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Short report

Training a new response using conditioned reinforcement

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ABSTRACT

Some of the most frequently used methods in the study of conditioned reinforcement seem to be insufficient to demonstrate the effect. The clearest way to assess this phenomenon is the training of a new response. In the present study, rats were exposed to a situation in which a primary reinforcer and an arbitrary stimulus were paired and subsequently the effect of this arbitrary event was assessed by presenting it following a new response. Subjects under these conditions emitted more responses compared to their own responding before the pairing and to their responding on a similar operandum that was available concurrently that had no programmed consequences. Response rates also were higher compared to responding by subjects in similar conditions in which there was no contingency (a) between the arbitrary stimulus and the reinforcer, (b) between the response and the arbitrary stimulus or (c) both. Results are discussed in terms of necessary and sufficient conditions to study conditioned reinforcement.

1. Introduction

Learning theorists have agreed that the concept of conditioned reinforcement refers to a neutral event that acquires reinforcing properties by its relation to a primary reinforcer (e.g., Schlinger and Blakely, 1994). Some authors state that this process is necessary to the development of complex behavioural patterns both in humans and in other animals, since primary reinforcement contingencies are not easily identified in most complex behavioural patterns (e.g., Williams, 1994; Donahoe and Palmer, 1994). The most frequently used procedures to study conditioned reinforcement are extinction (e.g., Skinner, 1938), chained schedules (e.g., Kendall, 1967), second-order schedules (e.g., Findley and Brady, 1965), and observing responses (e.g., Wyckoff, 1969). Nevertheless, these procedures have weaknesses that prevent an unequivocal demonstration of the phenomenon (see Williams, 1994 and Fantino, 1977, for an extensive critique of the procedures used to demonstrate the effect).

The new response technique using conditioned reinforcement is arguably the most adequate way to demonstrate the effect (Williams, 1994; Wyckoff, 1959). However, this procedure requires specific control conditions to make sure that (1) the supposed neutral event is not reinforcing by itself, (2) performance is not caused by an increase in general activity caused by the mere presentation of a stimulus previously paired with a reinforcer, and (3) the performance does not reflect an increase in general activity caused by the withdrawal of the primary reinforcer. Some of these controls were implemented in a number of studies (Bersh, 1951; Crowder et al., 1959; Fox and King, 1961; Keehn, 1962; Knott and Clayton, 1966; Saltzman, 1949; Skinner, 1938; Stein, 1958; Zimmerman, 1959; Snycerski et al., 2005; Sosa and Pulido, submitted for publication). Yet, none of these have implemented all the necessary control conditions at the same time. The aim of the present study is to evaluate the new response procedure taking into account all these control conditions that are necessary for an unequivocal demonstration of the phenomenon.

If subjects exposed to a pairing between an arbitrary stimulus and a primary reinforcer, but whose responses in the test had no relation with the presentation of the arbitrary stimulus (Control 1), responded at high rates, this effect could be attributed to the presentations of the stimulus previously paired with a primary reinforcer causing an increase in general activity. If there were an increase in response rate for subjects exposed neither to a pairing between an arbitrary stimulus and a primary reinforcer nor to a test condition in which its responses lead to reinforcement (Control 3), this could be interpreted as an increase in general activity caused by the withdrawal of free reinforcer presentations. If subjects exposed to non-paired stimulus presentations in the training phase and a contingency between the response and the arbitrary stimulus in the second (Control 2), responded at higher rates, the arbitrary stimulus may be assumed to have reinforcer properties. If only the subjects exposed to pairing between an arbitrary stimulus and a primary reinforcer during training responded more frequently in the test, during which the arbitrary stimulus is contingent on a response

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(Experimental Group), it could be claimed that the arbitrary stimulus actually had acquired reinforcing properties.

2. Materials and method

2.1. Subjects

Sixteen naïve, female Wistar Lewis rats, aged three months at the start of the experiment, weighing between 250 g and 300 g, were used. Rats were housed individually and maintained on a 12-hr light-dark cycle with lights on at 7:00 am. Subjects had access to water 30 min after the experimental sessions. All rats had continuous access to food in their home cages.

2.2. Apparatus

Two standard rat conditioning chambers (MED associates, Inc., Model ENV-008) were used. Chambers were housed in sound-attenuating cubicles (MED associates, Inc., Model ENV-022 M). Each chamber was equipped with two water dispensers (MED associates, Inc., Model ENV-201A); one of them installed in the central panel of the right wall and the other was outside the chamber but inside the sound-attenuating cubicle. Each chamber was equipped with two retractable levers situated on the front wall of the box at the lateral channel adjacent to the water dispenser. Levers were 2.5 cm above the grid floor and a force of 0.15 N was required to close the microswitch. The arbitrary stimulus was the following set of events, presented simultaneously: a 1 s, 60 dB white noise produced by a sonalert situated on the upper left corner of the back wall, a 1 s white light situated above the water dispenser and a click produced by the outside water dispenser. The event programming and data recording was conducted using MED-PC IV computer equipment, interface and software for Windows environment.

3. Procedure

3.1. Experimental design

A 2×2 factorial design was used, with contingency and phase as factors. Thus, four groups ($n = 4$) were used. All subjects were exposed to two phases –training and test– each of which consisted of two conditions. The first condition of training consisted of either paired (Experimental and Control 1) or unpaired (Control 2 and Control 3) presentations of the arbitrary stimulus and the primary reinforcer; the second condition consisted of a reduction in the proportion of primary reinforcer presentations with respect to arbitrary stimulus presentations to prevent a rapid extinction of the reinforcing value of the putative conditioned reinforcer. In the first condition of the test, the arbitrary stimulus was either contingent (Experimental and Control 2) or non contingent (Control 1 and Control 3) upon a response; in the second condition of the test, responding had no programmed consequences (Extinction). Two response levers were present throughout the experiment to assess baseline levels of responding.

3.2. Training

Both conditions of the training phase consisted of 24 presentations of the arbitrary stimulus according to a random time 120 s. These arbitrary stimuli were either paired (i.e., presented immediately before) with the presentation of water (for groups Experimental and Control 1) or non-paired (the arbitrary stimulus was arranged according to an independent random time schedule, groups Control 2 and Control 3). The non-paired condition was similar to a truly random procedure (Rescorla, 1967). In Condition 1, the proportion of water presentations given the arbitrary stimulus was 1.0 and, in Condition 2, this proportion was 0.5. Both conditions were conducted for four sessions. If a water presentation was scheduled, pressing either lever delayed it by 6 s; this contingency was implemented to prevent potential adventitious reinforcement.

3.3. Test

Test consisted of two conditions (Condition 3 and Condition 4). During Condition 3, responses on one of the levers (reinforcement operandum) produced the arbitrary stimulus according to a random interval 60 s for groups Experimental and Control 2; responses on the other lever (inoperative operandum) had no programmed consequences. During this condition, subjects of groups Control 1 and Control 3 were yoked to subjects of groups Experimental and Control 2 respectively, with regard to the presentations of the arbitrary stimulus: each time one of the subjects of groups Experimental and Control 2 fulfilled the requirement imposed by RI schedule, it produced an arbitrary stimulus for itself and for its yoked counterpart. One session was conducted each day and lasted for a maximum of 48 min or until subjects of the Experimental Group produced the arbitrary stimulus 20 times. If experimental subjects did not produce the arbitrary stimulus 20 times within one session, subsequent test sessions were conducted until the number of stimuli summed over all sessions was 20. During Condition 4, responses on either lever had no scheduled consequences for any of the groups. This condition consisted of two sessions.

4. Results

Fig. 1 shows response rates during training. Subjects of all groups showed low rates of responding (less than one response per minute) in the first phase of the experiment (i.e., training), with no apparent differences between response rates on either lever. Response rates for some subjects (C3, C4, C5, C7, C8, and C16) were somewhat higher in the first sessions of the training phase and decreased in the remaining sessions, which can be interpreted as an effect of novelty of the initial exposure to the operant chamber and experimental contingencies probably inducing exploratory behavior.

Fig. 2 depicts response rates during the test phase. During Condition 3, response rate on the reinforcement operandum for the Experimental Group was notably higher than response rates for the subjects of the remaining groups in this condition and higher than response rates during training for the same subjects. Numbers nearby continuous plots demonstrate that subjects of the Experimental Group produced the arbitrary stimulus 20 times in two to five sessions, while subjects of Control 2 produced it 12 times at most during the same period. Response rate on the inoperative operandum increased for two subjects of the Experimental Group (C1 and C5) and remained relatively low for the other subjects of that group (C9 and C13). For the animals in the other groups, response rate on inoperative operandum remained low during this condition. During Condition 4 (Extinction), response rate on the reinforcement operandum decreased for all subjects of the Experimental Group. For the remaining subjects, response rate in both operanda remained low during this condition, except for subject C4, which showed a mild increase in response rate in the first session.

We compared the response rate on the reinforcement operandum in the last session of each of the four conditions with a two-way repeated measures ANOVA, which yielded a significant main effect of condition [$F(1.41,16.91) = 9.49$, $P = 0.004$][1], and

[1] Given that the sphericity of variance–covariance matrix could not be assumed, the degrees of freedom were corrected by the Greenhouse-Geisser factor.