Acquisition and extinction of an instrumental running response with single- or multiple-pellet reward*

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Rats were given 5, 15, or 60 training trials for 500 mg of food, which was delivered in either single- or multiple-pellet form. The pellet groups did not differ after 5 or 60 trials either at terminal acquisition or in extinction. After 15 trials, however, multiple pellets produced superior performance in acquisition as well as more rapid extinction than single pellets.

Trapold and his associates (Trapold & Bell, 1964; Trapold & Doren, 1966) have argued that an approximation of the complete instrumental response is sufficient to affect the development of anticipatory reward (r_R). Following Trapold's thinking, Amsel, Hug, & Surridge (1968) reasoned that reward delivered in multiple-pellet form would result in several goal approaches on each training trial, yielding more rapid development of r_R than if the reward were of the same weight but delivered in single-pellet form. Since Amsel's system (1967) requires a certain minimum amount of r_R as necessary to the development of the partial reinforcement extinction effect (PREE), this effect was thought to be attainable with limited training if multiple, but not single, pellets were used. Amsel et al were able to support the Trapold hypothesis in demonstrating a PREE following six training trials when their Ss were rewarded with multiple pellets, but not when rewarded with single pellets.

Spence (1960) has assumed that the asymptotic development of r_R is a function of reward magnitude. If it is assumed that multiple pellets result only in more rapid development of r_R than single pellets, the same asymptote should be reached whether the reward is delivered in single- or multiple-pellet form. Given similar asymptotes for single and multiple pellets following extended training, both conditions should produce the PREE. Indeed, Amsel, Surridge, & Hug (1969) have shown that with extended training there is nondifferential extinction performance for these conditions. In both cases the PREE was obtained. If multiple pellets provide only for more rapid development of r_R, to an asymptote reached later in acquisition through single-pellet training, it follows that acquisition curves for these two conditions should initially diverge, then converge to the same terminal level.

Secondly, frustration theory (Amsel, 1967) holds that the amount of primary frustration (R_F) in early extinction is directly related to the extent to which r_R is suprathreshold for R_F. Further, the development of anticipatory frustration (r_F) is contingent on the presence of R_F, and resistance to extinction is assumed to be inversely related to r_F. It follows that where continuous reinforcement acquisition conditions produce similar levels of r_R, resistance to extinction should be comparable.[1] Hence, following either limited or extensive training, single- and multiple-pellet conditions should result in nondifferential resistance to extinction. With moderate training, on the other hand, multiple pellets would be expected to result in greater r_R than single pellets. Here, resistance to extinction should be less for multiple pellet reward.

The following experiment was conducted to test the assumptions that acquisition curves would initially diverge, then converge to the same asymptote, and further, where the multiple-pellet condition was superior in acquisition, its extinction would be more rapid.

SUBJECTS

The Ss were 48 male Holtzman rats, approximately 120 days old at the start of experimentation. They were housed in individual cages throughout the experiment.

APPARATUS

The apparatus was a straight alley, 5 ft long, separated from a 1-ft startbox and a 1½-ft goalbox by dropping aluminum guillotine doors. The startbox and runway segments were 3 in. wide, and the goalbox was 4 in. wide. Run time was measured from 12 in. into the alley to 1 in. before the goalbox door, covering a distance of approximately 4 ft.

Lighting in the sound-resistant experimental room was provided by three 40-W frosted bulbs suspended 1 ft above the clear Plexiglas top of the runway at the startbox and goalbox doors, as well as in the center of the runway proper.

PROCEDURE

On Day 1 all Ss were put on food deprivation and over Days 2-16 were stabilized to 80% of their normally growing body weight, six control Ss serving to monitor the normal growth weight. On Day 17 the Ss were given two nonreinforced running trials and assigned to groups such that operant-level run speeds were equated. Over Days 18-29 the 60-trial groups were given training at five trials per day. The 15-trial groups were given training on Days 27-29, while the 5-trial groups were given acquisition training only on Day 29. All Ss were run in squads of eight, which provided an ITI of approximately 10 min. On each acquisition trial, an S was placed in the startbox and the door was opened when S oriented toward it. As the S passed through the start- and goalbox doors, these doors were closed to prevent retracing. On each trial the single-pellet group received 1 500-mg pellet; the multiple-pellet group received 11 45-mg pellets. The Ss were allowed to consume the reward before being removed from the goalbox and on removal were placed in a portable carrying cage, which provided access to a water bottle. Between ½ h and 1 h after running, the Ss were fed their daily ration.

Twenty-five extinction trials were given over Days 30-40 under conditions similar to acquisition, with the exception that the goalbox was unbaited. The Ss were confined for 10 sec in the goalbox on each extinction trial. An S taking longer than 60 sec to traverse the alley was removed, and a time of 60 sec was recorded for that trial. Two successive 60-sec trials constituted extinction, and the S was no longer run for the remainder of the experimental days.

RESULTS AND DISCUSSION

Figure 1 shows terminal acquisition performance (means of median speeds over the last five trials) for each of the groups. The apparent divergence-convergence of the single- and multiple-pellet functions was supported in an analysis of variance by a reliable Training by Pellets interaction, $F_{(2,42)} = 4.26$, $p < .05$. Analysis of simple effects failed to show a reliable difference after either 5 or 60 trials; however, after 15 trials the multiple group ran faster, $F_{(1,42)} = 7.50$, $p < .01$. These data clearly showed early development of superior performance by the multiple-pellet Ss, followed by nondifferential performance later in training. They are consistent with
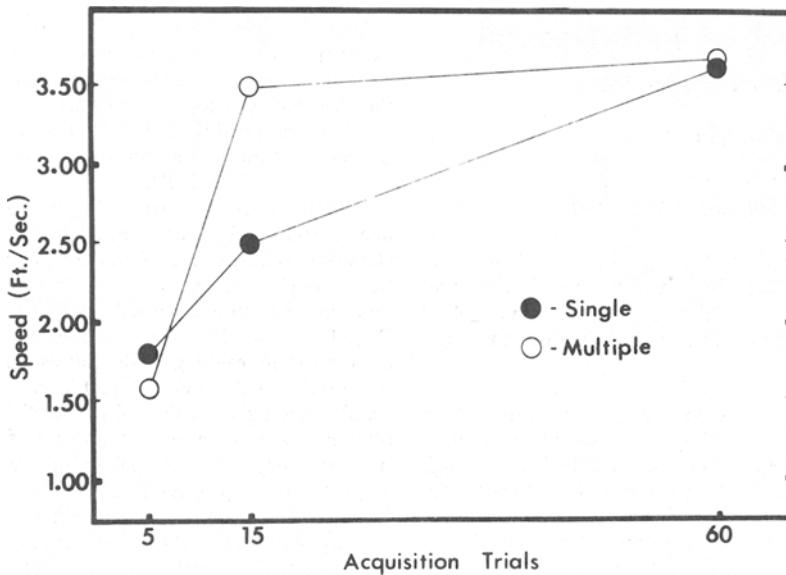
Fig. 1. Terminal acquisition running speed as a function of number of acquisition trials for groups given reward in single- or multiple-pellet form.

Table 1
Mean Number of Trials to a 5-Sec Running Time Criterion

	Acquisition Trials		
	5	15	60
Single	6.5	12.4	9.0
Multiple	3.9	5.9	8.4

Following 5 and 60 trials, terminal acquisition response speeds did not differ for the single- and multiple-pellet groups. Similarly, extinction produced nondifferential performance for the pellet groups after 5 and 60 training trials. These results support the prediction from frustration theory (Amsel, 1967) that where acquisition conditions have produced similar levels of r_R, extinction rates will also prove similar. Conversely, recall that acquisition performance at 15 trials showed superiority of the multiple-pellet group. Extinction resulted in both a faster run speed decrement and fewer trials to criterion for the multiple-pellet group. Hence, further support was found for the frustration interpretation in that treatments producing greater r_R likewise tend to result in less resistance to extinction.

A point seemingly contrary to the previous prediction lies in comparing the multiple-pellet groups after 15 and 60 training trials. Terminal acquisition for this comparison shows no difference, yet when given 15 trials, the multiple-pellet group appears to extinguish faster than when given 60 trials. While this result is not consistent with an explanation based solely on r_R, note that 60 trials should provide

the assumption that multiple pellets provide for more rapid development of r_R (Amsel, Hug, & Surridge, 1968) and further support the Trapold hypothesis (Trapold & Bell, 1964; Trapold & Doren, 1966).

The results are *not* consonant, however, with an assumption by some, (e.g., Logan, 1960; McCain, 1969) that multiple pellets have greater incentive value than single pellets, in the manner that large reward produce more incentive than small rewards. This assumption would require a similar rate of approach to a higher asymptote by multiple- than by single-pellet groups (Pubols, 1960). Though McCain (1969), for example, was able to show higher terminal acuqisition performance resulting from multiple-pellet conditions, his multiple-pellet group also approached asymptote at a more rapid rate, a result more in line with the present data.

Extinction response speeds for the single- and multiple-pellet groups at each level of training are shown in Fig. 2. An analysis of variance conducted over the means of the median response speeds for the first three blocks of five extinction trials[2] resulted in a Pellets by Trials by Rate of Extinction interaction, $F(4,84) = 2.85$, $p < .025$. Given 5 or 60 training trials, there was no interaction between pellets and extinction trial blocks ($Fs < 1.00$); however, both training levels resulted in reliable response decrements during extinction, $Fs(2,84) = 2.85$ and 6.48, ps $< .025$ and .005, respectively. After 15 training trials, on the other hand, extinction led to a more rapid response speed decrement by the multiple-pellet

group, providing a reliable Pellets by Extinction Blocks interaction, $F(2,84) = 5.21$, $p < .01$.

The number of trials to reach a criterion of 5 sec to traverse the run segment clearly supported the extinction run speed data (Table 1). There were nonreliable differences in trials to criterion after both 5, $F(1,42) = 1.25$, and 60 training trials, $F(1,42) = 1.00$. After 15 training trials the single-pellet group required more than twice as many trials to reach criterion than did the multiple-pellet group, $F(1,42) = 7.36$, $p = .05$.
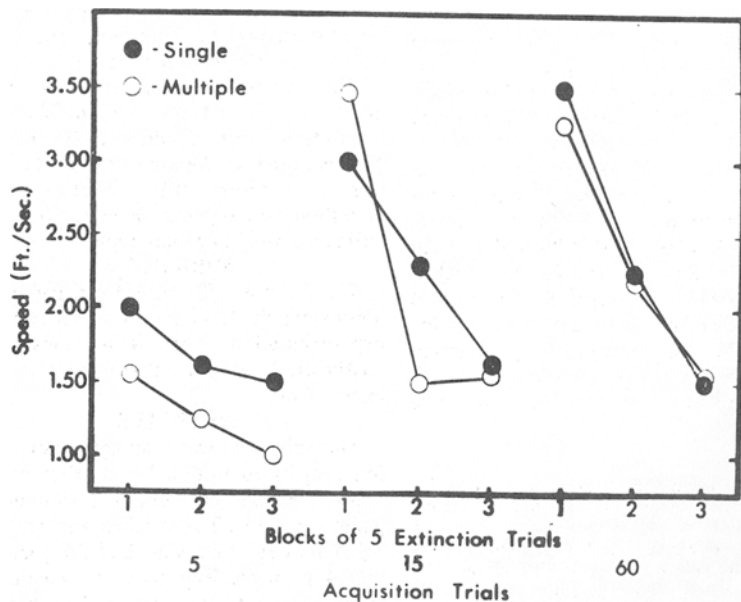

Fig. 2. Running speed over blocks of five extinction trials as a function of number of acquisition trials for groups given single- or multiple-pellet reward.

greater habit strength (H) than 15 trials. At the same time, r_R might be expected to have reached asymptote by 15 multiple-pellet trials. It is possible, then, to compare the single and multiple groups after 15 trials as having similar levels of H with the multiple group having greater r_R. Likewise, the 15-multiple-pellet group may be taken to have a similar level of r_R as the 60-multiple-pellet group, but less H. Given these reasonable assumptions, it can be concluded that with r_R equated, resistance to extinction will increase with H, but with H equated resistance to extinction will decrease with r_R. These conclusions are exactly those of Theios & Brelsford (1964), who provided goalbox placements to increase the strength of r_R while maintaining control over the growth of H. Goalbox placements are probably very similar to the multiple-pellet trials of the present experiment in that both appear to augment r_R while not substantially contributing to H. Thus, the evidence seems to favor the Trapold interpretation, that r_R can grow with approximations of the complete instrumental response.

It may also be noted that the present experiment found no extinction differences for the pellet groups following five training trials. Amsel, Hug, & Surridge (1968), on the other hand, demonstrated greater resistance to extinction following five trials when their Ss were given two pellets than when given 24 pellets. There are numerous procedural differences between the present experiment and that of Amsel et al, but perhaps the one most relevant to the dissimilarity in extinction is the reward magnitude employed. Amsel et al used a reward twice the size (1,000 mg) as that used in the present study (500 mg). With the larger reward, r_R should condition more rapidly; thus any differences due to r_R should tend to occur earlier in acquisition. It is not contradictory, then, that the more rapid extinction of the multiple-pellet group following 15 training trials observed in the present experiment was seen in the Amsel et al experiment following 5 training trials.

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NOTES

1. Note that this argument does not necessarily apply to partial reinforcement training, since here persistence training may enhance resistance to extinction above that attributable to r_R.
2. The last two blocks of five extinction trials were omitted from analysis since several Ss had reached the criterion for extinction, leaving some groups with too few Ss for reliable analysis.

Different nocturnal activity patterns of
Peromyscus californicus and *Peromyscus eremicus*
in lunar lighting

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The total night-time activity-wheel running by two sympatric species of mice, P. californicus and P. eremicus, was compared under the same simulated sun and moon cycles. Total running by P. californicus correlated negatively with the nightly duration of moonlight, while that of P. eremicus correlated positively. The results were discussed in terms of a temporal dimension of competitive exclusion.

The time of day at which a species is most active is ecologically significant. Most squirrels (family Sciuridae) have morphological, physiological, and behavioral adaptations for activity during sunlight, whereas most desert rodents are active at night, presumably an adaptation reducing dessication and predation. Many examples of much more precise timing of activities are known: the rising of the palolo worm (Clark & Hess, 1942), the synchrony of grunion spawning with tides (Walker, 1952), and the rhythm of emergence of *Drosophila* from pupae (e.g., Pittendrigh & Bruce, 1957) synchronized with the beginning of day in this diurnal animal. Thus there may be certain times of day or conditions during a day for which activity has been selected. Although the adaptive features are partly understood in many such instances, they are not understood in others, and the phenomena remain tentatively labeled "species differences" until analysis of the ecological significance provides an understanding of the selective advantage of the timing of the activity.

Among the many probable ecological factors relevant to activity, one could be temporal competitive exclusion. The competitive exclusion principle (e.g., Hardin, 1960) states that two species cannot occupy the same niche in the same way because one of them will be the more successful, be it ever so slight an advantage, will increase in proportion, and will eventually occupy the niche exclusively. The usual interpretation of this principle is spatial—that sympatric species are in somewhat different habitats within the area of overlap. It is possible, however, that the dimension in which lack of competition evolved can also be temporal. Two species active at different times during the 24-h day would not exploit the environment in exactly the same way and could therefore theoretically coexist.