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SHORT NOTE

RESPONSE FEEDBACK AND RESPONSE DURATION DIFFERENTIATION IN THE ALBINO RAT

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Twelve male albino rats were reinforced for lever press durations of 0.5, 1.0, 1.5, 2.0 and 2.5 seconds. Half of the subjects (F) received an auditory feedback after non-reinforced responses. The 6 other (Controls, C) worked without feedback. F rats emitted on the average higher mean response durations and earned more reinforcements than C subjects. The standard deviation and coefficient of variation of their response duration distributions were significantly lower than those of group C. These results tend to show that feedback stimulus following non-reinforced responses improve the accuracy of performance in the response duration differentiation schedule.

Temporal differentiation schedules reinforce and select temporal characteristics of behavior: inter-response times, response latencies or response durations. Numerous reports deal with inter-response time differentiation in the Differential Reinforcement of Low Rate (DRL) schedule (for classical data, see Kramer & Rilling, 1970; Richelle & Lejeune, 1980). Fewer studies have dealt with response latency (DRLL, Catania, 1970), or response duration reinforcement (Differential Reinforcement of Response Duration, DRRD - Platt et al., 1973; Platt & Scott, 1981; Platt, 1979, 1984). These schedules are of special interest because they provide for the separation between crucial and secondary variables with respect to the temporal regulation of behavior. The response latencies or durations proper are not merged with inter-response intervals or post-reinforcement pauses, as it is the case in DRL. Catania (1970) and Platt et al., (1973) have shown that a blackout between successive response latencies or the retraction of the response lever between successive response durations increases the mean response latency or duration as well as the efficiency of behavior (ratio between reinforced and total responses). Inter-trial-intervals (ITI) improve the temporal accuracy of the subjects.

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Several hypotheses have been made to explain this phenomenon. Two of them (Catania, 1970; Brandon, 1969) identify reinforcement density as the effective variable: the accuracy of behavior would be inversely related to the overall density of food presentation (similarly in DRL, the accuracy of behavior is inversely related to the magnitude of reinforcement, as shown by Beer & Trumble, 1965, in rats or Lejeune & Mantanus, 1980, in pigeons). A third hypothesis considers punishment as the relevant mechanism, after Kramer and Rilling (1970): Adding time-out (blackout) periods after too short IRTs in DRL selectively decreases such IRTs and thus improves the accuracy of behavior in pigeons. A further hypothesis stresses delay of reinforcement (Platt et al., 1973): Introducing an intertrial interval between responses in DRL or DRRD increases the delay of reinforcement for too short IRTs or response durations followed by reinforced ones (thus, reducing their probability of occurrence). This hypothesis identifies the effective ITIs as those following subcriterion behavior. A series of experiments by Platt et al., (1973) and Platt and Scott (1981) has led to question the reinforcement density, punishment and delay of reinforcement hypotheses, in favor of a feedback hypothesis. Inter-trials intervals after infra-criterion responses in DRRD would help the subjects to detect brief lever releases that otherwise would be unnoticed. Improved response discrimination would then lead to a stronger schedule control (Kuch & Platt, 1976).

This hypothesis implies that the duration of an ITI is not the crucial parameter, and that "any equally salient stimulus changes should be as effective as an ITI" (Platt & Scott, 1981, p. 277). These points were tested in the following experiment that compares two groups of albino rats in the Differential Reinforcement of Response Duration (DRRD) schedule. The experimental group (F, Feedback group) was given an auditory stimulus after infra-criterion response durations. The control group (C) underwent the same procedure, but without the stimulus.

METHODS

Subjects. Adult (3-month-old) male Wistar rats (N = 18) were housed separately and kept at 85 % of ad lib body weight. They all were naive.

Apparatus. The rats worked in an experimental cubicle (22 × 25 × 19 cm) equipped with a lever requiring .18 N force. The lever protruded 3 cm out of the left wall, 3 cm above the floor and 3 cm apart from the rear wall. Reinforcements (45mg food pellets) were dispensed in a tray, 8 cm to the

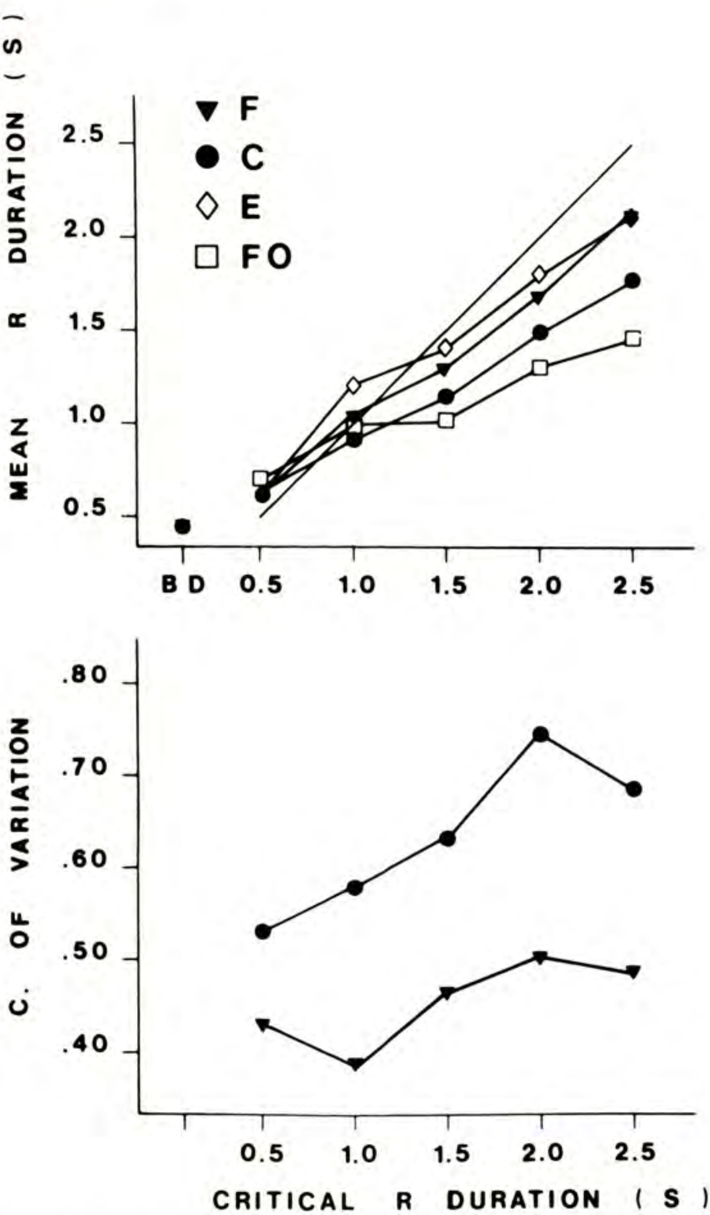

Fig. 1. — Mean response duration (top) and coefficient of variation (bottom) computed over the last 2 sessions at each reinforcement criterion (abscissa). Mean base duration pooled over the last 4 CRF sessions is also given (B.D., top left). Feedback group: F, ▼; Control group: C, ●; Data after Platt and Scott (1981) are given for comparison (E, ◇: group with Error-contingent ITI; FO, □: Free-Operant group without ITI — data computed as in the present experiment).

left of the response lever. The experimental cubicle was located in a sound attenuating and ventilated enclosure. Cubicle and enclosure had front windows allowing for the observation of the subjects. A loudspeaker was located 30 cm above the top of the cubicle.

Procedure. Two identical cubicles were used, one for the experimental group (F) with auditory response feedback, and the other for the control group (C) without feedback. After hand shaping, the rats went through Continuous Reinforcement (CRF) for ten sessions limited to 50 reinforcements each. Base response duration was obtained from the last 4 CRF sessions. Two groups of 6 rats (F and C) matched for mean response duration in CRF were selected out of the initial 18 subjects. These rats went through DRRD 0.5, 1.0, 1.5, 2.0 and 2.5 seconds. Ten sessions limited to 100 responses were performed at each reinforcement criterion. Successive reinforcement criteria and session limits were identical to those of Platt and Scott's (1981) experiment 1. The procedure followed here differed from Platt and Scott's in the number of sessions performed at CRF, DRRD .5 and 1.0 seconds. These authors ran 14 sessions at CRF, 16 at DRRD .5 and 20 at DRRD 1.0 seconds. The rats worked at a pace of 1 session a day. Session time was controlled in order to reduce the incidence of chronobiological and motivational variables on performance. All the subjects were kept on a 12:12 light-dark cycle. From DRRD 0.5 seconds on, group F was given an auditory stimulus (tone of 2000 Hz, 60 Db and 0.2 seconds duration) after each infra-criterion response. This stimulus is located in the range of frequencies and loudnesses well perceived by an albino rat (Kelly & Masterton, 1977).

Mean and standard deviations of response durations, efficiencies (ratio between reinforced and total response), response durations distributed in 12 bins (6 for the non-reinforced response) and cumulative records were obtained for each session. Data pooled over the last 2 sessions at each DRRD criterion were analyzed with an ANOVA for repeated measures.

Results

Figure 1 shows base response durations at CRF, mean response durations (top) and the coefficient of variation, i.e. the ratio between the standard deviation and mean response duration (bottom) at each DRRD criterion. Mean response durations in groups FO (Free Operant) and E (Error contingent Inter Trial Interval), after Platt and Scott

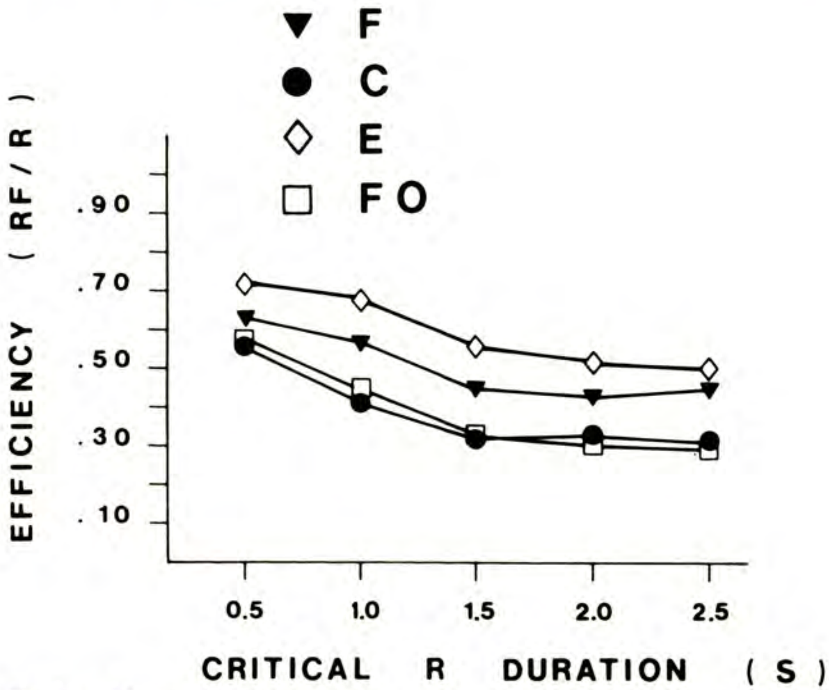

Fig. 2. — Mean efficiency of behavior (ratio between reinforced and total responses) computed and presented as in Figure 1.

(1981), are given for comparison. Base durations of F and C rats match at CRF. In DRRD, group F displays higher mean response durations than group C, but this difference does not reach statistical significance. The effect of criterion on performance is highly significant, $F(4,40) = 54.698$, $P \leq .001$, but criterion x experimental condition (F, C) interactions lack significance. This shows that the evolution of the mean response duration over criteria is similar in groups F and C. Standard deviations and coefficients of variation are significantly lower in group F ($F\ 1,10 = 6.527$, $P \leq .02$ and $F\ 1,10 = 5.880$, $P \leq .03$, respectively). Both measures increase significanly over successive criteria ($F\ 4,40 = 43.005$, $P \leq .001$, $F\ 4,40 = 5.809$, $P \leq .001$). Interactions do not reach significance, as was the case for mean response duration. Group F is more efficient at each criterion (Figure 2 — Efficiencies in groups FO and E after Platt & Scott, 1981, are given for comparison), but this effect does not reach significance. Efficiencies decrease over successive criteria in both groups. ($F\ 4,40 = 12.259$, $P \leq .001$). Interactions between criterion and experimental conditions do not reach significance.

Tab. 1. — Mean values and standard deviations as shown in Figures 1 and 2

CRIT.	Response duration				Coefficient of variation				Efficiency			
	F		C		F		C		F		C	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
0.5	.60	.06	.63	.13	.43	.07	.53	.08	.64	.12	.55	.16
1.0	1.03	.07	.90	.18	.38	.07	.58	.15	.57	.11	.41	.16
1.5	1.30	.19	1.13	.34	.46	.08	.63	.13	.44	.14	.31	.19
2.0	1.66	.26	1.49	.40	.50	.12	.74	.20	.42	.13	.32	.15
2.5	2.11	.44	1.85	.51	.48	.13	.68	.23	.44	.17	.30	.14

Table 1 presents mean values shown in Figures 1 and 2, as well as their standard deviations. This table clearly shows that, for each of the variables, standard deviations are much larger in group C than in group F.

Figure 3 presents response duration distributions at CRF and at each DRRD criterion for groups F and C. Response duration distributions do not significantly differ between groups at CRF (Kolmogoroff-Smirnov test). A schedule effect is present from DRRD 0.5 seconds on for each group (response duration distributions at CRF and DRRD 0.5 seconds differ significantly: $P \leq .0001$, Kolmogoroff-Smirnov). The frequency polygons also show that short response durations are less frequent and that response durations are located in a narrower range around modal value in group F. High frequencies in the last bin at CRF or DRRD 0.5 seconds were due to occasional lever holding with the left paw while pellet catching or eating. This behavior spontaneously disappeared at higher schedule criteria.

Discussion

Rats that were given a brief auditory stimulus after infra-criterion response durations improve the accuracy of behavior in the DRRD schedule. Mean response durations and efficiencies tend to be higher, standard deviations of response durations and coefficients of variation are significantly lower for group F.

Comparatively to the results of Platt and Scott (1981) in a similar experimental setting, it can be seen that the mean response durations of group F tend to match those of Platt and Scott's group E (with error-contingent inter-trial intervals, see Figure 1, and Figures 1 and 2 in Platt & Scott, 1981) but that their control group (FO, Free Operant) has a less accurate performance than group C from the present experiment. These

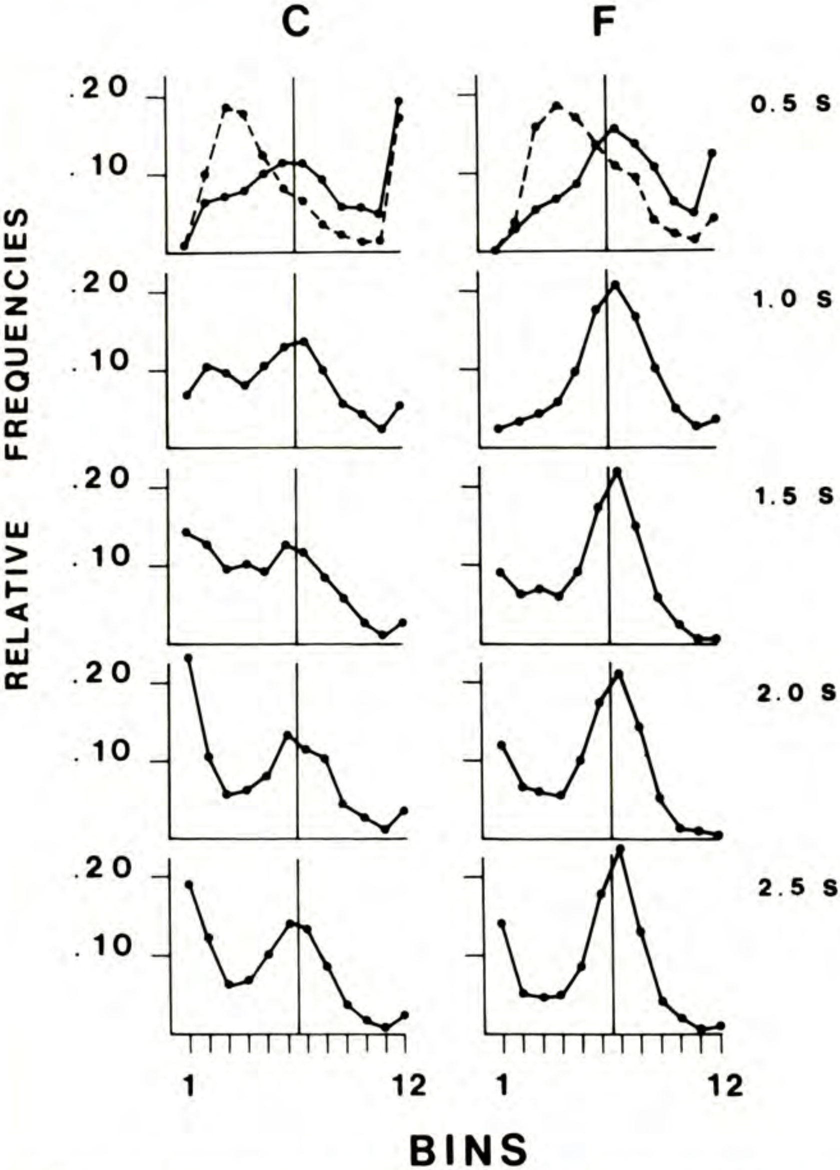

Fig. 3. — Response duration distributions at CRF (broken line, top) and at each reinforcement criterion (right ordinate) for Control (C, left) and Feedback rats (F, right). Each data point is computed as in Figures 1 and 2. Reinforced durations: bins 6 to 12.

results tend to confirm that salient stimulus changes are as effective as inter-trial intervals (lever retraction) in improving the temporal accuracy of responses. They support Platt and Scott's hypothesis (1981) according to which Inter-Trial Intervals (ITI) may act as feedback for brief lever releases. They also tend to confirm (as Platt & Scott guessed) that the duration of an ITI is not a crucial factor in improving response duration differentiation.

The duration of the auditory feedback stimulus was purposively short (0.2 seconds), in order to separate the auditory characteristics of the stimulus (frequency and loudness) from its duration. The importance of the duration of the stimulus is still open to inquiry.

It has been previously speculated that feedback from operant responses would be particularly useful in schedules with a weak periodic structure, i.e. schedules where the synchronizing function of the reinforcing event is lacking (Lejeune, 1978; Lejeune & Richelle, 1980, p. 217). The data available about response feedback in temporal differentiation schedules are very scarce. One report shows that response latencies increase and that variance sharply decreases in a DRLL schedule when a light is made contingent upon reinforcement in cats (Uramoto, 1971). However, Staddon (1969) concluded that visual informative feedback has no positive outcome on DRL keypecking in pigeons. These contradictory data just point to the need for complementary research that takes into account the species specific behavior repertoire as well as the status of the different types of feedback stimulus for the species under study.

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