RESPONSE DURATION IN OPERANT LEVEL, REGULAR REINFORCEMENT, AND EXTINCTION[1]

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An operant is ordinarily recorded as having occurred or not occurred. However, successive instances of these operants may differ in many different characteristics, such as peak force (Goldberg, 1959; Notterman, 1959), time integral of force (Trotter, 1956), position of the organism (Antonitis, 1951), or locus of occurrence (Antonitis, 1951). Quantitative investigations suggest an increased stereotopy in these measures during regular reinforcement, and an increased variability of performance during extinction.

The results of Notterman,[2] Hurwitz (1954), and Trotter (1957) suggest that similar conclusions also apply to duration measures. This study was intended, in part, to provide a more detailed account of the changes in response duration during regular reinforcement and extinction. The data also allowed a comparison of response duration in the early and late stages of both operant level and extinction.

Besides the more general statement indicating a decrease in variability during conditioning and increase in variability during extinction, Schoenfeld (1950) suggested a more detailed account of the acquisition-extinction relation. If this argument may be extended to duration, each response (such as a bar press) may be viewed as composed of several response subcategories (such as bar presses of 0-0.2 second, 0.2-0.4 second, or 0.4-0.6 second); and conditioning or extinguishing a response is regarded as not only raising or lowering response frequency of occurrence, but also as similarly affecting its constituent response subcategories. The simplifying assumption is then made that each response subcategory can be treated as an independent response, and that the same findings governing responses also govern response subcategories.

If we accept the finding[3] that the number of responses in extinction is a nondecreasing function of the number of regular reinforcements obtained, and that this finding also applies to response subcategories, we should expect those response subcategories receiving most reinforcements in conditioning to appear with greatest frequency in extinction and those response subcategories receiving least reinforcements in conditioning to appear least often in extinction. Thus, if the response-duration subcategory 0-0.2 second appeared most frequently in regular reinforcement, 0.2-0.4 second appeared with second greatest frequency, and 0.4-0.6 second appeared least often, we would again expect to find these response subcategories appearing in the same rank order in extinction.

Goldberg (1959) tested this formulation. Using a 3-gram force requirement for the bar press, he demonstrated significant concordance (the same rank order) between the force distributions in conditioning and in extinction. Goldberg further argued that any experimental procedure which altered the force distribution in conditioning would result in a new extinction distribution concordant with the new conditioning distribution. This was tested by using a 15-gram reinforcement criterion in conditioning, with the outcome that the extinction distribution was quite different from that with a 3-gram requirement, but concordant with the 15-gram conditioning distribution.

Another possible test of the dependence of the extinction distribution upon the conditioning distribution is also available. As conditioning proceeds, the studies quoted above would lead us to expect a shift to shorter response durations. Organisms which have received many reinforcements should yield conditioning distributions containing a large percentage of short responses, while those which have received few reinforcements should have fewer short durations in their conditioning distributions; and this difference should be reflected in the extinction distributions. This expectation has been tested in this study.

APPARATUS AND PROCEDURE

The subject were 30 male rats of the Wistar strain, 90-105 days old upon arrival at the laboratory. Each subject was allowed free access to Purina chow food in the home cage and run under 23 hours' water deprivation.

Two stainless steel cages, each containing a lever

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[2]Personal communication, 1960.

[3]Sidman (1952) has argued that the Perin (1942) and Williams (1938) data, which used groups of subjects to determine each point, do not allow us to specify, for individual subjects, the form of the function relating resistance to extinction to number of reinforcements. However, their data do indicate that the distribution is monotonic, and this is the only assumption necessary in the present study. Hearst (personal communication, 1960), using data obtained solely from individual subjects, has recently succeeded in demonstrating that this distribution is monotonic.

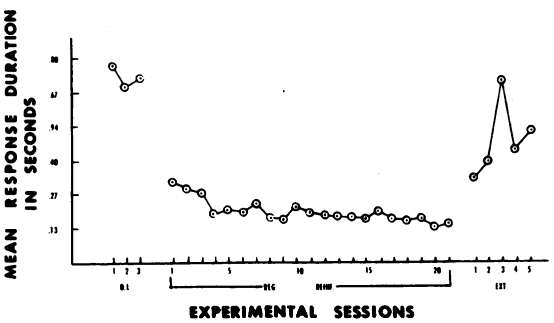

Fig. 1. Mean response duration as a function of experimental sessions for one subject (No. 83) receiving 1000 reinforcements.

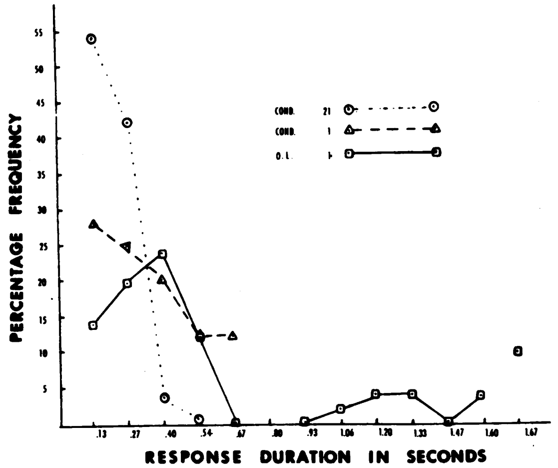

Fig. 2. Distributions of response duration in operant level, the first conditioning session, and the last conditioning session for one subject (No. 83).

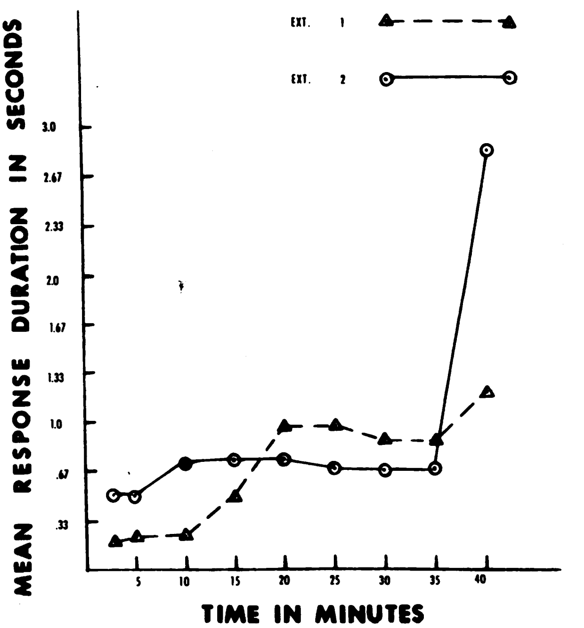

Fig. 3. Mean response duration as a function of time in the first and second extinction sessions for one subject (No. 88).

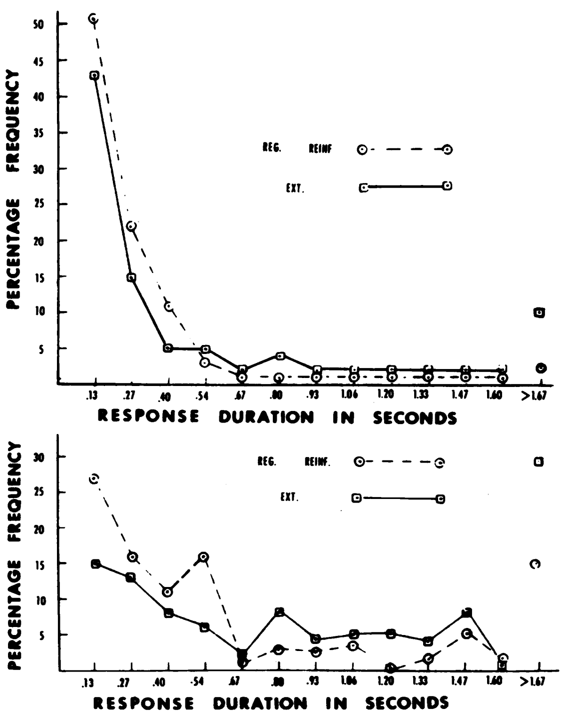

Fig. 4. Distributions of response duration during conditioning and extinction for each of two subjects. One subject (No. 88, upper figure) has received 1000 reinforcements, and one subject (No. 19) has received 100 reinforcements.

(0.75 inch wide, 2.25 inch long, and 0.125 inch thick) and a 0.03-cubic centimeter dipper, served as experimental work boxes. Each box was enclosed in a large, lightproof, sound-attenuating cubicle. A further sound screen, 60 decibels above reference level, was provided by the air-ventilating system.

The lever microswitch required a 6-gram actuating force. Response duration was defined as the length of time this microswitch remained closed, and was measured in 0.66-second units by stepping switches and counters. During the regular-reinforcement phase of this study, all responses of sufficient force to close the lever microswitch were reinforced. Reinforcement was given after the lever microswitch was released. No minimum duration criterion was imposed.

The 30 subjects used in this study were divided into five equal groups. All subjects received three 40-minute operant-level sessions, one 40-minute dipper-approach session with the lever covered, and either 25, 50, 100, 250 or 1000 regular reinforcements of the bar-release response. Subjects received 25 reinforcements a day for the first 2 days and 50 reinforcements a day thereafter, until the desired number of reinforcements was given. Thus, the number of regular-reinforcement sessions differed from group to group, the 25-reinforcement group receiving 1 session, and the 1000-reinforcement group receiving 21 sessions. Five 40-minute extinction sessions were given on the 5 days following the last reinforcement session.

RESULTS

Figure 1 presents mean response duration (abbreviated D) as a function of daily sessions for one representative subject. Examination suggests that D is high in operant level (abbreviated O.L.), declines toward an asymptote during regular reinforcement, and then returns to high values during extinction (abbreviated E). Whenever possible, the statistical significance of behavorial changes was tested by observing each subject's performance under different experimental conditions and evaluating the resultant changes by either a sign test or a Wilcoxon rank-order T test. Significant differences at, or below, the 0.5 level were obtained for each of the effects[4] discussed below.

[4]Wilcoxon Signed-Rank tests indicated, in part, the following significant effects: Decrease in D from O.L.1 to C.1; increase in D from C.21 to E.1; decrease in range from C.1 to C.21; increase in short response durations from C.1 to C.21; increase in D from first 5 minutes O.L.1 to last 5 minutes O.L.1; increase in D from first 5 minutes E.1 to last 5 minutes E.1; decrease in D from last 5 minutes E.1 to first 5 minutes E.2; increase in D from first 5 minutes E.2 to last 5 minutes E.2; increase in D.E.1 to D.E.2; and no difference D.E.3 and D.O.L.1. Rank-difference correlation coefficients, significant at the .05 level, were obtained between the two functions represented in Fig. 5, and between the individual conditioning and extinction duration-distributions (example, Fig. 4) for all but two of the subjects.

Figure 2 examines in greater detail the distribution of response durations in O.L.1 (operant level Session 1), C.1, and the last conditioning session (Session 21) for the same subject examined in Fig. 1. Inspection indicates that as one progresses from O.L.1 to late conditioning, long responses (response durations above 1.67 seconds) drop out, so that the range is greatly curtailed. The percentage of short duration responses (response durations less than 0.25 second) appears to increase with training, an effect which is also seen in the solid line of Fig. 5.

Both Hurwitz (1954) and Trotter (1957) have reported that the increase in D from the low values in conditioning to the high values in extinction is a continuous process, with durations longer as extinction proceeds. Figure 3 examines D in successive 5-minute intervals for one representative subject, and confirms the Hurwitz and Trotter findings. In addition, it shows that the second extinction period (spontaneous recovery period) begins with a lower D than that seen at the end of extinction Session 1 and terminates with a higher D than in the first extinction session. By the end of the third extinction session, D appears to have returned to the high values seen in operant level. The response-duration frequency distributions in the early part of the first extinction session look like those late in conditioning, whereas the distributions late in extinction look like those in operant level.

An examination of D in consecutive 5-minute intervals during operant level yields a function very similar to that in Fig. 3; D increases throughout the operant-level session.

Figure 4 examines response-duration frequency distributions of two representative subjects; one subject received 1000 reinforcements, and the other, 100 reinforcements. Here, as in the force data analyzed by Goldberg, the rank order of response subcategories is the same both in conditioning and extinction. Since the percentage of short duration responses in the conditioning distributions increases as more reinforcements are obtained, the Schoenfeld note also predicts a higher percentage of short duration responses in the extinction distribution. The functions presented in Fig. 5 appear to support this suggestion.

Skinner (1938, pp. 309-310) has presented additional data indicating the dependence of the extinction distribution upon the conditioning distribution. His results appear to indicate that if a high force criterion is set in conditioning, the percentage of high force responses in extinction is a function of the number of reinforcements presented. (An equivalent statement is that high force responses persist longer in extinction if differentiation training is prolonged.)

Response Rate

Cumulative-response curves (not reproduced in this report) obtained in operant level and extinction showed typical negative acceleration during these periods. In confirmation of previous findings (Hefferline, 1950; Schoenfeld, Antonitis, & Bersh, 1950),

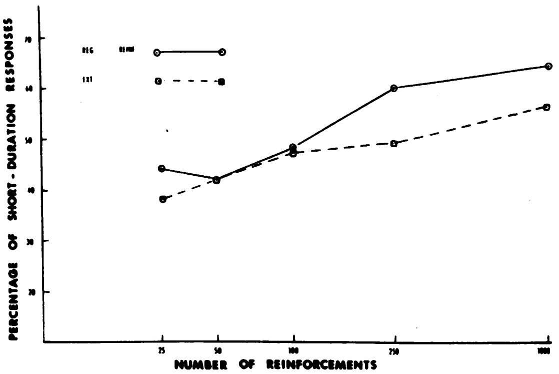

Fig. 5. Mean percentage of short duration responses as a function of reinforcement groups in regular reinforcement and extinction.

operant-level responding was highest in the first session, and declined thereafter.

Figure 6 presents the number of responses made in the first 40-minute extinction period as a function of number of reinforcements. Although more responses are made by the group receiving 25 reinforcements than by the group receiving 50 reinforcements, Fig. 6 appears to support the general finding of increased resistance to extinction with increased reinforcements. Although several previous studies (Perin, 1942; Williams, 1938) have suggested an asymptote at about 100 reinforcements, the present data indicate a significant increase in resistance to extinction between the groups receiving 100 and 1000 reinforcements. In this study, however, resistance to extinction was measured in a 40-minute period, rather than by the number of responses to some criterion.

Figure 7 indicates that the average number of responses made in successive extinction sessions declines.

The correlation between operant-level responding and the number of responses was examined in the first extinction session. Correlations were also obtained between operant-level responding and the number of responses in all five extinction periods. Since no significant correlations were obtained, it may be argued that operant-level responding is not a good predictor of resistance to extinction after regular reinforcement.

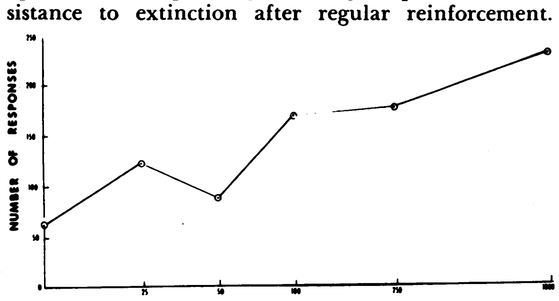

Fig. 6. Resistance to extinction (mean number of responses made in extinction Session 1) as a function of reinforcements. The zero-reinforcement group is the average number of responses made in operant level Session 1.

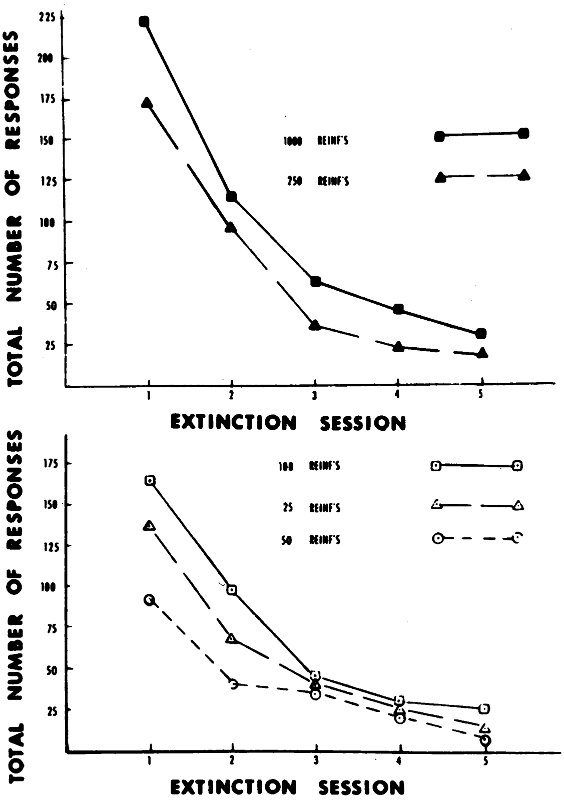

Fig. 7. Mean number of responses made in extinction Sessions 1-5 as a function of reinforcements. Two separate graphs have been used for easier examination.

However, Bullock (1950) has demonstrated a significant correlation between operant-level responding and resistance to extinction after partial reinforcement.

SUMMARY

Response duration, measured by the length of time the lever microswitch was closed, was recorded in operant level, regular reinforcement, and extinction. Mean response duration was high in operant level, declined to an asymptote in regular reinforcement, and again reached high values late in extinction. Response-duration distributions early in extinction were similar to those late in conditioning, whereas distributions late in extinction resembled those in operant level.

An analysis of different reinforcement groups suggests that the percentage of short duration responses in the conditioning distribution increases as a function of reinforcements. A consideration of regular-reinforcement extinction relations indicates that the percentage of short duration responses in extinction should also be a function of number of reinforcements, a suggestion which the present study appears to confirm.

In support of previous findings, mean number of responses made in extinction increases as a function of number of reinforcements; the number of responses made in successive spontaneous recovery sessions declines; and the number of responses made in operant level declines after the first session. No correlation was obtained between operant-level responding and resistance to extinction.

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