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Serial learning at one trial per day: Effects of interrun interval and interrun interval shifts

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Two groups of 6 rats each were trained for 24 days on a decreasing series of quantities of 45-mg food pellets 14-7-3-1-0. Throughout training there was only one series presentation (trial) per day. In Phase 1 the interrun interval (IRI) separating successive pattern elements was 15 sec for Group SSL and 15 min for Group LSL. Both groups received a 15-sec IRI for the 2 days of Phase 2 and a 15-min IRI for the 2 days of Phase 3. IRI had no effect on the rats' learning to anticipate, or track, the 0-pellet element in Phase 1. Tracking was eliminated in Group LSL by the shift from a long to a short IRI in Phase 2, but was not affected in Group SSL by the shift from a short to a long IRI in Phase 3. This pattern of results was compared with those obtained with multiple daily trials. Implications of these results for understanding IRI effects on serial learning were discussed.

Rats given the decreasing series of quantities of 45-mg food pellets 14-7-3-1-0 over successive runs in a runway learn to anticipate and run slowly to the terminal 0-pellet element. This behavior is called tracking. Roitblat, Pologe, and Scopatz (1983) and Haggbloom and Ekdahl (1985) reported that the development of tracking was impaired by a long (5-min) interrun interval (IRI) relative to a short (10-sec) IRI, and that tracking acquired at the short IRI was disrupted by a shift to the long IRI (S-L shift). Haggbloom and Ekdahl also reported that tracking was disrupted by a shift from a long to a short IRI (L-S shift). It now appears that S-L and L-S shifts in IRI disrupt tracking for different reasons.

Capaldi, Miller, and Nawrocki (1986) investigated the effects of IRI and IRI shifts on tracking using the decreasing series of pellet quantities 18-1-0. When rats received only one daily series presentation (each series presentation is called a trial), development of tracking was not differentially affected by IRI disparities as great as 1 versus 30 min, and tracking was not disrupted by an IRI shift in either direction (Experiments 1 and 2). However, in a group given three trials per day, Capaldi, Miller, and Nawrocki (1986, Experiment 3) reported that tracking was eliminated by an S-L shift. In that experiment, the 18-, 1-, and 0-pellet elements were separated by 15-sec IRIs, and successive series presentations or trials were separated by a 5-min interseries interval (ISI). The S-L shift in IRI was from 15 sec to 5 min.

Capaldi, Miller, and Nawrocki (1986) hypothesized that S-L shifts eliminate tracking under multiple daily trial conditions because the long ISI begins to signal the large reward at the start of each series presentation. When the IRI is increased, subjects cannot discriminate the long IRI that separates successive elements within the series from the long ISI that signals the start of a new series presentation. And since a long temporal interval is established as a signal for large reward, running is fast to all quantities and tracking is eliminated.

This hypothesis can account for the elimination of tracking by S-L shifts reported by Roitblat et al. (1983), who used four trials per day, and by Haggbloom and Ekdahl (1985), who used two trials per day. In both cases the long IRI following the S-L shift was difficult to discriminate from the ISI, which in both cases was a signal for 14 pellets. The hypothesis also predicts slower acquisition of tracking at a long IRI than at a short IRI with multiple trials per day, because long IRI subjects would have greater difficulty discriminating the IRI from the ISI. This, in turn, would make it difficult to discriminate elements within the series from the 14-pellet element at the start of a new series presentation.

If impaired tracking at a long IRI is a consequence of the similarity between the IRI and the ISI under multiple daily trial conditions, the development of tracking should not be impaired by a relatively long IRI when there is only one series presentation per day. The results reported by Capaldi, Miller, and Nawrocki (1986) were consistent with that prediction, but, as they noted, that result could be peculiar to the 18-1-0 series, which might be learned in a way that is very different from the way the 14-7-3-1-0 series is learned (e.g., run fast on Run 1 and slowly thereafter). Another indication that these two series yield disparate results is the fact that Capaldi, Miller, and Nawrocki (1986) found that tracking the 18-1-0 series was impaired by multiple versus single daily series presentations, but Haggbloom, Sheppard, and Hill (1986) reported that tracking the 14-7-3-1-0 series was facilitated by multiple daily trials.

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The purpose of the present experiment was to investigate the effects of a short versus a long IRI on the development of tracking, and the effects of S-L and L-S IRI shifts on tracking, using the 14-7-3-1-0 series and one trial per day. Group SSL received a short IRI through the first two training phases and a shift to a long IRI in Phase 3. Group LSL received a long IRI in Phase 1, followed by a shift to a short IRI in Phase 2, and a return to a long IRI in Phase 3.

METHOD

Subjects

The subjects were 12 experimentally naive male rats, bred in the laboratory from Holtzman stock and approximately 90 days old at the beginning of the experiment.

Apparatus

The apparatus was a straight enclosed runway modeled after that used by Hulse and Dorsky (1977). The runway was 92 cm long with a 30-cm startbox and a 30-cm goal area separated from the rest of the runway by manually operated guillotine doors. The goal area contained an 11-cm niche at a right angle to the runway and an unpainted goal cup positioned against the end wall of the goal area. The goal cup was constructed by drilling a 6-cm-diameter hole in a small block of wood. The inside width of the runway was 10 cm, and the height was 11 cm. The runway was painted flat black throughout. The start and goal areas were covered with hinged Plexiglas, and the runway proper was covered with hardware cloth. Raising the guillotine door between the startbox and the runway triggered a .01-sec timer that was stopped when the rat entered the goalbox and interrupted a photobeam 20 cm into the goal area. Food reinforcement consisted of an appropriate number of .045-g Noyes pellets.

Procedure

All rats were housed individually and had free access to water at all times. Two weeks before the beginnng of experimental training, the rats were placed on a food-deprivation schedule, consisting of 12 g of food per day, which continued throughout the experiment and was adjusted for the weight of food pellets consumed in the runway. On Days 12–14 of deprivation, the rats were handled in squads of 2 for 2–3 min per squad. In addition to being handled on Days 13 and 14, the rats were placed in the runway and allowed to explore it for 5 min. On both days four food pellets were scattered on the runway floor and the goal cup was baited with one pellet.

The rats were randomly divided into two groups, and experimental training began on Day 15 of deprivation. Both groups received a single daily presentation of the 14-7-3-1-0 series for 24 days. The IRI was 15 sec for Group SSL and 15 min for Group LSL. In Phase 2, Group LSL was shifted to a 15-sec IRI and Group SSL continued to receive a 15-sec IRI. There were 2 days of training in Phase 2. In Phase 3, both groups were shifted to the long, 15-min IRI for an additional 2 days of training.

A run was initiated by placing the rat in the startbox and, after approximately 3 sec, opening the startbox door. If the trial was not completed in 60 sec, the rat was placed in the goalbox and a time of 60 sec was recorded for that trial. The goalbox was baited with the appropriate number of .045-g food pellets on reinforced trials. On nonreinforced trials, the rat was confined to the unbaited goalbox for 10 sec.

RESULTS

Figure 1 shows running times to each pattern element collapsed across the 24 days of training in Phase 1 and the IRI shift days in Phases 2 and 3. As can be seen, IRI had no effect on tracking in Phase 1. An inspection of the data both early and late in training also showed no

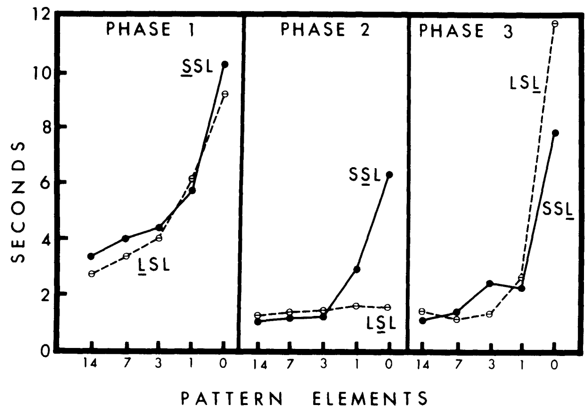

Figure 1. Mean running times for both groups to each pattern element averaged across Days 1–24 of Phase 1 (left panel) and both test days of Phases 2 (center panel) and 3 (right panel). Underscoring in group label indicates operative interrun interval, long (L) or short (S), during each phase.

difference in tracking between the two groups. The center panel shows that tracking in Group LSL was eliminated by the L-S shift. The right panel shows that tracking in Group SSL was not affected by the S-L shift.

A 2 × 5 × 24 (groups × runs × days) analysis of variance (ANOVA) applied to running times in Phase 1 showed no differences due to groups ($F < 1$). The very substantial tracking in both groups was reflected in a highly significant runs effect [$F(4,40) = 15.28$, $p < .001$], and, because of the virtually identical pattern of behavior in the two groups, there was no groups × runs interaction ($F < 1$).

The 2 × 5 × 2 (groups × runs × days) ANOVA applied to running times in Phase 2 yielded a reliable groups × runs interaction [$F(4,40) = 5.88, p < .01$]. No other effect or interaction was significant except runs. Planned comparisons between running time on Run 1 versus that on Run 5 showed very substantial tracking in Group SSL [$F(1,40) = 6.03, p < .05$] and no evidence of tracking in Group LSL ($F < 1$).

The 2 × 5 × 2 (groups × runs × days) ANOVA applied to running times in Phase 3 showed no differences due to groups ($F < 1$), a highly significant runs effect [$F(4,40) = 6.34, p < .001$], and no groups × runs interaction ($F < 1$), the latter indicating comparable tracking behavior in the two groups.

DISCUSSION

In the present experiment, rats' ability to track and run slowly to the 0-pellet element of the decreasing series of food quantities 14-7-3-1-0, presented once daily, was not impaired in original learning by a long IRI and was not disrupted by an S-L IRI shift. The present S-L shift results agree with those previously reported by Capaldi, Miller, and Nawrocki (1986) for single daily presentations of the series 18-1-0. Collectively, our results and theirs support their hypothesis that a long IRI and S-L IRI shifts retard the development of tracking, and disrupt established tracking only when, as in Roitblat et al. (1983) and Haggbloom and Ekdahl (1985), there are multiple daily trials, making it difficult for the rat to discriminate the IRI from the ISI. Unlike the results reported by Capaldi, Miller, and Nawrocki (1986) for the 18-1-0 series, however, we found in this study that tracking the 14-7-3-1-0 series was disrupted by an L-S IRI shift.

Roitblat et al. (1983) suggested that the development of tracking was retarded by a long IRI and that established tracking was disrupted by an S-L shift, because at the long IRI the rat has difficulty on a run remembering information—the item received on the preceding run, item information, or item information coupled with position cues—necessary to anticipate the next event in the series. However, it is well established that the rat has a highly developed ability to remember reward events even over very long (e.g., 24-h) temporal intervals (e.g., Capaldi & Spivey, 1964; Jobe, Mellgren, Feinberg, Littlejohn, & Rigby, 1977). The present findings, that tracking at one trial per day was impaired neither by a long IRI nor by an S-L shift, are inconsistent with the view of Roitblat et al. (1983).

Haggbloom and Ekdahl (1985) suggested that the disruptive effects of L-S and S-L IRI shifts that they reported might have been due to impaired memory retrieval of series events because of a change in IRI-related contextual stimuli or to the signal value established to time-related stimuli during the preshift phase. For S-L shifts and impaired development of tracking at a long IRI, we currently prefer the second possibility, developed more fully by Capaldi, Miller, and Nawrocki (1986) and tested by them and in the present experiment. That view is consistent with the findings that tracking is impaired by a long IRI and disrupted by an S-L shift with multiple daily trials (Haggbloom & Ekdahl, 1985; Roitblat et al., 1983), but not with one trial per day (Capaldi, Miller, & Nawrocki, 1986; the present experiment).

The finding in this study that an L-S shift disrupted tracking the 14-7-3-1-0 series even at one trial per day, however, cannot be explained in terms of the signal value established to a short IRI, because neither a short IRI nor a short ISI was previously experienced. This result is also inconsistent with the results obtained by Capaldi, Miller, and Nawrocki (1986) for the 18-1-0 series. We noted above that tracking these two series is also affected differently by number of daily trials: tracking the 14-7-3-1-0 series is facilitated by multiple trials (Haggbloom et al., 1986), and tracking the 18-1-0 series is impaired by multiple trials (Capaldi, Miller, & Nawrocki, 1986). Capaldi, Miller, and Nawrocki suggested that the rat might learn to run fast on Run 1 and slowly thereafter as the solution to the 18-1-0 series, a relatively easy discrimination that might not be especially sensitive to changes in temporal cues if the newly introduced cue has not been established as a signal for large reward. On the other hand, tracking the 14-7-3-1-0 series is highly dependent on the integrity of event memories (e.g., Haggbloom & Brooks, 1985), recall of which might be adversely affected by stimulus change accompanying an L-S shift. Although we generally think of recall being adversely affected by the lengthening of a retention interval, Capaldi, Nawrocki, Miller, and Verry (1986) recently showed that decreases in the retention interval also impaired recall. They showed that this impairment can occur when, as here, a long temporal interval precedes storage of an event memory and thus becomes part of the context in which the memory was stored, but a short temporal interval provides the context for recall.

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