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Effects of partial reinforcement (25%) in an autoshaping procedure*

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For three pigeons exposed to an autoshaping procedure, every signal (9-sec transillumination of the response key) was followed by a 4-sec access to grain. For three other pigeons, only 25% of the signals were paired with food. Total number of signal-food pairings was matched across groups. Relative to 100% reinforcement, 25% reinforcement delayed the development of asymptotic performance, and resulted in lower asymptotic proportions of signals with responses as well as longer response latencies during the signals.

If a pigeon's response key is repeatedly illuminated for several seconds preceding response-independent presentations of grain, keypecking will eventually occur during the signal. This phenomenon has been labeled "autoshaping" (Brown & Jenkins, 1968). The autoshaping procedure is formally similar to the Pavlovian conditioning procedure. The fact that keypecking, a complex skeletal response directed at a feature of the environment, can be engendered and maintained by response-independent presentations of grain has aroused considerable interest (e.g., Bolles, 1972; Moore, 1971; Seligman, 1970; Shettleworth, 1971; Staddon & Simmelhag, 1971).

A number of experiments have been performed to determine how the principles of Pavlovian conditioning and of operant conditioning can account for autoshaping. The results of experiments by Williams & Williams (1969), Gamzu & Williams (1971), Moore (1971), and Schwartz & Williams (1972a, b) suggest that while adventitious pairings of keypecking and food may modulate some of the characteristics of the keypecking responses which occur during the signal, the differential pairing of the signal with food is the more important determinant of autoshaping.

The present experiment was performed to assess the effect of "partial reinforcement" on the acquisition of keypecking under an autoshaping procedure. In Pavlovian conditioning experiments, partial reinforcement has usually referred to experimental conditions in which the probability of UCS immediately following the CS is greater than zero and less than one, but is zero at other times. Relative to 100% reinforcement, partial reinforcement has been reported to retard acquisition and to result in lower asymptotic levels of the CR in human eyeblink conditioning (cf. Ross & Hartman, 1965). However, the effects of partial reinforcement in Pavlovian conditioning experiments with animals have been inconsistent (cf. Gormezano & Moore, 1969, p. 166).

Williams & Williams (1968) and Schwartz & Williams (1972a, b) have demonstrated that keypecking can be established and maintained by autoshaping procedures in which the signal is only occasionally paired with food. However, there have been no reported comparisons of the course of acquisition of autoshaping under continuous and partial reinforcement schedules. The present experiment was designed to fill the gap.

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Fig. 1. Cumulative records, for each pigeon, of the first 50 signals during which at least one response occurred. The slopes of the curves represent the relative frequency of signals with responses. The slopes associated with relative frequencies of 1.0, .5, and .25 are shown in the insert. The number of signals prior to the first signal in which a response occurred is indicated at the beginning of each cumulative record.

METHOD

Subjects

Six experimentally naive male white Carneaux pigeons were maintained at 80% of their free-feeding weights for the duration of the experiment.

Apparatus

The apparatus consisted of six identical pigeon chambers, each 25 x 28 x 40 cm. During the sessions, a green overhead houselight was illuminated. The response key was 1.5 cm in diam. it was located 19 cm above the floor of the chamber, and it could be transilluminated by a white light. The grain magazine was located below the response key. During food presentation, the grain magazine was illuminated with white light and the green houselight was turned off. White noise masked extraneous sounds. Scheduling and recording equipment was located in an adjacent room.

Procedure

Over a period of several days, the pigeons were habituated to handling and to the chamber. They were then magazine trained. By the second session of magazine training, five of the six pigeons were observed to eat readily upon feeder operation. Pigeon 406, however, was given five magazine training sessions before it started to eat consistently. During this time, the other pigeons were given 100 daily reinforcements according to a variable time 1-min (VT 1 min) schedule. The autoshaping procedure was instigated for all pigeons the day following the sixth magazine training session. The autoshaping sessions for the six pigeons were always started simultaneously. Under this procedure, trials occurred according to a VT schedule consisting of 18 intervals varying from 15-185 sec, with a mean of 50 sec. Keypecks occurring during the last 5 sec of each intertrial interval postponed the occurrence of the trial until 5 sec had elapsed without a peck. This contingency was yoked across the six chambers so that the distribution of trials in time was identical for all pigeons whose sessions were concurrently in effect. A trial consisted of a 9-sec signal followed either by a 4-sec food presentation (during which the houselight was turned off) or a 4-sec blackout. The signal was the transillumination of the response key with white light. For three pigeons, each signal was followed by food. This was the 100% reinforcement condition. These pigeons received 100 trials per session. For the remaining three pigeons, only a randomly selected 25% of the signals were followed by access to grain; the rest were followed by blackouts. The pigeons in the 25% reinforcement group received 400 trials per session and, therefore, 100 signal-food pairings. All pigeons were run for 11 consecutive daily sessions.

On every session, the following measurements were obtained: (1) number of signals during which at least one response occurred; (2) time (in 10ths of seconds) from signal onset to first

response or, if no response occurred, to signal offset; (3) number of responses during the signals; and (4) number of responses in the intertrial intervals.

RESULTS

Autoshaping occurred in all the pigeons. The development of keypecking during the signal is illustrated for each pigeon in Fig. 1. In this figure, the ordinate represents the cumulative frequency of signals during which at least one response occurred. The abscissa represents consecutive signals. The curves are cumulative records, for each pigeon, of the first 50 signals during which at least one response occurred. The number of signals prior to the first signal in which a response occurred is indicated at the beginning of each cumulative record. This number varied considerably within each of the two groups and did not clearly differentiate between them. However, once the pigeons had responded during a signal, the transition to a stable performance, characterized by a high proportion of signals with responses, occurred more rapidly for each of the pigeons under 100% reinforcement than for any of the pigeons under 25% reinforcement.

The graphs in the left-hand column of Fig. 2 show the relative frequency of signals with responses across the 11 sessions for each of the two groups of pigeons. The pigeons in the 100% reinforcement group (bottom graph) attained stable asymptotic proportions approaching 1.0, the maximum relative frequency. Two of the three pigeons on 25% reinforcement attained lower terminal levels of signals with responses than did the pigeons on 100% reinforcement. The graphs in the middle column of Fig. 2 show the mean latencies to the first response that occurred during each signal. Signals during which no responses occurred did not contribute to this measure. The mean latencies were approximately twice as long for the pigeons in the 25% reinforcement group as for the pigeons in the 100% reinforcement group. Mean running rates of keypecking during the signal are shown for each pigeon across sessions in the two right-hand graphs of Fig. 2. The running rate is the ratio of responses emitted during a signal to the

Fig. 2. Proportion of signals with responses, mean latency of the first response during signals, and mean running rate during the signals, over each session for each of the pigeons under 25% reinforcement (upper figures) and under 100% reinforcement (lower figures).

difference between the signal duration and the latency of the first response in the signal. The highest running rates were attained by Pigeons 406 and 408 in the 100% reinforcement group; however, there is too much overlap in running rates between the two groups of pigeons to justify a statement about differences between the groups.

The total number of intertrial responses for Pigeons 406, 408, and 410, in the 100% reinforcement group, were 723, 732, and 510, respectively. For Pigeons 405, 407, and 409, in the 25% reinforcement group, the total number of intertrial responses were 714, 1,187, and 648, respectively. All pigeons emitted more intertrial responses in the initial sessions than in the last five sessions.

DISCUSSION

The results indicate that 25% reinforcement in an autoshaping procedure affects both the rate of acquisition and the asymptotic level of responding relative to the 100% reinforcement condition. Note, however, that the effects observed on the asymptotic performance were comparatively small, considering the large difference between the two groups in the proportion of signals paired with food. Furthermore, the various behavioral measures were differentially sensitive to partial reinforcement. Although number of trials prior to the first signal in which responding occurred did not appear to differ between the two groups of pigeons, the cumulative records displayed in Fig. 1 show that the early performances of the pigeons in the two groups were different. Similarly, the latency measure (Fig. 2) showed the effect of partial reinforcement to a greater extent than either the proportion of signals with responses or the running rate during the signals. These results suggest that cumulative records of the type shown in Fig. 1 and the latency measure might be sensitive dependent variables worthwhile considering in autoshaping experiments in which parameters other than probability of reinforcement are manipulated.

The pigeons in the 100% and in the 25% reinforcement groups emitted approximately the same total number of intertrial responses. This suggests that the pigeons in the 25% reinforcement group did not come in contact with the trial delay contingency any more frequently than did the pigeons in the 100% reinforcement group, even though they had many more opportunities to do so. Therefore, it is unlikely that the observed differences between the 25% and 100% reinforcement groups resulted from differential exposure to the trial delay contingency that preceded the signals.

For the pigeons under 100% reinforcement, the number of

trials to the first signal in which a response occurred was considerably larger than has been reported in other studies, e.g., Brown & Jenkins (1968). The reasons for this are not clear. Perhaps the low illumination produced by the green houselight was a factor. Wasserman, Markman, & Hearst (1971) have performed a series of experiments which indicate that houselight illumination can be an important variable determining behavior under autoshaping procedures. Another possibility is that the prolonged magazine training period impaired the development of autoshaping. Engberg, Hansen, Welker, & Thomas (1972), for example, have demonstrated that keypeck autoshaping occurs more slowly in pigeons having a prior history of response-independent food presentation than in naive pigeons.

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