulness in depicting the formation of a "go-no go" discrimination to exteroceptive stimuli.

SUMMARY

Force measures of bar-pressing responses were obtained during the formation of a simple light-dark discrimination. The data obtained reveal that force emission during the "dark" (unreinforced) cycle is consistently higher than that for the "light" (reinforced), even though bar pressing is less frequent during the dark cycle. An attempt is made to account for these higher forces by means of a process termed "incidental directional reinforcement."

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