

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.

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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

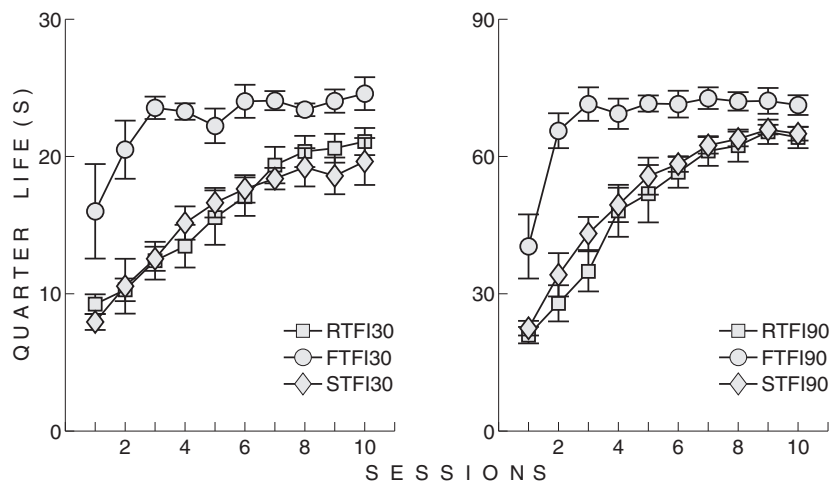


Fig. 1. Mean quarter-life for groups submitted to FI 30 s (left graph) and to FI 90 s (right graph) during the first 10 sessions on the testing phase of the first experiment. The bars for each average point depict the standard error.

the chamber on the second phase, but no particular re-shaping of the response was attempted. The progression of interval values of the RT schedules was obtained with a time base of 0.9 s and setting the probability of delivering a reinforcer at .03 for the RT 30 s, and at .01 for the RT 90 s, on each cycle. To ensure a stable schedule control, training on non-contingent groups and testing on all groups were run for a relatively long number of sessions, comparable to that of other reports (Baron and Leinenweber, 1995; Cole, 2001; López and Menez, 2005); hence the first phase was in effect for 45 sessions for FT and RT groups, and the second phase for 60 sessions for all groups. Each session started with the chamber light on and ended by the delivery of the 46th reinforcer. When the schedule requirement was met the chamber light was turned off, the dipper access light was turned on, and the dipper was raised for 3 s.

2.1.4. Data analyses

Data obtained before the first reinforcer in a session were excluded from all analyses. Responses of each rat in a session were tallied into 10 equally successive bins starting at the termination of the reinforcer period, with bin 1 having a lower bound of 0. Two indexes of temporal control were analyzed: quarter-life (QL) for lever-press (LP) responding, and response pattern for both LP and head-entries into the feeder (HE). QL was calculated by finding the time in which one fourth of responses in an interval occurred.

2.1.5. Results and discussion

To compare response rates at the introduction of the FI schedules, mean overall response rates (responses/min) were calculated for the first session on FI of each rat. A one-way ANOVA was performed with Group as factor and mean response rate as dependent variable. No statistical differences were found among groups [$F(5, 24) = 2.5, p > .05$]. The mean response rate of all groups was relatively low and similar (range of 3.8–9.9 responses/min).

Next, daily QL indexes of LP on the testing phase were analyzed to evaluate possible differences in the speed of temporal control acquisition. Because major changes occurred within the first 10 sessions, these sessions were chosen for analysis. Fig. 1 shows the mean QL and the standard error obtained on each session, for groups submitted to FI 30 s (left graph) and FI 90 s (right graph). These data were analyzed by a two-factor mixed model ANOVA with Group as between factor and Session as within factor. The data and statistical analysis indicate that the mean QL differed among groups [main effect of group, $F(5, 24) = 163.59, p < .001$], that QL increased over the course of training [main effect of session, Wilks' Lambda = 0.06, $F(9, 16) = 26.79, p < .001$], but that the rate of

increase differed among groups [interaction of Group vs. Session, Wilks' Lambda = 0.01, $F(45, 74.7) = 2.92, p < .001$]. Specific analyses were performed to compare the rate of increase in QL among the different training conditions: QL increased at a faster rate for the FT than for the ST and RT groups [linear trend, $F(1, 24) = 29.20, p < .001$], but no difference in rate of increase was found between the ST and RT groups [$F(1, 24) = 1.28, p > .05$]. In addition, it is clear from data in Fig. 1 that QL reached higher levels by sessions 8–10 on FI 90 s (range of 52.74–78.14 s) than on FI 30 s (range of 14.74–28.24 s). The mean QL for sessions 56–60 of the condition was 73.00 s for FI 90 s and 21.02 s for FI 30 s, which closely approximated to those obtained by sessions 8–10 for each group.

In sum, the previous analyses indicate that temporal control in FI schedules occurs earlier with prior training on FT than on RT reinforcement schedules or standard training. Because the response rates were similar for all groups at the introduction of the FI schedules, results cannot be attributed to differences in this variable. Instead, the data suggest that the periodicity of reinforcer delivery on the training phase is involved in the speeding up of temporal control development observed during the testing phase. However, evidence is required about the nature of learning during the conditioning histories so as to obtain some clues about the process leading to the observed differences. With this purpose, an analysis of both head-entry and lever-press gradients was performed. Fig. 2 displays HE (open circles) and LP (filled circles) response rate curves for groups exposed to FI 30 s (left graph) and to FI 90 s (right graph) on the testing phase. Data represent group averages obtained on the last five sessions (left plots of each graph) of the first phase, and the first (center plots of each graph) and last five (right plots of each graph) sessions of the second phase. On the last sessions of the first phase, RT schedules (upper row) tended to generate relatively flat response patterns of HE through the interval on both RTFI30 and RTFI90 groups. In contrast, FT schedules (center row) tended to generate increasing response rates of HE through the interval on both FTFI30 and FTFI90. On the second phase, at the introduction of the FI reinforcement schedule, the pattern of HE remained as in the previous phase: flat for the RTFI30 and RTFI90 groups and positively increasing for the FTFI30 and FTFI90 groups. Also, the gradients of LP closely resembled those of HE. In general, temporal gradients of LP indicating temporal regulation were already exhibited by the first sessions on FI following FT but not following RT or ST. The response gradients obtained on the first five sessions on FI for the STFI30 and STFI90 groups closely resembled those obtained with RTFI30 and RTFI90 groups: a relatively flat or slightly increasing pattern for both LP and HE responding. Finally, on the last sessions of the

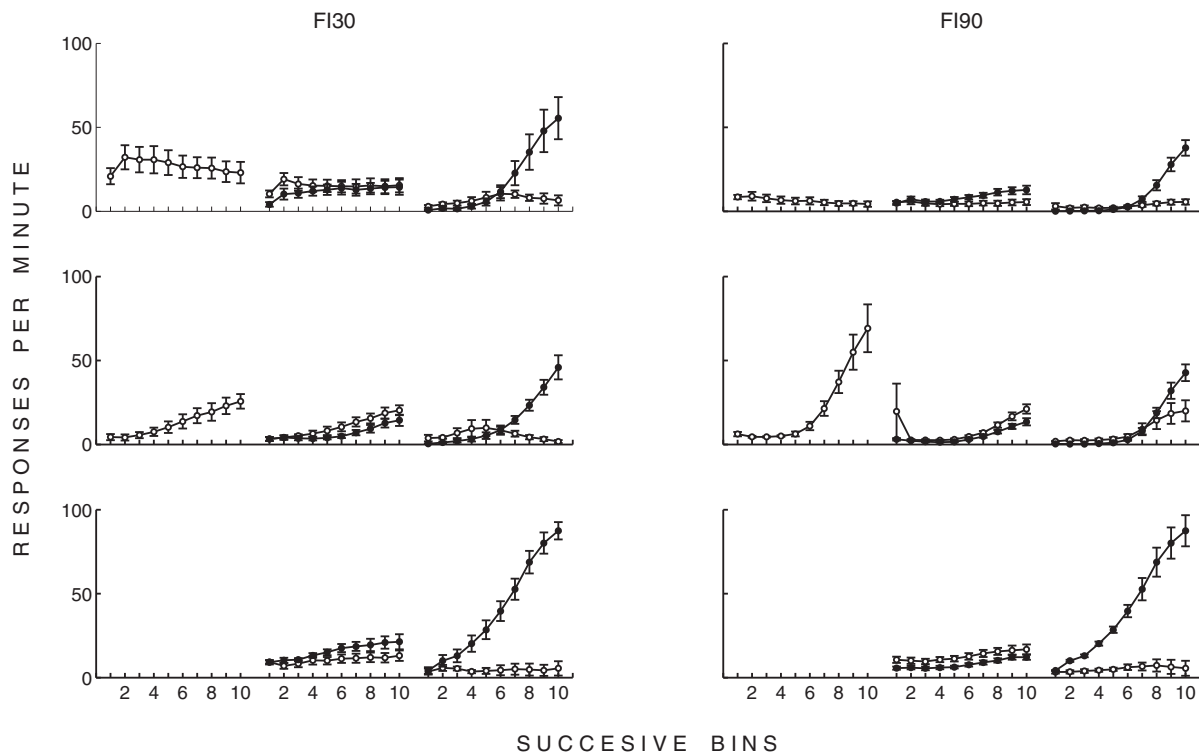


Fig. 2. Rate of lever presses (filled circles) and head entries (open circles) as a function of time since reinforcement. On the left graph, data are presented for RTFI30 (upper row), FTFI30 (center row), and STFI30 (lower row) groups. On the right graph, data are presented for RTFI90 (upper row), FTFI90 (center row), and STFI90 (lower row) groups. Data are group averages across the last five sessions on the first phase (left plots), the first five sessions on FI (center plots) and the last five sessions on FI (right plots). The bars for each average point depict the standard error.

second phase all groups displayed a sigmoid pattern of LP responding with HE decreasing as LP increased through the interval.

In general, the present findings are congruent with the idea that some kind of temporal learning is acquired during FT training and that it transfers to the FI in the testing phase, thus facilitating the development of temporal control. Additionally, the similarity of the pattern of HE responding during the last and the first sessions of the training and testing phases respectively, and of HE and LP during the first sessions of the second phase, suggest some sort of transference from HE to LP responding.

3. Experiment 2

In the previous experiment it was observed that temporal control transfer strongly develops on FI schedules with prior training on FT schedules as compared with RT and standard training. However, because the effect was observed when both the training FT and the testing FI schedules were of the same value, the question remains as to whether this effect is the result of discriminating the specific trained duration. To evaluate this possibility, acquisition of temporal control on FI 90 s was observed following prior training on a FT 30 s schedule. Two comparison groups were run: one with prior training on a RT 30 s and another with a FI 30 s schedule.

3.1. Method

3.1.1. Subjects and apparatus

The subjects were 15 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 as described in Experiment 1. The apparatus were the same as described in Experiment 1.

3.1.2. Procedure

Sessions were conducted seven days a week. All rats were trained to press a lever as in Experiment 1, and then were randomly assigned to one of three groups of 5 animals each. Groups differed in the conditions programmed in the training phase: One group (FT30FI90) experienced a fixed-time 30 s reinforcement schedule; a second group (FI30FI90), a fixed-interval 30 s, and the third group (RT30FI90), a random-time 30 s. The response lever was retracted during the FT and RT schedules. In the testing phase, all rats of all groups were submitted to a FI 90 s reinforcement schedule.

The training phase was in effect for 45 sessions and the testing phase for 30 sessions. Each session was ended by the delivery of the 46th reinforcer. The reinforcer was a mix of tap water with condensed milk and was delivered as in the first experiment. In the second phase, the lever was introduced into the chamber for the groups with prior FT and RT, but no particular re-shaping of the lever press was attempted.

3.1.3. Data analyses

The same as in Experiment 1.

3.2. Results and discussion

Mean overall response rates (responses/min) were calculated for the first session on FI 90 s of each rat. A one-way ANOVA was performed with Group as factor and the mean response rate of each subject as dependent variable. Overall ANOVA was significant [$F(2, 12) = 11.33; p < .01$]. Specific comparisons indicated that response rates were higher for the FI30FT90 group (range 17.43–36.34 responses/min) than for the RT30FI90 (range 3.09–13.60 responses/min) and FT30FI90 (range 7.87–23.92 responses/min) groups [$F(1, 12) = 20.93; p < .01$], whereas the latter groups responded at similar low rates [$F(1, 12) = 1.74; p > .05$].

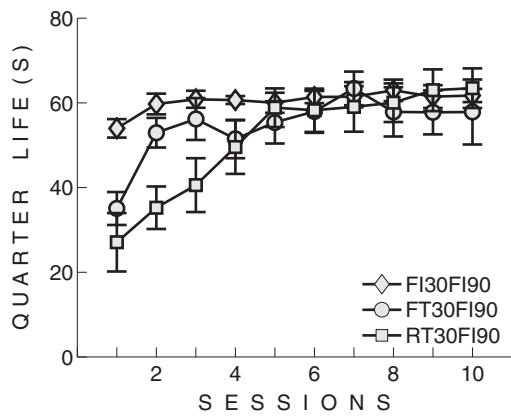


Fig. 3. Mean quarter-life for each group during the first 10 sessions on FI 90 s of the second experiment. The bars for each average point depict the standard error.

Fig. 3 shows the mean QL and standard error obtained on each of the first 10 sessions on FI 90 s for each group. These data were analyzed by a two-factor mixed model ANOVA with Group as between factor and Session as within factor. The data and statistical analysis indicated that the mean QL did not differ among groups [main effect of Group, $F(2, 12) = 1.54$; $p > .05$], that QL increased over the course of training [main effect of Session, Wilks' Lambda = 0.007, $F(9, 4) = 18.33$; $p < .001$], but that the rate of increase differed among groups [interaction of Group vs. Session, Wilks' Lambda = 0.008, $F(18, 8) = 4.54$; $p < .05$]. Specific analyses were performed to compare the rate of increase in QL among the different groups: QL increased at a faster rate for FI30FI90 than for the FT30FI90 and RT30FI90 groups [linear trend, $F(1, 12) = 7.04$; $p < .05$; quadratic trend, $F(1, 12) = 6.25$; $p < .05$] and QL increased at a faster rate for FT30FI90 than for the RT30FI90 group [linear trend, $F(1, 12) = 5.47$; $p < .05$]. In sum, The QL data show that FT 30 s speeded up temporal control acquisition on FI 90 s as compared with RT 30 s training, but that the fastest acquisition occurred following FI 30 s training. The mean QL value obtained for sessions 6–10 was similar for all groups (range of 57.75–63.46 s), which was very close to the one observed during sessions 26–30 of the FI 90 s phase (range of 61.59–65.87 s).

Fig. 4 displays response rate curves of LP (filled circles) and HE (open circles). Data are group averages across the last five sessions of the training phase (left plots), and across the first (center plots) and last five sessions (right plots) of the testing phase. Notice that bin width was 3 s and 9 s for the first and the second phase, respectively. The pattern of HE responding observed at the end of the first phase tended to persist at the introduction of FI 90 s in the second phase, in which a sigmoid response pattern of LP was already observed on the FI30FI90 rats. Both FT30FI90 and RT30FI90 groups displayed an increasing pattern of responding, although the former displayed a positively increasing response rate whereas the latter showed a constantly increasing rate through the interval. By the last sessions on FI 90 s all groups had developed a temporally discriminated response pattern for both HE and LP responding. However, LP increased at a higher rate and reached higher values than HE.

In sum, this experiment shows that the speeding up of temporal control on FI is related to the periodicity of reinforcer delivery during training. In general, periodic contingent or non-contingent reinforcer delivery during training facilitated temporal control acquisition under the FI 90 s schedule. However, transfer effects of FT were not as pronounced as those observed in the comparable FI of Experiment 1. The degree of transference may be related to the similarity between the temporal values experienced on the training and testing phases: temporal values during the training and the testing phases were the same in the first experiment while, in the

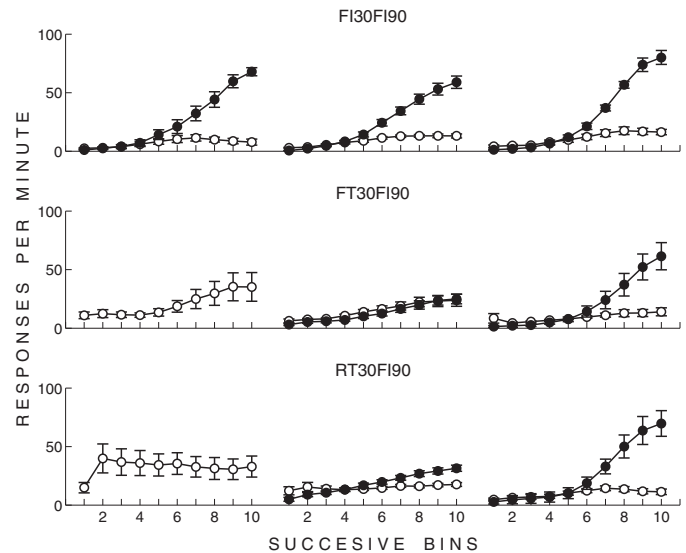


Fig. 4. Rate of lever presses (filled circles) and head entries (open circles) as a function of time since reinforcement for each group of the second experiment. Data are group averages across the last five sessions on the first phase (left plots), the first five sessions on FI (center plots) and the last five sessions on FI (right plots). The bars for each average point depict the standard error.

current experiment there was a threefold increase from the training to the testing phase.

4. General discussion

The current experiments examined the influence of response and time factors on the speed of acquisition of temporal control on FI schedules. It was found that temporal control in FI schedules developed at a faster pace with prior experience on FT than on RT reinforcement schedules or standard training, but no differences were found between the two latter conditions. These findings agree to other reports indicating that temporal discrimination on FI developed at a faster pace with prior training on FT schedules than with training on non-periodic reinforcement schedules (López and Menez, 2005; Trapold et al., 1965). Additionally, the accelerated temporal control acquisition was observed with equal interval values on the training and testing phases, on the two temporal FI values analyzed in the first experiment, and with a three-fold increase from the training to the testing temporal value on the second experiment. These results indicate that the facilitation of the temporal control acquisition on FI schedules was the result of reinforcement periodicity in the training history. Because groups with FT and RT schedules on the training phase had similar response rates at the start of the FI, an explanation in terms of differences in response rate per se was not supported.

In addition, our results suggest that the differences in the speed of temporal control acquisition on FI may be the result of what the animals learned during the training phase. On the one side, the HE distributions displayed an increasing response pattern across the last sessions on FT but a relatively constant pattern on RT schedules (Figs. 2 and 4). These results indicate that rats were sensitive to the temporal distribution of reinforcers and, in particular, that rats in the FT groups discriminated time as the best predictor of reinforcement. On the other side, the patterns of HE responding on the last sessions of training on FT and RT schedules tended to persist through the first sessions of FI on the testing phase and to be mimicked by LP responding. Therefore, this pattern of results indicates that the temporal discrimination acquired during FT training transferred to LP responding during testing. In contrast, because neither the RT nor the regular training set conditions for time

discrimination, its acquisition during FI had to evolve from the outset on both cases and no differences between them were found.

One additional question is whether the transfer of time discrimination was specific to the scheduled time during the training phase. This possibility may be explored by comparing temporal control acquisition on FI 90 s following FT 90 s training (Experiment 1) with FI 90 s following FT 30 s training (Experiment 2): First, with FT training transference of temporal control strongly develops on FI 90 s, as shown by QL data on Figs. 1 and 3. However, QL increased more rapidly when the FT value scheduled during the training phase was 90 s (Fig. 1) than when it was 30 s (Fig. 3). Second, similar temporal gradients on FI 90 s were obtained following FI 30 s or FT 30 s training (although shallower in the latter case; Fig. 4). This similarity of gradients may indicate that it was the specific FT value that transferred to the FI 90 s schedule because, in transfer tests, performance on the initial sessions on the testing phase is expected to be controlled by the previous rather than by the current schedule (see Caetano et al., 2007). Altogether, these pieces of information give some support to the idea of specificity of the transfer of time learning from training to testing. However, at the present level of analysis the evidence is not conclusive on this regard and more focused research is needed.

Notwithstanding, the pattern of results of the experiments suggests that the control of HE acquired during training transferred to LP during testing and accounted for the observed differences on the speed of acquisition. The persistence of the HE pattern of responding, through the first sessions of FI and the similarity of the LP and HE patterns suggest that both behaviors share a common controlling factor. Under these conditions, with prior FT training the increasing experience with FI schedules would sharpen the LP temporal control but, with prior RT training, it would reshape the LP response pattern. In consequence, the acquisition of temporal control would be comparatively delayed on the latter condition. A remaining question relates to the common factor mediating the transfer effects. Our experiments do not directly address this question, but the pattern of results does suggest some empirical research possibilities. In particular, we consider the involvement of the organization of behavior around the times of food delivery observed under periodic reinforcement schedules (see, for example, Anderson and Shettleworth, 1977; Staddon and Simmelhag, 1971). In this context, a couple of possibilities may be worth to explore. Response substitution: lever press substitutes HE, which is already under temporal control, at the introduction of FI because (1) it is the now required response for reinforcer delivery, (2) belongs to the same response class as HE, and (3) HE is an instance of terminal behavior that tend to occur on the last segment of the interval in periodic schedules. Response competition: general search behavior, such as locomotion remote from the feeder, which occurs in the initial segment of the interval (Silva and Timberlake, 1998), is generated by the FT schedule. Its persistence at the introduction of the FI schedule decreases the probability of LP responding in the initial but not in the latter segments of the interval. The occurrence of either or both of these processes may facilitate the acquisition of temporal control on FI schedules preceded by periodic FT schedules. Notwithstanding, more focused research is needed to substantiate the outlined inferences. At present, detailed accounts based on these possibilities would be unnecessarily speculative.

Finally, our data show that in spite of the observed differences in the speed of temporal control acquisition resulting from the different training histories, no major differences were found in the long-term performance. At the last sessions on FI of comparable values, no differences in response pattern among groups were found and QL values converged to similar values. These findings agree to, and extend, previous reports indicating that the effects of

conditioning histories on FI responding are transient and that, in the long run, they tend to vanish out (Baron and Leinenweber, 1995; Cole, 2001; López and Menez, 2005; Reed and Morgan, 2008). In general, the present results indicate that the steady-state behavioral performance does not necessarily result from similar processes (see, Caetano et al., 2007) and that differences in process involve the way in which the animal adapts to temporal contingencies. More research is needed to address this question because of its importance to understand adaptive mechanisms in which changes in response selection quickly entrain with learned temporal cues.

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