

*OPERANT EXTINCTION NEAR ZERO*¹

G. S. REYNOLDS

THE UNIVERSITY OF CHICAGO

Extinction in the presence of each of two stimuli reduces the rate of pecking in the presence of each of them to zero or near zero. When, however, pecking a third stimulus is reinforced, responding is resumed under the other stimuli, and more responses are made to the stimulus least associated with extinction.

Pavlov studied "extinction . . . beyond the point of reducing a reflex to zero" (1927, p. 57). He reduced to zero the magnitude of the salivary response to a conditioned stimulus (CS) by presenting the CS alone on each trial, withholding the unconditioned stimulus (US). This required perhaps 10 presentations of the CS. The measured magnitude of responding was also zero after the CS had been presented alone five additional times, to a total of 15 presentations. Next he noted that five presentations of the CS, reinforced with the US, increased the salivary response to the CS alone to a greater magnitude when it had been extinguished for only 10 trials than when it had been extinguished for 15 trials. (It also required a different number of reinforced trials to produce the first measurable secretion in the two cases.) The inference was that 10 and 15 presentations of the CS in extinction produced different strengths of responding, one zero and one beyond zero or negative, since the same operation, five reinforced presentations of the CS, had an effect of different magnitude in each case.

Pavlov dealt with the strength of a conditioned reflex, the eliciting relation between a stimulus and a response. The present paper deals with the difference between the strengths of two discriminative operants, *i.e.*, with an organism's tendency to emit or actual rate of emission of behavior in the presence of two

discriminative stimuli (Skinner, 1938). Can a difference be shown between the strengths of two discriminative operants at a time when no responses, or the same small number of responses, are emitted in the presence of each stimulus?

Pavlov measured a negative tendency to respond in terms of the number of reinforced presentations of the CS that produced a measurable conditioned response. This metric is not appropriate to the difference between the strengths of two discriminative operants, primarily because it is not certain that each discriminative operant will be reinforced at even approximately the same time. In Pavlov's procedure, the occurrence of the US depended only on the occurrence of the CS. Reinforcement of an operant, however, requires that the response occur, an event not precisely controllable after extinction has taken place. A different technique was therefore used to increase both strengths of responding at the same time. Responding was reinforced in the presence of a third discriminative stimulus to induce responding in the presence of the other two. The amount of induction was taken to show the strength of responding when no responses were actually occurring.

METHOD

Subject

Four adult male, white Carneaux pigeons were maintained at 80% of their free-feeding weights.

Apparatus

A standard experimental space for pigeons contained a response key, which was operated

¹Research supported by National Science Foundation grants 18167 to Harvard University (B. F. Skinner, Principal Investigator) and B316 to the University of Chicago (G. S. Reynolds, Principal Investigator). Reprints may be obtained from G. S. Reynolds, Dept. of Psychology, University of Chicago, 5728 S. Ellis Ave., Chicago 37, Illinois.

by an effective force of about 15 g, a grain dispenser, lights for illuminating the key from behind, general overhead illumination, and a white masking noise.

Procedure

The procedure is summarized in Table 1, where + indicates that pecks were intermittently reinforced with 3 sec of access to mixed grain, and 0 indicates that pecks were not reinforced. Pecks on red, green, and yellow response keys were reinforced on a single variable-interval schedule with a 3-min average interval. In a daily session, each of the three colors appeared on the key 11 times for 3-min periods. The order of presentation was irregular, but it was always the same in each session.

Table 1

Summary of Procedure

(+ means reinforcement, 0 means extinction)

Pigeon:	36 and 52			37 and 53		
Discriminative Stimulus:	Red	Green	Yellow	Red	Green	Yellow
Procedure:	+	+	+	+	+	+
	+	0	+	+	+	0
	+	0	0	+	0	0
	0	0	0	0	0	0
	+	0	0	+	0	0

When the rates of pecking at the red, green, and yellow keys were about the same, pecks on the green key (pigeons 36 and 52) or on the yellow key (pigeons 37 and 53) were not reinforced (extinguished) for 16 sessions. Then, pecks on the green key and on the yellow key were extinguished for 16 sessions for all four birds. Next, pecks on all three colors were extinguished until no systematic differences appeared in the rates of pecking the yellow and green keys. This took 20 sessions for pigeons 37 and 53, 22 for 36, and 25 for 52. At this point, the green key had been associated with extinction for 16 sessions more than the yellow key for pigeons 36 and 52. The yellow key had been associated with extinction for 16 sessions more than the green key for pigeons 37 and 53. Finally, pecks on the red key were again reinforced for all four birds. Pecks on a green or on a yellow key were not reinforced, but were separately recorded.

RESULTS

The results are summarized for each bird in a separate panel of Fig. 1. Ordinates show the difference between the rates of pecking the yellow and green keys. A positive difference indicates more pecks on the color least associated with extinction. The difference is near or equal to zero in the first five sessions, the last sessions in which pecking at each of the three colors was extinguished. When pecks on the red key were reinforced (numbered sessions on abscissa), the difference between the rate of pecking the yellow key and the rate of pecking the green key increased; there were more pecks on the color least associated with extinction, or, alternately, the color more recently associated with reinforcement. The difference later decreased, as is characteristic of induced, unreinforced responding (*e.g.*, Reynolds, 1961).

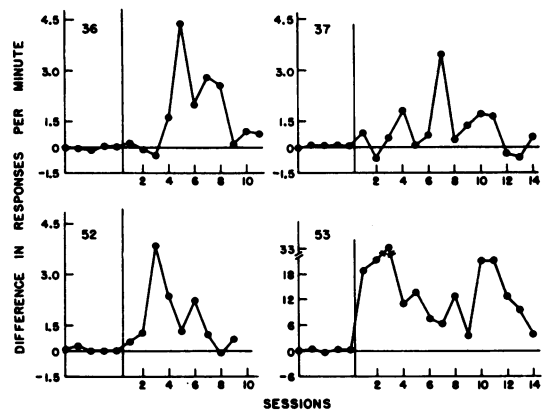


Fig. 1. The rate of responding during the presentation of the stimulus least associated with extinction minus the rate during the stimulus associated with extinction for a longer time, in each session. Each panel shows the differences for a different bird, identified by number. The five points to the left of the vertical line in each graph come from the last five sessions during which responding during the presentation of all three stimuli was extinguished. In the numbered sessions, responding during the third stimulus was reinforced.

Figures 2 and 3 show the absolute rates of pecking from which the differences in Fig. 1 are derived. Figure 2 shows the rate of pecking on the green key (filled circles) and on the yellow key (unfilled circles) during the last five sessions during which pecks on each of the three colors were extinguished. The maximum rate is 0.48 responses per min (a total of 16 pecks in the 33 min during which the

key was green in session 2 for pigeon 53), and the rates are generally less than 0.15 responses per min (5 in 33 min). For three birds, the rates in the last session are equal; for two of them, the rates are equal at zero. The fourth bird (53) did not consistently peck either of the colors more frequently.

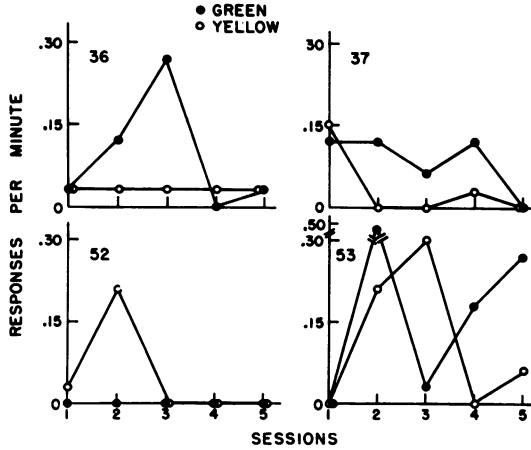


Fig. 2. The rate of pecking the green (filled points) and the yellow (unfilled points) key during the last five sessions in which pecking the red key was also extinguished, for each bird as indicated by the bird's number. The differences between these ordinates are shown in Fig. 1 to the left of the vertical line.

Figure 3 shows the rate of pecking the green key (filled circles) and the rate of pecking the yellow key (unfilled circles) after pecks on the red key were again reinforced. Induction from the reinforced pecking on the red is seen in the increases in the rates of pecking both the green and the yellow key. The amount of induction first increases, then decreases, as is typical (Reynolds, 1961). The yellow key was pecked more frequently by pigeons 36 and 52, the green key more frequently by 37 and 53. These were the colors least associated with extinction in the immediate history of the pigeons.

DISCUSSION

Induction increased to measurable different values the rates of responding in the presence of two stimuli. The reinforcement of pecks on the red key resulted directly in an increase in the frequency of pecking on the red key and in an induced increase in the frequency of pecking on the green and on the yellow key. The amount of the increase in pecking

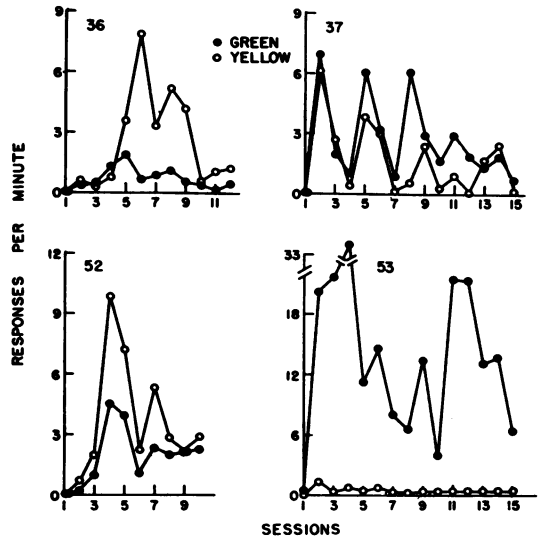


Fig. 3. The rate of pecking the green (filled points) and the yellow (unfilled points) key during the sessions, following those in Fig. 2, in which pecking the red key was reinforced, for each bird as indicated by the bird's number. The differences between these ordinates are shown in Fig. 1 to the right of the vertical line.

on the green and on the yellow key was different depending on the previous history of reinforcement associated with these colors. In general, induction produced a higher rate of responding in the presence of the color associated with extinction for the shorter time.

Consider the effects of induction relative to the rates of responding prevailing in the single session immediately preceding reinforcement of pecks on the red key (session 5, Fig. 2). Relative to this baseline, induction increased an existing small difference between the rates of responding of one pigeon (53), and created a difference between the rates of responding of the other pigeons, a difference that was not present in the rate of pecking before induction.

The creation by induction of differences between rates of responding that were formerly zero (pigeons 52 and 37) suggests that differential tendencies to respond in the presence of two stimuli may continue to exist even when no responses occur. Pavlov's conception was that at least one tendency became negative; the strength of responding decreased beyond zero during extinction. This is a simple, but not a necessary assumption. It is as feasible to assume, for one alternative, that both tendencies continue to be positive but very small fractions of one response in terms of the rate of responding.

The assumption of a negative tendency places some limits on the way in which it can be increased by induction. For example, induction could not be simple multiplication by a positive constant, since that would not increase a negative tendency to greater than zero. Since the exact effects of induction on response tendencies of various magnitudes are not known, however, they cannot be used to decide between the alternatives. Moreover, even were the exact effects known for rates of responding greater than zero, they could be different for the response tendencies that linger when the rate is zero. It is clear only that induction increases both tendencies and that the previously hidden difference between the rates of responding appears.

Additional examples of the preservation of differential tendencies to respond in the absence of responding are presumably available in such fields as emotion and punishment. A conditioned aversive stimulus, or the administration of punishment following each response, may reduce to zero the rate of each of two discriminative operants. Nevertheless,

the withdrawal of the aversive events or, perhaps, the introduction of reinforcement in the presence of a different stimulus as here, can produce different effects on the subsequent rates of the two discriminative operants. In such cases it is tempting to infer that the two strengths of responding were different, and perhaps at least one negative, even though the rate of responding was of value zero for both. It is tempting if only because it maintains a comforting continuity of response strength over time—a sort of continual potentiality for differential responding—within the organism.

Whether or not extinction for a sufficiently long time would abolish all vestiges of differential responding is presently unknown.

REFERENCES

- Pavlov, I. P. *Conditioned Reflexes*, tr. G. v. Anrep, Oxford 1927.
- Reynolds, G. S. An analysis of interactions in a multiple schedule. *J. exp. Anal. Behav.*, 1961, 4, 107-117.
- Skinner, B. F. *The Behavior of Organisms*, New York, Appleton-Century, 1938.

Received July 9, 1963