

# Effects of partial and continuous reinforcement on acquisition and extinction in classical appetitive conditioning\*

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A study was conducted to determine the effects of a continuous and random 50% schedule of reinforcement on classical appetitive conditioning and extinction of the rabbit's jaw movement response. It was found that partial reinforcement led to a slower rate of acquisition, lower asymptotic level, and slower rate of extinction. The findings were discussed with regard to incentive theory and stimulus aftereffects accounts of partial reinforcement effects in instrumental reward conditioning.

## METHOD

The only systematic investigation of the effects of partial and continuous reinforcement on classical appetitive conditioning in infrahumans are those reported by Wagner, Siegel, Thomas, and Ellison (1964) and Holmes and Gormezano (1970). Wagner et al examined the salivary response to food in dogs, and Holmes and Gormezano examined the jaw movement response (a component of the swallow reflex) to a squirt of water to the oral cavity of rabbits. Both investigations revealed a higher final level of performance for continuous than for partial reinforcement and a minimal partial reinforcement extinction effect (PREE) as revealed by a significant Groups by Trials interaction.

In the Wagner et al study, the first trial of extinction was the only acquisition data reported, whereas the Holmes and Gormezano study did not unequivocally demonstrate that the acquisition differences obtained under partial and continuous reinforcement were asymptotic. Furthermore, the finding by Poulos, Sheafor, and Gormezano (1971) that the extent of single alternation of classical appetitive jaw movement CRs under a single-alternation schedule was a monotonic increasing function of US magnitude suggested that the obtaining of only a marginal PREE by Holmes and Gormezano may have been due to the small US magnitude (1-cc squirt of water) employed. Such an inference arises from the assumption that stimulus aftereffects accounts (cf. Capaldi, 1967; Sheffield, 1949) would expect variables affecting single-alternation behavior to also affect the PREE. Accordingly, the present study was designed to assess the acquisition and extinction effects of partial and continuous reinforcement under more extended acquisition training and larger US magnitude than previously employed.

### Subjects

The Ss were 24 male and female albino rabbits 80-100 days old, and each weighed about 2.2 kg on arrival.

### Apparatus

The apparatus and recording technique has been described by Mitchell and Gormezano (1970), who detail departures from earlier procedures (Smith, DiLollo, & Gormezano, 1966). The US was a pulsed delivery of 13 cc of distilled water into the rabbit's oral cavity, with each pulse consisting of a 1-cc squirt delivered over a .3-sec interval. The interval between each successive 1-cc squirt was .45 sec and provided an almost uninterrupted stream of water. Thus, the total duration of the 13-cc US was 9.3 sec. The CS was an 80-dB 1,000-Hz tone which was 8 dB above a continuous white noise. The CS-US interval was 500 msec with the CS terminating at the point of US onset.

### Procedure

The Ss were anesthetized, a polyethylene cannula was permanently inserted through a fistula in their left cheek, and a wound clip was applied to the lower jaw. After a 48-h recovery period, the Ss were restricted to 104 cc of water per day for the duration of the experiment. Prior to the availability of water on the fourth day, the Ss were adapted to the apparatus and their base level of jaw movements recorded at times corresponding to the CR observation interval of subsequent acquisition and extinction sessions. Thirty-six days of acquisition training began on the following day with Ss randomly assigned to a random 50% and 100% reinforcement condition. All Ss then received 12 days of extinction training.

In acquisition and extinction, all Ss received eight trials per day at random intertrial intervals of 170, 210, and 250 sec (mean of 210 sec). A CR was defined as a jaw movement of at least .25 mm from baseline during the 25- to 525-msec interval following CS onset. Under the present volume of US delivery, there was some differential ability among Ss to totally consume the US. Accordingly, individual records of water loss were obtained and each S was individually supplemented to maintain its 104-cc per day regime. The average amount of water loss per session was approximately 10%.

## RESULTS

Figure 1 presents the mean base rate of responding in adaptation and the mean percentage of CRs over 3-day blocks in acquisition and 2-day blocks in extinction.

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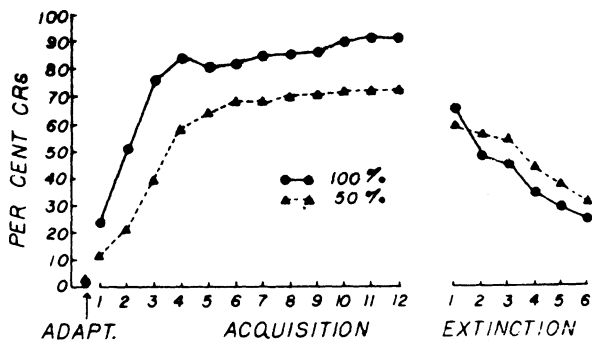


Fig. 1. The mean base rate of responding in adaptation and the mean percentage of CRs plotted in 3-day blocks in acquisition and 2-day blocks in extinction.

Examination of the figure reveals a base rate of less than 2% in adaptation and a differential rate of increase in percentage CRs over acquisition to essentially asymptotic levels of responding of 73% and 90% for the 50% and 100% groups, respectively. An analysis of variance performed on the percentage CRs in 3-day acquisition blocks yield significant effects of groups ( $F = 16.25$ ,  $df = 1/264$ ,  $p < .01$ ), blocks ( $F = 19.79$ ,  $df = 11/264$ ,  $p < .01$ ), and Groups by Blocks ( $F = 2.30$ ,  $df = 11/264$ ,  $p < .01$ ). Furthermore, a determination of the number of trials to the first CR for the 50% and 100% groups yielded significantly different means of 25.17 and 13.33, respectively ( $t = 2.37$ ,  $df = 22$ ,  $p < .05$ ).

Examination of the extinction performance portrayed in Fig. 1 reveals that the percentage CRs of the 100% group dropped rapidly in the first extinction block to a level slightly above the 50% group, followed by a crossover in the second block to a level of responding that remained below the 50% group throughout all subsequent blocks of extinction. An analysis of variance on the percentage CRs, in 2-day blocks, revealed significant effects of blocks ( $F = 3.23$ ,  $df = 5/132$ ,  $p < .01$ ) and Groups by Blocks ( $F = 2.37$ ,  $df = 5/132$ ,  $p < .05$ ), but no significant groups effect ( $F < 1.0$ ).

## DISCUSSION

The observation in the present study of a slower rate of acquisition and lower asymptotic level of performance under partial than under continuous reinforcement represents fairly strong documentation of the detrimental effects of nonreinforcement on the acquisition of classical appetitive CRs. In particular, any simple strength model that does not recognize any unique detrimental effect of nonreinforcement (e.g., Hull, 1952) would expect the larger US magnitude and the more extended acquisition training employed (relative to the Holmes and Gormezano study) to have eventually led the partial reinforcement group to equal asymptotic levels of performance.

On the other hand, the observed acquisition partial reinforcement effects are consistent with any of the variety of learning formulations which assume response strength to be increased by reinforcement and decreased by nonreinforcement (e.g., Bush & Mosteller, 1955; Estes, 1950). Furthermore, the finding of a lower asymptote under partial reinforcement bears upon the account given by incentive theory, and its extension through the concept of frustration (Amsel, 1958; Spence, 1960), of partial reinforcement effects in instrumental reward conditioning. Since the argument has been developed elsewhere (Holmes & Gormezano, 1970), it will not be treated here except to indicate that the present finding complicates the theory's prediction of performance asymptotes under partial and continuous reinforcement.

Although the PREE defined by a groups effect did not materialize, a PREE was revealed by a Groups by Blocks interaction that, unlike those obtained in the previous classical appetitive conditioning studies, was produced by a crossover during extinction by the continuous reinforcement group. That is, the continuous group performed at a higher level than the partial group during the initial extinction block and then dropped to a lower level of performance during the subsequent extinction blocks. Thus, the interaction cannot be attributed merely to the differences in final level of acquisition. This more convincing demonstration of a PREE with the employment of a large US magnitude and the earlier finding that single alternation of classical appetitive CRs was a function of US magnitude (Poulos, Sheafor, & Gormezano, 1971) suggests that the stimulus aftereffects accounts (cf. Capaldi, 1967; Sheffield, 1949) of the partial reinforcement variable in instrumental appetitive conditioning may be applicable to classical appetitive conditioning.

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