METHODS & DESIGNS

One-trial-a-day avoidance learning

DONALD J. LEVIS*
University of Iowa, Iowa City, Iowa 52240

A one-trial-a-day discrete-trial avoidance conditioning procedure run for 30 consecutive days was compared with a massed-trial procedure where Ss received 30 consecutive trials within 1 day. The Ss in both groups were equated for time each S spent in the nonshock compartment of the apparatus, number of times the transport box carrying Ss was lifted out of the nonshock compartment, and the number of times each S was handled. The main difference between groups was the intersession trial length of 24 h for the one-trial-a-day Ss. Learning was rapid for both groups. The groups did not differ reliably on six acquisition indices. The methodological advantages of the one-trial-a-day procedure and its theoretical importance were discussed.

Procedures that incorporate a discrete-trial avoidance conditioning paradigm typically involve the presentation of more than one trial in a given testing period. Little consideration in the avoidance literature has been given to the possibility that massed trials may introduce a number of complexities into the analysis of performance. It has been established in the instrumental appetitive reward situation that this possibility is indeed a matter of concern (Cotton & Lewis, 1957; Logan, 1960). Thus, for example, Logan (1960, p. 62) has concluded that a one-trial-a-day procedure has distinct methodological advantages over the typically employed massed-practice procedure. Some of the methodological issues he raises have implications for the avoidance area. For one thing, it is possible that with massed-trial procedures short-duration stimulus traces from one trial could persist as a significant component of the stimulus complex for a later trial. In the appetitive reward situation, Logan has provided data consistent with the assertion that a second trial under a massed procedure is simply not the same as a first trial, having a somewhat different stimulus and being subject to unique effects of fatigue, warm-up, drive reduction, etc. For another, the reinforcement of the avoidance response (e.g., reduction in conditioned aversiveness or decrease in US frequency) may also be confounded with the intertrial interval, the length of which has been demonstrated to have a significant effect on avoidance performance (Denny, in press). Moreover, the possibility exists that incompatible avoidance response tendencies such as freezing or relaxation may occur during the intertrial interval. Again, the extent to which these effects carry over to the next trial may be dependent upon the use of a massed-training procedure.

The present study is designed to compare a massed-training procedure with a one-trial-a-day procedure. Of principal concern is the question of whether or not avoidance learning can in fact occur under the latter procedure, and, if so, in what way it differs from the learning produced by the massed-trial procedure.

SUBJECTS

The Ss were 20 experimentally naive male Blue Spruce rats bred in the University of Iowa's Department of Psychology colony. The animals ranged in age from 113 to 132 days and were housed in individual cages.

APPARATUS

The apparatus, a modified Mowrer-Miller one-way box, was divided into two equal compartments. The walls of Compartment S (shock side) were covered on the outside by black opaque paper, and the grid floor was exposed. The walls and grid floor of Compartment NS (nonshock side) were covered with white paper. Inserted inside this compartment was a clear Plexiglas transport box. A more complete description of the transport box and apparatus has been provided in a previous report (Levis, 1970).

The apparatus was programmed to produce flashing lights, tone, and shock. The lights were produced by six 7-W, 28-V bayonet-based lamps mounted 1 in. below the grid floor of Compartment S in facing pairs at distances of 4½, 9½, and 14½ in. from the end of the compartment. When activated, the lamps flashed once per second, with a stimulus duration of 500 msec. The tone stimulus (4,000 Hz) was produced by an Eico audio signal generator and a 2-in. speaker mounted 6 in. below the grid floor at the left center of Compartment S. Measurements made at the center of Compartment S, 1½ in. off the grid floor, with a General Radio sound-level meter (Model 1551-C) indicated the ambient noise level to be 64 dB (Setting C, slow speed). The 4,000-Hz tone from the speaker increased this level to 74 dB. The shock was produced by a Grason-Stadler shock source and grid scrambler (Model E 1064GS). All three of the above stimuli were programmed automatically once the sequence was initiated by pressing a hand-operated microswitch. The closure of the microswitch also started a Standard Electric stopclock which indicated response latencies to the nearest 0.1 sec. The programming equipment was placed in a separate room away from the apparatus that was housed in a walk-in sound-attenuated chamber.

PROCEDURE

Immediately prior to the start of the first training trial, each S was given a 5-min adaptation period to each compartment of the apparatus. Ss were adapted to Compartment S first. A delayed conditioning procedure was used with a CS-US interval of 10 sec. The CS was a two-component compound consisting of flashing lights and tone plus apparatus stimuli. These compound stimuli were presented simultaneously throughout the CS-US interval. The shock US, which was delivered to the grid floor of Compartment S, was set at 1 mA. A response was defined as movement from Compartment S to Compartment NS that resulted in the activation of the floor microswitch of Compartment NS. Immediately following a response, E sealed off the open end of the transport box by inserting a white sliding panel. An escape response from shock terminated both the CS and US, while an avoidance response terminated the CS and prevented US onset.

Ten Ss were assigned unsystematically to one of two groups.

---

*The research reported in this manuscript was supported by Grant MH 16584 from the National Institutes of Health. The author also wishes to express his gratitude to Mark Holtkamp for his assistance in the collection of data.

Table 1
Means and Standard Deviations (in Parentheses) for the Acquisition Indices

Groups	(1) Shock Trials	(2) Trial Last Shock	(3) Shock Duration (Seconds)	(4) Trial First Avoidance	(5) Trial 10th Consecutive Avoidance	(6) Latencies (Seconds)
D	3.6 (1.2)	11.0 (5.0)	3.2 (1.1)	3.2 (0.9)	15.7 (3.3)	4.3 (2.3)
M	2.5 (1.1)	5.8 (7.7)	3.2 (1.5)	2.9 (0.8)	13.6 (2.4)	3.8 (2.1)

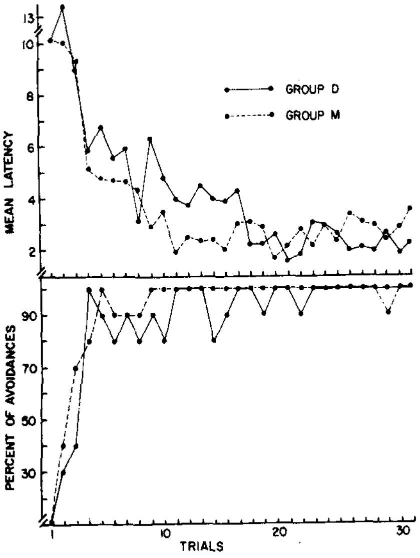

Fig. 1. Mean latency of responses across trials (upper half) and percent of avoidance trials across trials (bottom half).

Group D (distributed trials) received one trial a day for 30 days. On each day before the start of a trial, S was moved by hand from his home cage into the transport box located in Compartment NS for a 60-sec period. (On Trial 1 this 60-sec period was added to his adaptation time in Compartment NS.) After this period, E lifted the transport box out of Compartment NS and placed it on a table in front of the apparatus. A duplicate empty transport box was then inserted into Compartment NS. Following this, the transport box holding S was picked up and inserted into Compartment S. As the bottom of the transport box touched the grid floor, the lug holding the floor in place was released, and the transport box was lifted out of Compartment S. This maneuver gently slid S onto the grid floor. At this point, E operated the microswitch which started the CS-US interval. After a response, each S remained in Compartment NS for a 60-sec intertrial interval. At this point S was lifted out of Compartment NS via the transport box and deposited into his home cage, which was located close to the apparatus. The home cage, with S inside, was then carried back to the colony room, where S remained for an intersession interval of approximately 24 h.

Group M (massed trials) received all 30 training trials within the same day. In an attempt to equate Group M with D on the time each S spent in Compartment NS, the number of times the transport box was lifted out of Compartment NS, and the number of times S was handled, the following procedure was employed for Group M. Sixty seconds after the adaptation period to Compartment NS, S was placed into Compartment S in the manner described for Group D. After a response, S was left in Compartment NS for a 60-sec period. At this point, as with Group D, S was lifted out of Compartment NS via the transport box and deposited into his home cage. The transport box was reinserted into Compartment NS, after which S was picked up by hand and returned to Compartment NS for another 60 sec. At this point, he was again lifted out of Compartment NS in the manner described for starting a new trial. Thus, before the start of each trial, Ss in both groups spent 120 sec in Compartment NS, were picked up via the transport box twice, and were handled once. The main difference between groups was the intersession trial length of 24 h for Group D.

RESULTS AND DISCUSSION

The acquisition indices analyzed were (1) number of shock trials, (2) trial number of last shock trial, (3) mean duration of shock, (4) trial number of first CAR, (5) trial number of 10th consecutive avoidance, and (6) mean latency of responding. Table 1 provides the means and standard deviations of both groups for these indices. Figure 1 (upper half) provides a graphic representation of the latencies across trials and (bottom half) the percent of avoidance responding across trials. An analysis of variance over each index did not reveal any statistically significant differences between groups. However, Index 1, number of shock trials, barely missed the .05 level ($F = 4.05$, $df = 1/18$, $p < .10$), and Index 2, trial number of last shock trial, missed the .10 level ($F = 2.9$, $df = 1/18$, $p < .15$). None of the other between-group comparisons approached significance. Analysis of Index 6, mean latency of responding, produced a significant trial effect ($F = 17.1$, $df = 29/522$, $p < .01$), with the Trial by Group interaction not reaching a significant level.

It is apparent from Table 1 and Fig. 1 that both Groups D and M learned the avoidance response rapidly. Clearly, one-trial-a-day avoidance can produce learning, and from the available evidence, this procedure produces comparable performance to that obtained under the massed procedure. Nevertheless, caution should be exercised in accepting the conclusion that the intersession interval of 24 h has no effect since two of the acquisition indices, number of shock trials and trial number of last shock trial, approached statistical significance. It is of interest to note that, with respect to the spacing of shock trials, 10% of Group M Ss compared to 40% of Group D Ss received a shock trial after they made 10 consecutive avoidances. Whether the intersession interval of 24 h for Group D results in a slight forgetting or extinction effect or whether such an outcome is related to a "warm-up" effect is in need of further study. Nevertheless, it can be concluded that learning did not appear to be dependent upon the trial-to-trial carryover effects of postshock or CS emotionality. Furthermore, the one-trial-a-day presentation may provide a useful procedure for those theorists interested in investigating whether intertrial interval effects are simply time-dependent or a function of the stimulus situation in which they occur.

The above data may also have some implication for Herrnstein's (1969) one-factor reinforcement theory. According to this viewpoint, the sole reinforcement for avoidance responding is a reduction in shock frequency. Thus, learning occurs because the avoidance response is followed by a reduction in shock rate. For Group M, the typical rate change was from three shocks in 6 min to one shock in 54 min, while for Group D the rate change was from three shocks in 72 h to one shock in 628 h. One might argue that, especially for Ss in Group D, both the high- and low-density shock rates were at such a low rate to begin with that it is unlikely that the change in rate between these schedules is sufficient to serve as a reinforcer. However, a more explicit statement of Herrnstein's explanatory principle is needed before the role of the intersession interval can be evaluated adequately.

REFERENCES

COTTON, J. W., & LEWIS, D. J. Effects of intertrial interval on acquisition and extinction of a running response. Journal of Experimental Psychology, 1957, 54, 15-20.

DENNY, M. R. Relaxation theory and experiments. In F. R. Brush (Ed.), *Aversive conditioning and learning*. New York: Academic Press, in press.

HERRNSTEIN, R. J. Method and theory in the study of avoidance. Psychological Review, 1969, 76, 49-69.

LEVIS, D. J. Between-trial transporting of animals: A methodological consideration. Behavior Research Methods & Instrumentation, 1970, 2, 157-160.

LOGAN, F. A. *Incentive*. New Haven: Yale University Press, 1960.

Measuring clustering differences among categories in the same list*

KARL HUNT
University of Tennessee at Chattanooga, Chattanooga, Tennessee 37401

A method is presented for analysis of clustering differences among categories in the same list. This allows category characteristics to be varied within Ss by using mixed lists, whereas previously only homogeneous lists could be employed.

When a list of items is presented for free recall, related items are often recalled contiguously, regardless of their order of presentation. Bousfield (1953) called this phenomenon "clustering" and measured it by counting repetitions. A repetition is the contiguous recall of two related items; thus a sequence of three such items contains two repetitions. For example, S might recall, ". . . horse, oak, pine, maple, book . . . ." If the relationship of interest is "tree-ness," the pairs oak-pine and pine-maple each represent a repetition. If "birch" were recalled in place of "book," the number of repetitions would increase from two to three. Various types of relationships have been used in studies of clustering, e.g., membership in the same taxonomic category (Bousfield & Puff, 1965), common grammatical classification (Koplin & Moates, 1968), phonemic similarity (Bousfield & Wicklund, 1969), etc. Here the term *category* will be arbitrarily used to refer to any group of related items whatever the relationship may be.

In a randomly ordered list of items, a certain number of repetitions may occur by chance. Therefore, some repetitions in a response protocol might reflect chance ordering rather than S's recall processes. Bousfield and Bousfield (1966) provide equations for the expected values of chance repetitions for an entire list, and for individual categories within the list:

$$E(R) = \left(\sum_{i=1}^{k} m_i^2/n \right) - 1 \qquad (1)$$

$$E(R_i) = m_i(m_i - 1)/n \qquad (2)$$

where R is the number of repetitions for the whole list, R_i the repetitions for Category i, m_i the number of items recalled from Category i, n the total number of items recalled, and k the number of categories represented by items in the list. By subtracting the expected chance values from observed values, one obtains a measure of the extent to which S has actually clustered the items. The measure is designed to be independent of the number of items recalled, as n and m are treated as constants for a given recall sequence.

Unfortunately, these equations are appropriate only for measuring clustering for an entire list rather than separate categories within the list. As Bousfield and Bousfield indicate, Eq. 2 does not take into account the amount of clustering in categories other than i. Because more clustering in the other categories effectively increases $E(R_i)$ beyond the value given by Eq. 2, it cannot be used to compare separate categories or types of categories within lists. An additional problem, highly similar to that discussed by Hudson and Dunn (1969), is that the variance for the distribution of chance values of R_i will change with different values of n, R, and m_i. Again, this prevents comparison of intralist categories with the Bousfield and Bousfield formula. The methods presented here correct these problems, allowing estimation of clustering differences among the categories in a single stimulus list.

REMOVAL OF INTERCATEGORY CLUSTERING DEPENDENCIES

Equations 1 and 2 assume that the n elements of a list are independently ordered, i.e., in a random sequence. However, if S recalls two items together because of some common feature, the two items are no longer independently ordered. Therefore, they should be treated as a single item rather than two. Why this is so might be clarified by a rearrangement and examination of Eq. 2:

$$E(R_i) = (m_i - 1)m_i/n \qquad (2a)$$

As stated before, n and m_i are fixed for a given recall protocol. The S's behavior is analogous to placing all n items recalled into a row of n boxes, one item per box, where m_i of the boxes will hold the Category i items. The first factor in Eq. 2a, $m_i - 1$, is the number of boxes in which a Category i item may be placed *adjacent* to another box already holding a Category i item. The 1 is subtracted since additional category members cannot be placed next to the last item in the category. The second factor, m_i/n, is the probability that any one of the n boxes will be filled by one of the m_i items, assuming random selection. Multiplying the two factors is the same as adding the probabilities for the $(m_i - 1)$ positions. If the number of boxes becomes less than n, then there are fewer boxes that can be filled by an m_i item. In turn, m_i/n will underestimate the probability of an item being in a particular box.

Clustering of two items from a non-i category has the effect of removing one of the n boxes available to Category i items, because the second item in he cluster must, by definition, occupy the box adjacent to the first. A possible solution to the problem might be to subtract the number of repetitions in non-i categories from n. However, this would be an overcorrection if some of the repetitions occurred by chance. Instead, only those repetitions which exceed chance should be subtracted. If Eqs. 1 and 2 are used to calculate the chance repetitions, the corrected value of $E(R_i)$ is given by

$$E(R_i)' = \frac{m_i(m_i - 1)}{n_i'} \qquad (3)$$

where

$$n_i' = n - [R - E(R)] + [R_i - E(R_i)]. \qquad (4)$$

The first term in brackets in Eq. 4 is, of course, the number of "nonchance" repetitions for an entire list and is a

---

*Supported in part by a Faculty Research Grant from the University of Tennessee at Chattanooga.