INDUCTION, CONTRAST, AND RESISTANCE TO EXTINCTION¹

G. S. REYNOLDS

UNIVERSITY OF CALIFORNIA, SAN DIEGO

The resistance of responding to extinction after variable-interval reinforcement in one of two components of a multiple schedule of reinforcement was (1) greater, when responding in the second component was reinforced on a variable-interval schedule than when responding there was extinguished, (2) not reduced, by a more rapid decrease in the rate of responding than occurs in ordinary extinction in the second component, and, (3) increased, by the occurrence of positive behavioral contrast before the beginning of extinction.

A previous analysis of some of the interactions between component schedules of a multiple schedule of reinforcement (Reynolds, 1961a) pointed out that the speed with which responding decreases in extinction in one component is in part determined by the schedule of reinforcement in the second component. Extinction is more rapid in the first component when responding is also extinguished in the second component than when responding in the second component is reinforced on a variable-interval schedule. Some of the present data confirm that finding.

Of those two extinction curves, one is shallow when responding in the other component is reinforced and the other is steep when responding in the other component is extinguished. It is impossible to decide from the curves alone whether the difference in slope is due to inhibition of responding in the steep curve by extinction in the second component, or to facilitation of responding in the shallow curve by reinforcement in the second component, or to a combination of both. That is to say, it is not known whether the steep curve has been made steeper by extinction in the other component, or whether the shallow curve has been made shallower by

reinforcement in the other component, or both. At first glance, this problem would seem easily solved if an ordinary, normal extinction curve were available for comparison. Reflection reveals, however, that an ordinary extinction curve—one which is not influenced by the schedule of reinforcement in the second component—cannot be obtained in a two-component multiple schedule. It would be possible, of course, to assess the form of the extinction curve in isolation, without employing a multiple schedule. But this involves the doubtful assumption that extinction curves obtained in multiple schedules and in isolation are directly and thoroughly comparable.

The difference between the slopes of the extinction curves in one component of a multiple schedule can be explored further by obtaining a third extinction curve, although it will not be a normal, ordinary curve uninfluenced by the conditions prevailing in the second component. In the present paper, the third extinction curve is obtained from one component of a multiple schedule when responding in the other component is neither reinforced nor conventionally extinguished, but is brought abruptly to a rate of nearly zero by darkening the key during that component. Thus, the rate at which responding extinguishes in the first component of the multiple schedule can be compared under two conditions: one, the gradual cessation of responding in extinction in the second component and, two, the abrupt cessation of responding in the second component when the key is dark. If the difference in the slopes of

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the original two extinction curves arises in part from the decrease in responding during the second component, then extinction in the first component might be expected to occur faster, the faster the decline of responding in extinction in the second component.

These data also bear on an additional problem: whether or not the prior occurrence of positive behavioral contrast influences the subsequent resistance of responding to extinction.

METHOD

Subjects

Two experimentally naive, adult male, White Carneaux pigeons were maintained at 80% of their free-feeding weights.

Apparatus

The experimental space has been described in detail in a previous paper (Reynolds, 1961a). The single key could be illuminated by either red or green light or could be dark. Reinforcement was 3-sec access to mixed grain.

Procedure

Both birds were trained to eat from the grain magazine and to peck a red key. Thirty consecutive pecks on the red key were reinforced on each of two consecutive days. Seventeen daily sessions followed in which pecks of both birds were reinforced for 3 hr on a variable-interval schedule of 3-min (VI 3-min). A total of 9 hr of extinction followed.

After this preliminary training, a daily 3-hr experimental session consisted of 30 cycles of a two-component multiple schedule. Each cycle consisted of 3 min of red illumination of the key followed by 3 min of green illumination. In some stages of the experiment, the key was not illuminated. The reinforcement schedule associated with each key-color was either VI 3-min or extinction. The sequence of multiple schedules to which the birds were exposed, together with the number of sessions on each schedule for each bird, is shown in Table 1.

RESULTS

The upper two graphs (A and B) in Fig. 1 show the number of responses per session for Pigeon 1; the lower two (C and D), for Pigeon

Table 1

Multiple Schedule	Number of Sessions	
	Bird 1	Bird 2
VI VI	5	5
EXT EXT (dk)	3	3
VI VI	3	3
VI EXT	10	12
EXT EXT	5	5
VI VI	5	7
EXT EXT	4	3
VI VI	7	6
EXT EXT (dk)	5	4
VI VI	5	5
EXT VI	5	5

2. Logarithmic ordinates serve to separate the curves at low numbers of responses, although they enhance the appearance of the variability.

Fig. 1. The total number of responses per session for two pigeons (rows) in the first (column I) and second (column II) components of a two-component multiple schedule. In column I, the label of each curve gives the sequence of schedules in the other component of the multiple schedule. In column II, the label of each curve gives the sequence of schedules in the component for which responding is plotted. A logarithmic ordinate has been used to separate the curves at low numbers of responses.

The left-hand graphs (A and C) in Fig. 1 each show five extinction curves from one component of the multiple schedule. During Session 0, responding in this component was reinforced on the VI schedule. In subsequent sessions, no responses were reinforced (extinction). The procedures generating the five extinction curves differed only in the sequence of schedules in the second component of the multiple schedule. This sequence in the second component is indicated by the label attached to each of the curves in parts A and C of the figure. For example, the two curves labelled "VI-to-dk" come from sessions in which the first component was changed from variable-interval reinforcement to extinction with no illumination of the key (dark key). The labels, "EXT-to-EXT" and "VI-to-VI", indicate that the second component was maintained as extinction or as variable-interval reinforcement throughout the course of extinction in the first component. If extinction in the first component is influenced by the schedule in the second component, there will be consistent differences among the curves in parts A and C of Fig. 1.

Responding in the second component of the multiple schedule is shown in the right-hand graphs (B and D) of Fig. 1. The labels in the right-hand graphs refer to the sequence of schedules in that component, from which responding is plotted.

As a further example of how to read these figures, consider the transition between the fourth and fifth multiple schedules in Table 1. The pigeon was first reinforced on a multiple schedule consisting of a variable-interval component and an extinction component. Then, the reinforcement component was changed to extinction and the extinction component continued to be extinction. Such a sequence of two multiple schedules generates two curves. The responding in the first component of the schedule, where the sequence was from reinforcement to extinction, appears in the left-hand graph and is labelled "EXT-to-EXT", because that is the sequence of schedules in the other component. Responding in that component, which continues to be extinction, appears in the right-hand graph and is labelled "EXT-to-EXT", because the labels

in the right-hand graph refer to the sequence of schedules in the component from which responding is plotted.

Average normalized curves of the responding in each component are shown in Fig. 2. Before averaging, each curve was normalized by dividing the number of re-

Fig. 2. Averaged normalized curves for each sequence of schedules in the first component (Part A) and in the second component (Part B) of the multiple schedule. Before averaging, each curve was normalized by dividing the number of responses in each session by the number of responses in Session 0.

sponses in each session by the number of responses in session 0. This facilitates comparisons among the slopes of the extinction curves.

Consider first the extinction curves produced by changing one component of the multiple schedule from variable-interval reinforcement to extinction. The present results confirm (*cf.* Reynolds, 1961a) that extinction is slower in one component when responding is reinforced in the second component than when responding is extinguished in the second component. This is especially clear in these data during the first session of extinction (Session 0 to Session 1 in Part A and C of Fig. 1; to the left of the vertical dashes). Extinction curves obtained with reinforcement in the other component (the "VI-to-VI" curves) have shallower slopes than those obtained with extinction in the other component (the "VI-to-dk", "VI-to-EXT", "EXT-to-EXT", curves) in parts A and C of Fig. 1 and in Fig. 2.

The increase in the "VI-to-VI" curve in the right-hand column represents positive behavioral contrast (Reynolds, 1961b), which is usually obtained when one component of a multiple schedule is maintained as reinforcement while the other is changed to extinction to begin the formation of the discrimination.

The extinction curves from the second component (parts B and D, Fig. 1. and part B, Fig. 2.) have very different forms. The "VI-to-dk" curve is steeper than the "VI-to-EXT" curve for each bird. The dark-key condition produces an abrupt cessation of responding while normal extinction with a lighted key produces a slow decrease in responding. The slopes of the two steeper extinction curves in the first component (parts A and C, Fig. 1. and part A, Fig. 2) do not, however, vary consistently with these two patterns of extinction in the second component. The "VI-to-EXT" and "VI-to-dk" extinction curves in the first component have very similar forms. In these data, a more rapid decline of responding in extinction in the second component of the multiple schedule did not increase the rate of decline of responding in extinction in the first component.

The effect of the prior occurrence of positive behavioral contrast on subsequent resistance to extinction may be seen by comparing the "EXT-to-EXT" curve with

the "VI-to-EXT" and "VI-to-dk" curves in Parts A and C of Fig. 1. and Part A of Fig. 2. Each of these three conditions produces an extinction curve in the first component while responding is also undergoing extinction in the second component. Only the "EXT-to-EXT" condition, however, results in behavioral contrast before extinction begins, because only in this condition is the schedule in the other component extinction rather than reinforcement during Session 0. The "EXT-to-EXT" curve in Fig. 1 begins at a higher level of responding at Session 0 (Parts A and C of Fig. 1). It also is slightly less steep than either the "VI-to-EXT" or the "VI-to-dk" curves (Fig. 2). The occurrence of contrast means a higher initial rate of responding and also a relatively slower decrease of responding during subsequent extinction. The progress of extinction is not, however, slowed as much as by reinforcement in the other component: the "VI-to-VI" curve has a shallower slope than those obtained with extinction in the other component.

Finally, it should be noted that the "EXT-to-EXT" curves in Parts B and D of Fig. 1 confirm a previous finding (Reynolds, 1961b) that the rate of responding during extinction in one component of a multiple schedule gradually decreases toward zero when responding is no longer reinforced in the other component of the multiple schedule.

DISCUSSION

The several interactions between the component schedules of a multiple schedule of reinforcement which these results only serve to confirm have been discussed in detail elsewhere (Reynolds, 1961a, 1961b). The two new findings in this set of data warrant some discussion.

The first of these is that the subsequent resistance of responding to extinction is enhanced by the prior occurrence of behavioral contrast. A higher initial rate of responding prevails after the appearance of contrast, and the speed of the subsequent extinction is less than with no prior contrast but with the same lack of reinforcement in the second component. Contrast involves not only facilitated reinforced responding; it also persists as enhanced responding during subsequent extinction. Although there is no ready account

of why contrast should be followed by increased resistance to extinction, account of it should be taken in a thorough formulation of the functions of contrast.

In this experiment, the extinction curves from one component were essentially identical regardless of whether responding in the other component declined slowly in ordinary extinction with a lighted key or nearly to zero immediately in extinction in the presence of a dark key. It was not possible to increase the rapidity with which responding declined in extinction in one component by increasing the rate of decline of responding in the other component. One interpretation of this failure is related to the hypothesis that differences in the rapidity of extinction in one component of a multiple schedule are created by various amounts of facilitation of responding by the conditions prevailing in the other component, rather than by inhibition of responding by the other component. Thus, the slower progress of extinction with reinforcement rather than extinction in the second component is interpreted as the result of facilitation, rather than inhibition from the second component.

Also, extinction is not more rapid in the first component with the dark-key condition, rather than regular extinction in the second component, because the dark-key condition does not produce less facilitation than extinction, which produces none at all. While these data cannot prove the absence of inhibitory phenomena, they, as well as interactions between components of multiple schedules in general, simply do not offer salient examples of inhibitory phenomena or of generalized or induced decrements in responding. In fact, positive behavioral contrast is the antithesis of such a notion, a facilitation of responding during both reinforcement and subsequent extinction.

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