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Effects of trials per session on conditioning of the rabbit's nictitating membrane response*

E. JAMES KEHOE and I. GORMEZANO
University of Iowa, Iowa City, Iowa 52242

A study was conducted to determine the effects of 1, 5, 10, and 50 conditioning trials per session on classical conditioning of the rabbit's nictitating membrane response. It was found that single-trial sessions produced more rapid increases in CR frequence across trials and required fewer trials to attain criterial performance than multiple-trial sessions. The finding of a superiority of single-trial sessions on CR acquisition was discussed with regard to traditional accounts of trial distribution effects on learning (i.e., reactive inhibition, stimulus sampling, and consolidation hypothesis), as well as with regard to stimulus variability accounts. Moreover, consideration was given to the issue of retention as it bears upon time-dependent acquisition processes.

Among those formulations directed at time-dependent processes in learning, Hull's (1943, 1952) construct of reactive inhibition, Estes's (1955) stimulus-fluctuation model, and the consolidation hypothesis (e.g., Glickman, 1961) all contend that the rate of response acquisition should increase as the interval between successive training trials increases. Accordingly, extending this prediction of trial distribution effects to a modest limit, these formulations would lead to the expectation that one trial per daily session would produce more rapid response acquisition on a trial-by-trial basis than multiple-trial sessions. Yet, by so articulating the expectations of these trial distribution accounts, it becomes apparent that they have not addressed themselves to the role of retention (memory) as a factor in time-dependent acquisition processes. For, on the one hand, it could be argued that trial distribution accounts make the implicit assumption that organisms possess the capacity for temporally unlimited retention of the consequences of a single trial. On the other hand, if retention of the consequences of a single training trial decreases with time (cf. Peterson & Peterson, 1959), then acquisition trials separated by a day (or more), could be less effective than multiple-trial acquisition sessions.

In the animal learning literature, there is a minimal amount of data bearing upon the two counterposed time-dependent effects expected from trial distribution accounts and concerns with retentive capacity. Studies concerned with the determination of the retentive capacity of animals have ordinarily employed multiple-trial acquisition sessions prior to the imposition of a retention interval (cf. Gleitman, 1971); whereas, determinations of the effects of trial distribution have typically used multiple-trial sessions with manipulations of intertrial intervals over a few seconds to several minutes (cf. Gormezano & Moore, 1969). In the few reported instances where the efficacy of single-trial sessions have been assessed directly against multiple-trial sessions, singletrial sessions appear to have produced more rapid response acquisition (Brimer & Dockrill, 1966; Holland, 1953a; Levinthal, 1973). However, while the observation of Brimer and Dockrill (1966) was statistically reliable, the observations of Holland (1953a) and Levinthal (1973) were not accompanied by appropriate statistical documentation of differences in rate of acquisition across trials. Accordingly, in order to further assess and document the effects of one trial per sessions, single trial sessions appear to have produced more rapid response acquisition (Brimer & Dockrill, 50 conditioning trials per session on conditioning of the rabbit's nictitating membrane response.

METHOD

Subjects

The Ss were 48 naive male and female albino rabbit's 80-100 days old and each weighed about 2.2 kg on arrival.

Apparatus

The conditioning chambers, apparatus, and transducer for recording the nictitating membrane response have been described by Coleman and Gormezano (1971) who detail departures from earlier specifications (Gormezano, 1966; Gormezano, Schneiderman, Deaux, & Fuentes, 1962). The CS was a 92-dB (.0002 dynes/cm^2 reference) 400-msec 1,000-Hz tone superimposed on a 75-dB white-noise background. The US was a 50-msec 3-mA 60-Hz shock delivered to the S's paraorbital region through two stainless steel Autoclip sutures positioned 15-mm apart and 15-mm posterior to the dorsal canthus of the right eye. The CS-US interval was 400 msec.

Procedure

Prior to acquisition training, all Ss received 1 day of preparation followed by a 1-day recovery period, and 1 day of adaptation. On the preparation day, a small loop of

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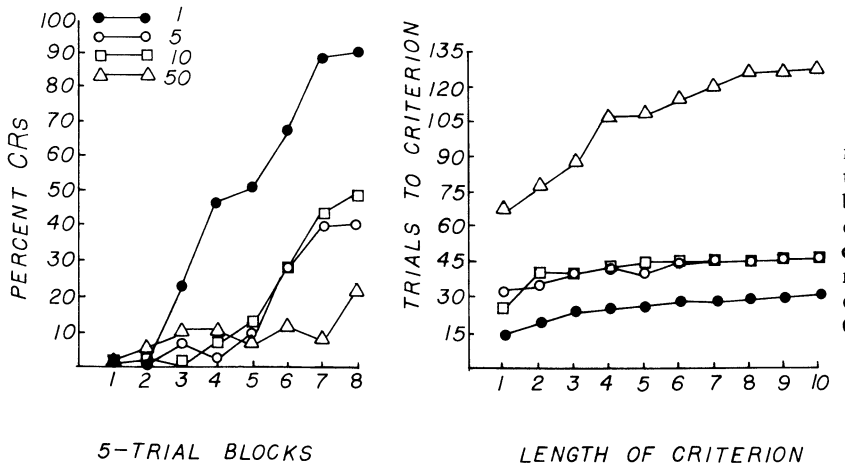

Fig. 1. The left-hand panel presents the mean percentage of CRs for the first 40 trials of each group plotted over five-trial blocks. The right-hand panel presents for each group the mean number of trials to the occurrence of the first CR, as well as the mean number of trials to successively longer criteria (up to and including 10 consecutive CRs).

monofilament nylon was sutured to the right nictitating membrane, the surrounding hair was removed, and US electrodes were implanted. On the adaptation day, the restrained Ss were placed in the conditioning chambers with recording apparatus attached for a period of time equivalent to the length of subsequent acquisition sessions. In acquisition, 12 Ss were assigned to each of four groups receiving 1, 5, 10, or 50 CS-US trials per daily session, and these groups are labeled accordingly. The intertrial intervals (ITIs) for Groups 5, 10, and 50 were randomly varied between 50, 60, and 70 sec, with a mean of 60 sec. In Group 1, a single CS-US trial was given 3, 6, or 9 min following the start of an approximately 12-min session. By varying the duration of time in which Ss remained in the experimental chambers before and after conditioning trials were presented, Groups 1, 5, and 10, experienced essentially equivalent session lengths of approximately 12 min. On the other hand, Group 50's session length lasted for approximately 55 min. The number of days of acquisition training for Groups 1, 5, 10, and 50 were 42, 21, 21, and 12 days, respectively. Throughout acquisition training, a CR was defined as a membrane extension of .5 mm or more, occurring within 400 msec after CS onset.

RESULTS

The left-hand panel of Fig. 1 presents the mean percentage of CRs for the first 40 trials of each group plotted over 5-trial blocks. Examination of the figure reveals that the rate of CR acquisition was generally inversely related to the number of trials per session, with Group 1 showing the most rapid rate of acquisition and a terminal level of responding of approximately 90%. Moreover, the relatively high level of responding attained by Group 1 can be seen in the relationship between trials per session and the overall group means, which were 45.4, 15.7, 17.8, and 9.2% for Groups 1, 5, 10, and 50, respectively. These descriptive characteristics of the first 40 trials of the data were corroborated by an analysis of variance which revealed significant effects of groups ($F = 11.84$, $df = 3/44$, $p < .001$), trials ($F = 40.44$, $df = 7/308$, $p < .001$), and groups by trials ($F = 5.29$, $df = 21/308$, $p < .001$). An analysis of trend (with orthogonal polynomial coefficients for unequal intervals) applied to the group means confirmed the efficacy of one trial sessions by revealing a significant linear ($F = 14.41$, $df = 1/44$, $p < .001$) and quadratic ($F = 13.06$, $df = 1/44$, $p < .001$) trend. Furthermore, the near equality of means for Groups 5 and 10 was sufficient to produce a significant cubic trend ($F = 8.15$, $df = 1/44$, $p < .01$).

The right-hand panel of Fig. 1 presents for each group the mean number of trials to the occurrence of the first CR, as well as the mean number of trials to successively longer criteria (up to and including 10 consecutive CRs). If more than one criterion was attained in the same run of CRs, the same score was assigned to that S for each of the relevant criteria. (In Group 1, two Ss failed to attain all criteria and were assigned a score of 42 for the unattained criteria.) Examination of the figure again reveals the potency of the trials per session variable, since decreasing the number of trials per session produced a decreasing number of trials to criterion, with Group 50 showing the largest and Group 1 the lowest number of trials to each successive criterion. Using successive criteria as a repeated measure, an analysis of variance of number of trials to each successive criterion revealed significant effects of groups ($F = 19.49$, $df = 3/44$, $p < .001$), criterion ($F = 24.02$, $df = 9/396$, $p < .001$), and groups by criterion ($F = 4.77$, $df = 27/396$, $p < .001$). The significant interaction primarily reflected the steeper function revealed by Group 50 relative to the much shallower functions exhibited by the other three groups.

While the left- and right-hand panels of Fig. 1 amply illustrated the greater effectiveness per trial of the one-trial per session condition, examination of the CR-acquisition function for each group when plotted as a function of sessions, reveals just the converse relationship. Specifically Fig. 2, which depicts the mean percentage of CRs as a function of two-session blocks, indicates that the rate of CR acquisition was a direct function of the number of trails per session. That is, the greater the number of trials per session, the fewer the sessions required to attain comparable asymptotic levels

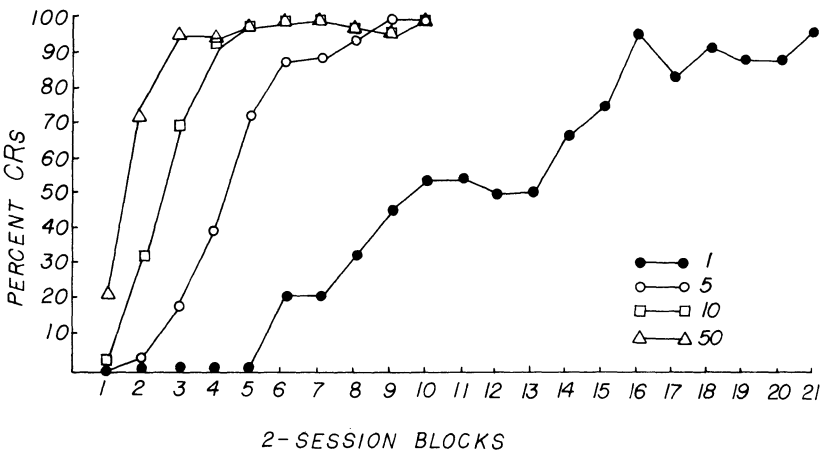

Fig. 2. The mean percentage of CRs for each group as a function of two-session blocks.

of responding. An analysis of variance applied to the percentage CRs over blocks for which there were data for all groups (i.e., the first six two-session blocks) revealed significant effects of groups ($F = 97.91$, $df = 3/44$, $p < .001$) and sessions ($F = 113.68$, $df = 5/220$, $p < .001$). Moreover, the substantially slower rate of acquisition across sessions for Group 1, relative to the other groups, and in particular Group 50, was reflected in a significant Groups by Sessions interaction ($F = 16.07$, $df = 15/220$, $p < .001$).

DISCUSSION

At the minimum, the observation that single-trial sessions revealed more rapid increases in CR frequency across trials and required fewer trials to attain criterial performance than multiple-trial sessions indicates substantial retention of the consequences of a single trial over a 24-h interval. Moreover, the generally inverse relationship between trials per session and trial measures of CR acquisition suggests that a common mechanism underlies the effects of single- and multiple-trial sessions. As to such a common mechanism, trial distribution accounts assume that the same time-dependent process of either reactive inhibition (Hull, 1943, 1952), stimulus fluctuation (Estes, 1955), or consolidation (e.g., Glickman, 1961) operates between any two successive trials regardless of whether the trials are separated by a within- or between-session interval. Hence, as a result of the concomitantly larger relative frequency of 24-h intersession intervals, trial distribution accounts would expect an increase in CR acquisition rate with decreases in trials per session. As an alternative to trial distribution accounts, the effects of trials per session can be derived from a stimulus variability mechanism (Hull, 1943; Voeks, 1950) by assuming that perseverative stimuli from preceding trials constitute a portion of the effective CS complex on subsequent trials (cf. Holland, 1953b; Rothkopf, 1955). Accordingly, successive trials within a session would presumably be presented under progressively different stimulus complexes, with the intersession interval serving to effectively renew this progression in subsequent sessions. As a consequence, on a trial-by-trial basis, decreasing the number of trials per session would concentrate training for any given number of trials on a smaller number of different stimulus complexes and, thereby, lead to an increase in the overall rate of CR acquisition.

The limit of retention, if any, for the consequences of a single conditioning trial remains to be determined. Clearly, the present study indicated that a determination of the limit would require trial distributions more extreme than one trial per daily session. It is also important to note, that while decreasing the number of trials per session increased the trial-by-trial rate of CR acquisition, the effect was achieved at the expense of a substantial increase in the number of daily sessions required to attain comparable performance level. In fact, considering all groups, the general function obtained revealed that on a session-by-session basis, increasing the number of trials per session produced a monotonic increase in rate of CR acquisition.

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