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Transference effects of prior non-contingent reinforcement on the acquisition of temporal control on fixed-interval schedules

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ABSTRACT

In two experiments we examined the influence of response and time factors on the speed of acquisition of temporal control on FI schedules. In Experiment 1, prior exposure to FT accelerated the development of temporal control on FI schedules of the same temporal value. It was also found that the slower acquisition on FI with prior RT was similar to that of rats with prior standard training. In Experiment 2, prior exposure to FT accelerated the development of temporal control on a FI schedule with a threefold increase in temporal value. Additionally, it was found that with prior FI 30 s training, acquisition of temporal control on FI 90 s was even faster than with prior FT 30 s. Measures of head-entries into the feeder along the experiments indicated that temporal control was already developed during the periodic but not during the non-periodic histories and that this control transferred to lever press during FI testing phase.

1. Introduction

Fixed-interval (FI) reinforcement is a widely used procedure to study temporally regulated behavior. After several sessions on this schedule, rats display a characteristic pattern of responding: a pause after the reinforcer delivery, followed by an accelerated or a constant response rate until the next reinforcer (Baron and Leinenweber, 1994; Dews, 1970; Ferster and Skinner, 1957; Gentry et al., 1983; Schneider, 1969). Also, it is frequently observed that the point of transition from not responding to responding increases as a power or a proportional function of the FI value (Hanson and Killeen, 1981). These regularities are considered the empirical referents of temporal control or discrimination.

Most research on FI schedules has focused on steady-state properties of temporal control rather than on its acquisition. However, acquisition analysis has recently received closer attention because of its importance for the identification of factors involved in temporal learning (Guilhardi and Church, 2005; Machado and Cevik, 1998). The acquisition of temporal control under FI schedules involves the progress from a temporally undifferentiated response pattern in the initial sessions, to a differentiated one in advanced sessions. A qualitative description of this process was first reported by Ferster and Skinner (1957) and more recently quantitative analyses were presented by Baron and Leinenweber (1994) and Machado and Cevik (1998). Both qualitative and quantitative accounts assume a typical pre-training procedure (i.e. a relatively brief exposure to a continuous reinforcement schedule before the introduction of the FI schedule). However, as Machado (1997) has noted, it is conceivable that the process of temporal control acquisition varies with different conditioning histories and amount of training.

According to Guilhardi and Church (2005), the speed of learning of a temporal discrimination is one dimension which may vary depending on prior experience. In fact, there is evidence supporting the previous assertion. For example, Urbain et al. (1978) observed that the acquisition of temporal discrimination under FI 15 s was much slower with prior exposure to a fixed-ratio (FR) 40 than with prior exposure to an interresponse-time-greater-than 11 s (IRT > 11 s). Also, Wanchisen et al. (1989) reported that the acquisition of temporal control on FI 30 s was slower with prior exposure to a variable-ratio (VR) 30 s than with regular magazine and lever-press training. In a more recent study, rapid development of temporal control in FI was reported by López and Menez (2005) when FI training was preceded by a history on non-contingent periodic delivery of reinforcers. Specifically, the post-reinforcer-pause (PRP) and response pattern analyses showed that temporal control appeared on earlier sessions on FI with prior exposure to fixed-time (FT) than to random-interval (RI) or to FR 1 schedules. In general, while evidence suggests that the speed of acquisition of temporal control on FI schedules depends on the prior reinforcement history, a question remains of what are the means by which variation in speed occurs.

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At present, research suggests two factors that may affect the speed of temporal control acquisition. One is the response rate at the introduction of the FI schedule: histories that generate low rates induce a faster acquisition of temporal control than histories that generate relatively high rates as in FT vs. FR 1, or RI schedules (López and Menez, 2005); or as in IRT > *t* vs. FR (Urbain et al., 1978). Under these conditions, facilitation of temporal control may occur because rate of responding on the early segment of FI is already low and is associated to the absence of reinforcement. Therefore, responding would remain low or decrease further in the early segment and increase in the latter segment approximating to a temporally discriminated pattern in a rapid fashion. The other factor refers to the learning of time as a predictor of the reinforcer: conditioning histories observed to speed up temporal control acquisition, as IRT > *t* or FT, require that a fixed time from a time marker elapses for a reinforcer to be delivered. In comparison, histories that are followed by a slower temporal control acquisition, as ratio and RI schedules do not require such fixed elapsed time. Therefore, the former but not the latter schedules provide conditions to learn time as the best predictor of reinforcer delivery. Under these conditions, it is possible that this learning transfers to the FI condition thus facilitating the temporal control acquisition.

Notwithstanding, to evaluate the previous hypotheses it is necessary to partial out the contribution of time and response rate factors. A former research by Trapold et al. (1965) seems to meet this requirement. These authors compared temporal control acquisition in groups of rats with FI 120 s following prior experience with a FT 120 s, a VT 120 s, or regular training. They found that the most rapid acquisition occurred following FT and the least rapid following VT, with the regular training group intermediate. This evidence argues against the initial response-rate hypothesis because the least speed facilitation occurred with prior VT not with the regular training, and response rate was lower in the former than in the latter. The results bring some support to the temporal learning hypothesis because temporal control on FI developed at a faster pace with the FT history than with the VT history and, apparently, both schedules generated similar response rates at the start of FI training. However, because no evidence of time discrimination during training was obtained, it remains unclear whether some form of temporal learning on the FT conditioning history or other performance factors was responsible for the facilitation of temporal control on FI.

In the current study, we present two experiments aimed to further explore the contribution of response and time factors on the speed of FI temporal control acquisition. An effort was made to gather data about the nature of control during the training histories by measuring head entries into the feeder tray throughout the experiments. It is well known that rats exposed to periodic access to food generally display behavior in a predictable temporal order (Lucas et al., 1988; Reid et al., 1993; Staddon and Simmelhag, 1971). In particular, rats display head poking around the feeder opening by the second half of the interval and head entries into the food tray exhibit an increasing temporally differentiated pattern indicative of temporal discrimination (see, for example, Kirkpatrick and Church, 2003). Therefore, by measuring this behavior some indication of the nature of learning during the history conditions and of its involvement in the speeding up of temporal control can be obtained.

2. Experiment 1

The acquisition of temporal control of lever-press responding on FI 30 s and FI 90 s schedules was observed following exposure of groups of rats to fixed-time or random-time (RT) schedules. Because FT and RT deliver reinforcers independently of the rat's behavior, similar low response rates were expected at the introduction of the FI with either prior training. Therefore, the isolated effects of reinforcement periodicity could be observed. A third group directly submitted to the FI schedules following regular lever-press pre-training was used as an additional comparison condition. This group served as a baseline condition representing the typical pre-training under which most research on FI schedules has been undertaken.

2.1. Method

2.1.1. Subjects

The subjects were 30 experimentally naive male Wistar rats, bred in a local colony at the Graduate School of Psychology. Rats were approximately 90 days old at the beginning of the experiment and were maintained at 80% of their free-feeding weights throughout the experiment. They were individually housed in a vivarium with free access to water and under a 12:12 h light/dark cycle.

2.1.2. Apparatus

Six similar experimental chambers (260 mm deep by 260 mm wide by 180 mm high), each equipped with a retractable response lever and a motor-operated dipper mechanism. The lever was 48 mm wide and extended 20 mm into the chamber. It was located on the front wall 70 mm above the chamber floor and 75 mm from the left wall, below one stimulus lamp (3 W), and was connected to a microswitch that required approximately 0.3 N to operate. A 3 W lamp located in the upper center of the back wall provided general illumination of the operant chamber. The reinforcer consisted of a mix of tap water with condensed milk in a 2:1 volume to volume proportion, delivered into a 0.01 mL dipper that could be accessed through a cylindrical opening located at the center of the front wall, 20 mm above the grid floor. A photo beam located at about 10 mm inside of the dipper cylinder opening detected a response each time it was interrupted. A Gateway Pentium 2000 computer running the Med-PC Medstate Notation, Version 2.0 (Tatham et al., 1991), controlled experimental events and recorded the time at which events (stimuli, responses, and reinforcers) occurred with 10 ms resolution.

2.1.3. Procedure

Sessions were conducted seven days a week. To reduce the possibility of variations in time before rats started responding at the introduction of the FI schedules, which may take up to three days (López and Menez, 2005) in the present study all rats were trained to press the lever at the start of the experiment. All rats received four sessions with 46-cycles of feeder and lever press training. On these sessions, a reinforcer was delivered after 60 s have elapsed or one lever press occurred, whichever came first. Afterwards, rats that had not learned to respond to the lever were manually shaped until reliable responding occurred. Finally, all rats were exposed to a FR 1 reinforcement schedule for the next two sessions. Then, rats were randomly assigned to one of six groups of 5 rats each and submitted to training and testing phases according to the following arrangements:

In the first phase, one group (FTFI30) was submitted to a FT 30 s, a second group (RTFI30) to a random time (RT) 30 s. On the testing phase, both groups were submitted to a FI 30 s. A third group (FTFI90) was submitted to a FT 90 s, a fourth group (RTFI90) to a random time 90 s and, on the testing phase, both groups were submitted to a FI 90 s. Two groups with standard training (ST) received five additional sessions on a FR 1 schedule and then the corresponding testing phase was directly introduced: FI 30 s for one group (STFI30) and FI 90 s for the other group (STFI90).

For those groups with FT or RT schedules, the response lever was kept retracted throughout the first phase, and it was extended into