The Influence of Prior Training on the Acquisition of DRL Performance

Susan E. Jasin

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THE INFLUENCE OF PRIOR TRAINING 
ON THE ACQUISITION OF DRL PERFORMANCE

by

Susan E. Jasin

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Susan E. Jasin
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CHAPTER I

THE PROBLEM AND ITS BACKGROUND

The dynamic temporal effect of reinforcement is a popular explanation for the existence of response bursts during DRL performance. According to Morse (1966), most schedule-controlled responding results from the joint effect, and possible interaction, of the differential or selective reinforcement of IRTs and a generalized strengthening of responding known as the enhancement effect or dynamic effect of reinforcement. Reynolds explains that a DRL schedule:

"... places in opposition two functions of reinforcement: the reinforcement of responses tends to increase the rate of responding, but reinforcement of responses in the presence of the stimuli associated with long IRTs tends to decrease the rate. The stable drl performance seems to be the result of an equilibrium between these two effects." (p. 89)

A popular example of this intensification has been the increase in rate during extinction. Morse (1966) explained that this increase in rate should not be considered a separate effect of extinction but rather a demonstration of the dynamic effect of reinforcement. Other aspects of conditioned behavior like force of a response (Skinner, 1938), stereotyping (Antonitis, 1951, Herrnstein, 1961), and duration of responding have also been related by Morse to the dynamic effect of reinforcement.
Horse's theory of the dynamic effect, however palatable, is weakened when DRL acquisition without bursting is demonstrated. Kelleher, Fry and Cook (1959) have investigated the behavior of rats under several DRL schedules with a limited hold (LH). This procedure consists of reinforcing only those IRTs which fall within a specified range. That is, a reinforced IRT must not only be longer than some minimum value (as in DRL) but also shorter than some maximum value. Thus reinforcement is available for only a limited period of time. Kelleher et al found almost no response bursting after extended training. In general, the probability of a response remained very low during the first three-fourths of the minimum required interval had elapsed but then showed a sharp increase to the highest level of probability in the region around the reinforced IRT value. In addition, Kelleher et al (1959), presented a loud click after each response. To check whether these two variables, the LH and auditory feedback, accounted for the lack of bursting a further experiment was performed. Two new rats were trained on a DRL 20 seconds (no LH) and without any auditory feedback. After 30 hours of training short IRTs were very infrequent and the subjects were responding efficiently on the DRL 20 second schedule. This experiment demonstrated that neither the auditory feedback nor the LH were necessary for the development of "non-bursting" DRL performance. In explanation,
Kelleher et al suggest other variables such as reinforcers, apparatus, or state of deprivation to account for this discrepancy. Those investigators who report a high proportion of very short IRTs have consistently used liquid reinforcement delivered by a motor driven cup. The cup rests in the up position and when reinforcement is delivered the cup descends into the supply of liquid and then comes up again to allow the subject access to the reinforcer. If a response which meets the DRL requirement is quickly followed by a second response (or short burst of responses) before the cup reappears, a very short IRT is adventitiously reinforced. Kelleher's study used a more immediate reinforcer, access to a food pellet, which thus decreased the possibility of adventitious reinforcement of bursting.

Secondly, Kelleher et al (1959) have pointed to deprivation level as a variable relevant to the production of response bursts. Although most experimental rats are tested at 80% of their free-feed weight, Kelleher et al ran theirs at 65%. However, rather than eliminating bursting it would seem that increased deprivation would increase motivation and thus would tend to produce even more bursting. Thus, it is difficult to understand Kelleher's explanation for the lack of bursting as a function of increased deprivation.

A more straightforward explanation for the almost total lack of bursting may be proposed: that bursting is
simply a product of the subject's prior training. Skinner (1938) and Anger (1956) have stated that reinforcers delivered on a FR schedule produce a high frequency short IRTs. Although IRTs of any length are equally likely to be reinforced on an FR schedule, the relative frequency or density of reinforcement (e.g. reinforcers per hour) is greater for short IRTs. This higher frequency of reinforcement selectively strengthens short IRTs and as a result FR responding is characterized by short IRTs. Anger adds that, in fact, most schedule-maintained behavior tends to produce distributions of IRTs with a high frequency of short IRTs but that generally more short IRTs are reinforced on an FR schedule than on a FI schedule. Thus if an animal exposed to a DRL schedule has been trained on a FI or FR baseline (if he has been trained on one of these schedules until the behavior stabilizes) prior to exposure to the DRL schedule he will respond during early DRL training as though he were still on the FR or FI schedule. At first he will emit responses with short IRTs because in the past they produced the highest frequency of reinforcement. After considerable exposure to the DRL contingency, however, these short IRTs will extinguish and the subject will acquire the temporal discrimination appropriate to the DRL schedule.

Part of the Kelleher et al (1959) study which depicts IRT distributions for subjects with different histories
lends support to this theory of historical influences on DRL acquisition. In the DRL 18 second LH 3 second experiment two types of histories were investigated. Four subjects received twenty reinforcements on CRF and two subjects were reinforced on an FR 10 schedule for 10 hours. After these histories all subjects were exposed to a DRL 18 second schedule. The IRT distributions for the twenty CRF subjects indicate no consistent trend and no pattern of response bursting after reinforcement. The data for the subjects with the FR history, on the other hand, show a great proportion of short IRTs. Interresponse times of 0-3 seconds accounted for about 60% of responding during session 1 and did not reach near zero level until after session 20. Concomitantly the probability of responses in the 18-21 second IRT class was only .05 in session 1, rising to .51-69% during sessions 50-130. It is also of interest to note the initial cumulative records of the subjects with a FR history resembled those obtained when extinction is programmed following FR training. In short, it is likely that the FR history animals came to the DRL experiment trained to emit responses with very short IRTs while the subjects with a history of only 20 CRFs were not as extensively trained. Thus much more bursting was seen in records for FR subjects than for CRF subjects. The discrepancy in prior training may be an influential factor in explaining differences in early DRL performance. With pro-
longed DRL training both groups developed temporal discriminations appropriate to the DRL schedule. Fixed-ratio animals, however, took longer to develop the discrimination than did CRF animals. This may be because the FR subjects went through two training phases: extinction of short IRTs and strengthening of long IRTs which met the requirement criterion. The CRF animals needed only to develop appropriate discrimination of long IRTs so their total training time was considerably less.

The foregoing explanation of DRL bursting as a product of prior training may help obviate the need for Morse's postulation of a dynamic effect of reinforcement. If bursting on a DRL schedule is produced solely by the subject's experimental history there will be little need for postulating an energizing effect of reinforcement. Further experiments might also investigate the effects of prior training on stereotyping, resistance to extinction and other aspects of behavior that have been considered until now a by-product of the dynamic effect of reinforcement. Eventually the theoretical explanation of the effects of reinforcement might be limited to the selective strengthening of various aspects of response topography.

Since Kelleher's study stands alone in its analysis of DRL bursting, further research along these lines is necessary. A more thorough analysis of DRL acquisition as a function of various experimental histories would either
strengthen or weaken the status of historical influence on DRL acquisition.
CHAPTER II

METHOD

Subjects

The subjects were 10 experimentally naive Sprague-Dawley male albino rats approximately 180 days old. They were maintained at approximately 75% of their ad lib weight. There was free access to water in the home cages.

Apparatus

The apparatus used was a 2-lever rat chamber equipped with a liquid feeder. The experimental space measured 14" x 9" x 8½". The centers of the 2 levers were 11" apart and 1" above the chamber floor. The liquid feeder was located 4½" from the left lever and 6½" from the right lever. Directly above each lever were three cue lights. Appropriate electro-mechanical equipment was used to program the various schedules and to record the behavior. All such equipment was housed in a nearby room.

Procedure

All subjects were trained and maintained on various schedules using 3 second access to .1 cc of 20% sugar solution as a reinforcer. When reinforcement was available the houselight in the experimental chamber was turned on and an audible click was presented. At all other times the three
cue lights over the left lever were illuminated and the houselights were extinguished. Four groups of subjects were tested:

**Naive group.** Each of three naive subjects was magazine trained and shaped to one bar press on the left lever using a DRL 3 second schedule. During a 5 second changeover delay after a second response had been made, the reinforcement schedule was changed to DRL 18 seconds. The subject was exposed to this DRL 18 second schedule until 300 reinforcements were earned. The schedule was then changed from DRL 18 seconds to EXT until the subject had not emitted a response for a 5 minute period.

**120 CRF group.** During session one each of 2 subjects was magazine trained, shaped to press the left lever, and exposed to a CRF schedule until 100 reinforcements were earned. During session two the subject earned 20 reinforcements on CRF, then after a 5 second changeover delay the subject was exposed to a DRL 18 second schedule until 300 reinforcements had been delivered. The schedule was then changed to EXT until the subject had not emitted a response for a 5 minute period.

**1520 CRF group.** During session one each of 2 subjects was magazine trained, shaped to press the left lever and exposed to a CRF schedule until 100 reinforcements had been
earned. In each of sessions 2-15 the subject earned 100 reinforcements on a CRF schedule. During session 16 the subject first earned 20 reinforcements on a CRF schedule; then after a 5 second changeover delay the subject was exposed to a DRL 18 second schedule until 300 reinforcements had been delivered. The schedule was then changed from DRL 18 seconds to EXT until the subject had not emitted a response for a 5 minute period.

**FR 20 group.** During session one each of 2 subjects was magazine trained, shaped to press the left lever, and exposed to a CRF schedule until 100 reinforcements had been earned. During session two the subject was exposed to an FR 5 schedule until 100 reinforcements had been delivered; during session three, to an FR 10 schedule until 100 reinforcements had been delivered; during session four to an FR 20 schedule until 100 reinforcements had been delivered. During session five subject was first exposed to an FR 20 schedule until 20 reinforcements had been earned then after a 5 second changeover delay the subject was exposed to a DRL 18 second schedule until 300 reinforcements had been earned. The schedule was then changed from DRL 18 seconds to EXT until the subject had not emitted a response for a 5 minute period.
A number of dependent measures were recorded in this study. All IRTs were recorded both by electromechanical counters and by an Esterline-Angus digital recorder. Interresponse times were recorded in 3 second class intervals by 10 counters. An additional set of four counters recorded only the IRTs that occurred during the 12 seconds immediately following reinforcement and, as with the other counters, grouped them into 3 second IRT bins or classes. Readings from all these counters were taken after every block of 25 reinforcements. During extinction, readings were taken every 5 minutes. The Esterline-Angus pens were arranged to separate responses into the various IRT classes. In addition to this method of obtaining an IRT distribution, a single counter and a single EA pen recorded total responses regardless of IRT length. Recordings from this counter were made after blocks of 25 reinforcements and every 5 minutes during extinction. A cumulative recorder was also used during every session to record responses and reinforcements. The cumulative recorder was typically reset after every 25 reinforcements and at the onset of extinction to facilitate comparisons of response slopes between blocks of reinforcements and between subjects.
Session duration was recorded after the subject had earned blocks of 25 reinforcements and constituted another dependent variable. Further calculations yielded several additional dependent measures. A relative frequency IRT distribution was calculated for all the responses within successive 25 reinforcement blocks. The number of responses in every IRT class was divided by the total number of responses emitted during that block and the quotient was then converted to a percentage. The relative frequency distribution of IRTs during the first 12 seconds after reinforcement was also calculated in the same manner. An additional measure was obtained for responding following reinforcement. The number of responses in each of the four bins following reinforcement was divided by the total number of responses within the IRT class. This quotient represented the percent of a particular IRT class that occurred during the first 12 seconds after reinforcement.

Figures 1, 2, and 3 are frequency polygons that show how the number of responses to earn blocks of 50 reinforcements changes. Figure 1 depicts the data for the naive subjects; Figure 2 for the subjects with a CRF history; Figure 3 for the subjects with a history of responding on an FR 20 schedule. Subject 2 (Fig. 1) emitted more responses than any other subject used in this experiment. Although he emitted the least number of responses to earn the first 50 reinforcements (443 responses), a total of
Figure 1. Frequency Polygons of Responses Per Block of 50 Reinforcements
7,423 responses were emitted to produce the total 300 reinforcements on the DRL 18 second schedule. The slope of this graph is positively accelerated and is not typical of the other naive subjects. (see p. 11) Subjects 1 and 3 (Fig. 1), the other naive animals, responded much less. Subject 1 emitted 582 responses to produce the first 50 reinforcements and a total of 2,740 responses to earn 300 reinforcements. Subject 3 emitted 482 responses to earn the first 50 reinforcements and a total of 1,890 responses to earn 300 reinforcements. The slopes of these graphs for Subjects 1 and 3 are negatively accelerated.

Figure 2 shows that Subject 4, who had a prior history of 120 reinforcements on CRF, emitted 1,292 responses to produce the first 50 reinforcements and a total of 3,938 responses to produce 300 reinforcements. Subject 5, with a like history, emitted 701 responses to earn the first 50 reinforcements and a total of 2,853 responses for 300 reinforcements on DRL. Both of these CRF subjects responded more in the DRL session than either of the 2 typical naive subjects.

Subject 6 had more extensive training on CRF as he earned 1,520 reinforcements on that schedule before exposure to DRL. Subject 6 emitted 876 responses to produce the first 50 reinforcements and a session total of 2,102.

Figure 3 shows the rate of responding for Subjects 7 and 8 who had prior training on an FR 20 schedule. Subject
Figure 2. Frequency Polygons of Responses Per Block of 50 Reinforcements
Figure 3. Frequency Polygons of Responses Per Block of 50 Reinforcements
Subject 7 emitted 2,078 responses to produce the first 50 reinforcements and a total of 5293 to earn 300 reinforcements. Subject 8 emitted 1,222 responses to earn the first 50 reinforcements and a total of 2,576 to earn 300 reinforcements. The graphs for both of these subjects show an overall negative acceleration although the decline in Subject 8's rate is much more pronounced.

The graphs for all subjects (except Subject 2) are negatively accelerated. The magnitude of this negative acceleration, however, is greatest for Subjects 7 and 8. The two subjects with a history of responding on an FR 20 schedule showed the most significant decreases in responses necessary to earn blocks of 50 reinforcements, however, much of this effect is due to their initial high rate of responding.

Figures 4, 5, and 6 are frequency polygons showing the time in minutes to earn blocks of 50 reinforcements. Figure 4 shows the data for the naive subjects; Figure 5, the data for the CRF subjects; Figure 6, the data for the FR 20 subjects.

Subject 1 (Fig. 4) took 129 minutes to earn the first 50 reinforcements and a total of 390 minutes to earn 300 reinforcements. Fifty-three minutes elapsed before Subject 3 (Fig. 4) had produced 50 reinforcements and 353 minutes elapsed before the total 300 reinforcements were produced. Subject 2 (Fig. 4) again performed quite differently from
Figure 4. Frequency Polygons of Time in Minutes Per Block of Reinforcements
the other two naive subjects. Although only 64 minutes passed before the first 50 reinforcements had been earned, 518 minutes elapsed before Subject 2 produced 300 reinforcements on DRL.

Figure 5, depicting the time used by subjects with a CRF history, shows that both Subject 4 and Subject 5 took approximately the same time to earn the first 50 reinforcements. Subject 4 took 88 minutes and Subject 5 took 94 minutes. Three hundred eighty minutes elapsed before Subject 4 produced 300 reinforcements whereas 457 minutes passed before Subject 5 completed the DRL phase. Subject 6 (with a history of 1,520 reinforcements on CRF) earned reinforcements on the DRL schedule more rapidly. Seventy minutes were required to produce the first 50 reinforcements and a total of only 373 minutes to produce 300 reinforcements.

Figure 6 shows the time used by subjects with FR 20 history. These subjects produced reinforcements at an almost equal rate. For Subject 7 and Subject 8, 65 and 70 minutes respectively elapsed before the first 50 reinforcements were produced and 350 and 328 minutes, respectively passed before 300 reinforcements were produced.

Figures 7 through 14 are histograms depicting post-reinforcement bursting data. Each figure is composed of a set of histograms showing the frequency of IRTs of less than 13 seconds for each block of 50 reinforcements for a
Figure 5. Frequency Polygons of Time in Minutes per Block of 50 Reinforcements
Figure 6. Frequency Polygons of Time in Minutes per Block of 50 Reinforcements
given subject. Figures 7 and 9 show the data for Subjects 1 and 3, the typical naive subjects. Total bursting responses decreased steadily and markedly with continued exposure to the DRL schedule. Subject 1 emitted 122 bursting responses during the first block of 50 reinforcements but only 19 during the last block of 50 reinforcements. In like manner, Subject 3 emitted 127 bursting responses during the first block but only 17 during the last block of 50 reinforcements.

The data depicted in Figure 8 for Subject 2 are again atypical. Post-reinforcement bursting increased rather than decreased with continued exposure to the DRL schedule with 106 0-12 second IRTs during the first block and 126 0-12 second IRTs during the last block of 50 reinforcements.

Figures 10 and 11 show the bursting data for the two subjects with a history of 120 reinforcements on CRF. Both of these subjects emitted more short IRTs after reinforcement during the first block of 50 reinforcements than any naive subject. One-hundred and sixty-two responses were emitted by Subject 4 and 152 by Subject 5 during the first 50 reinforcements. This initial difference between the naive and CRF subjects diminished as the subjects were trained on the DRL schedule. During the last block of 50 reinforcements the frequency of 0-12 second IRTs dropped to 12 for Subject 4 and 29 for Subject 5.

Subject 6 (Fig. 12), who had prolonged exposure to the
Figure 7. Total Bursting Responses Following Reinforcements for Subject 1
Figure 8. Total Bursting Responses Following Reinforcements for Subject 2
Figure 9. Total Bursting Responses Following Reinforcements for Subject 3.
Figure 10. Total Bursting Responses Following Reinforcements for Subject 4
Figure 11. Total Bursting Responses Following Reinforcements for Subject 5
Figure 12. Total Bursting Responses Following Reinforcements for Subject 6
CRF schedule, produced similar data with 136 bursting responses during the first block and 25 bursting responses during the last block of 50 reinforcements.

Figures 13 and 14 show the bursting data for Subjects 7 and 8 who had been trained on a FR 20 schedule prior to the DEL session. Subject 7 emitted 410 short IRTs during the first block of 50 reinforcements. This number far exceeded the totals for any other subject. However, Figure 13 shows a tremendous decrease in post-reinforcement bursting as the session progressed. During the last block of reinforcements Subject 7 emitted 27 0-12 second IRTs, much like the data for the CRF subjects. The data for Subject 8 are not consistent with this trend. Seventy bursting responses occurred during the first block and 27 during the last block of reinforcements.

Figures 15, 16, and 17 show the extinction data. Number of responses are plotted as a function of successive 5 minute intervals during extinction. The first two points (1 and 2) on each graph indicate the number of responses made during the last two 5 minute periods prior to the onset of extinction conditions. To the right of the broken line are points that indicate the total number of responses made during successive 5 minute periods of extinction. All naive subjects showed a transient increase in response rate after the onset of extinction. Although very slight for Subject 1 and Subject 3 (2 and 1 responses respec-
Figure 13. Total Bursting Responses Following Reinforcements for Subject 7
Figure 14. Total Bursting Responses Following Reinforcements for Subject 8
Figure 15. Rate of Responding Prior to and during Extinction for Subjects 1, 2, 3
ively), the increase in rate was very dramatic for Subject 2 who emitted 88 responses during the last 5 minutes of DRL and 127 during the first 5 minutes of extinction. Thirty-five minutes elapsed before Subject 1 met the extinction criterion of 5 minutes with no responding. Fifty-five minutes were required for Subject 2 to reach criterion while only 15 minutes were required for Subject 3.

Figure 16 shows extinction data for Subject 4, Subject 5, and Subject 6. All subjects show an increase in rate when reinforcement was withheld. Subject 5 showed the greatest increase. He emitted 23 responses in the last 5 minutes of the DRL schedule and 63 responses during the first 5 minutes of extinction. Subject 5 showed less of an increase. Twenty-nine responses occurred during the last 5 minutes of the DRL and 42 occurred during the first 5 minutes of extinction. The rate of Subject 6 changed from 28 to 33 responses in 2 successive periods—the least increase of any subjects with histories of responding on a CEF schedule. The behavior of Subject 4 took the longest to extinguish as fifty-five minutes elapsed before the 5 minute criterion was reached. Subjects 5 and 6 were kept on the extinction schedule for 20 and 30 minutes respectively. Figure 17 shows the extinction data for Subject 7 and Subject 8—those subjects who were given a history of responding on a FR schedule. Both of these subjects showed a decrease in rate after extinction procedures were instituted.
Figure 16. Rate of responding prior to and during extinction for Subjects 4, 5, 6.
Figure 17. Rate of responding prior to and during extinction for Subjects 7 and 8.
Subject 7 emitted 28 responses in the 5 minutes before extinction and 27 responses during the first 5 minutes of extinction. Thirty responses were recorded for Subject 8 in the 5 minutes that preceded extinction, while 26 were recorded during the first 5 minutes of extinction. Subject 7 met the extinction criterion after 25 minutes and Subject 8 after 40 minutes.
CHAPTER IV

DISCUSSION

The foregoing data lend support to the idea that response bursting after reinforcement on a DRL schedule is related to prior learning conditions. Thus subjects who have been reinforced for short IRTs will continue to respond in bursts when placed on a DRL schedule until the bursting behavior has extinguished. The disappearance of short IRTs with continuing exposure to the DRL contingency is also influenced by the cumulative selective effect of reinforcing long IRTs. The fact that even experimentally naive subjects emitted some bursting responses is not necessarily inconsistent with the explanation offered. Short IRTs may have been selectively reinforced in the home cage by natural contingencies. Turning quickly to a sound, for instance, is often reinforced with immediate access to a food pellet which has been tossed in by a caretaker. Turning quickly from tactual stimulation may result in avoidance of rough handling.

Although both were used, responses per block of 50 reinforcements seems to be a more sensitive measure than time per block of 50 reinforcements. This is probably because as DRL training progresses there is a more sub-
stantial decrease in short IRTs rather than a decrease in longer unreinforced IRTs.
REFERENCES


