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Effects of pretraining US density and test ITI upon the acquisition of autoshaping

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Four groups of pigeons were tested for the acquisition of autoshaping to a green key CS following 30 days of pretraining involving intermittent, unsignaled US (food) presentations. The groups were arranged in a 2 by 2 factorial design with two levels of pretraining schedule (VT 30 sec vs. VT 90 sec) and two levels of test schedule (VT 30 sec vs. VT 90 sec). The data revealed a main effect of test schedule such that subjects tested under the VT 90-sec schedule acquired the keypeck CR faster than subjects tested under the VT 30-sec schedule. There was no main effect of pretraining schedule and no interaction effect between pretraining and testing schedules. Implications for theories of acquisition and retardation of autoshaping are discussed.

The acquisition of a Pavlovian CR is reliably retarded by the administration during pretraining of intermittent, unsignaled US presentations (cf. Baker & Mackintosh, 1979; Cannon, Berman, Baker, & Atkinson, 1975; Kamin, 1961; Mis & Moore, 1973; Randich & LoLordo, 1979; Siegel & Domjan, 1971; Taylor, 1956; Chambers & Szakmary, Note 1). This retardation effect has been extensively documented in studies utilizing the autoshaping procedure (Brown & Jenkins, 1968). That is, pigeons given extensive experience with unpredictable presentations of food (US) are subsequently retarded in acquiring the keypecking CR, when the illumination of the pecking key (CS) is followed by the response-independent presentation of the food US (cf. Downing & Neuringer, 1976; Engberg, Hansen, Welker, & Thomas, 1972; Tomie, 1976, in press; Tomie, Murphy, Fath, & Jackson, 1980, Wasserman, 1972; Schwartz & Balsam, Note 2).

Different theoretical interpretations of the retardation effect in autoshaping have been set forth. For example, Engberg et al. (1972) have suggested that US-only pretraining teaches the subject that the occurrence of the US is uncontrollable. This learning produces a general cognitive associative deficit, analogous to the "learned helplessness" cognition (cf. Maier, Seligman, & Solomon, 1969), which transfers to the autoshaping situation and interferes with the learning of the CS-US association. That is, learning that the US is uncontrollable makes it more difficult for the subject to perceive any associative relationships involving the US.

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An alternative theoretical account of the retardation effect is based upon the blocking phenomenon (Kamin, 1969). Kamin has noted that conditioning to a novel CS is retarded if that CS is compounded with another CS_X, which has been previously conditioned to the US. Moreover, the magnitude of the blocking effect is directly related to the amount of conditioning that is accrued to CS_X prior to the introduction of the novel CS. Since the static background contextual stimuli are present in the conditioning environment during pretraining and paired with unsignaled US presentations, the context should be conditioned by US-only pretraining; moreover, the context should subsequently exert a blocking influence when compounded with the illuminated key CS during the autoshaping test (Tomie, 1976).

The context-blocking formulation assumes that the retardation of autoshaping reflects the degree to which the autoshaping context is conditioned at the time of testing. Several lines of evidence derived from the literature on the effects of US-only pretraining on autoshaping support this notion. Downing and Neuringer (1976) and Schwartz and Balsam (Note 2) have parametrically varied the number of pretraining US-only presentations and have observed a positive relationship between the number of unpredictable feedings and the magnitude of the subsequently observed retardation. Their data support the contex-blocking hypothesis, in that the strength of the contextt-food association should be directly related to the number of context-food pairings experienced during pretraining.

Further support is derived from the observation that the retardation effect following US-only pretraining is context specific (cf. Tomie, 1976; Tomie et al., 1980; Schwartz & Balsam, Note 2). That is, gross alteration of the background contextual stimuli between pretraining and testing alleviates the deleterious effects of US-only pretraining upon subsequent autoshaping. Alleviation of retardation should be engendered by any manipulation

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that provides for reduction in the excitatory strength of the test context. Tomie (1976; Experiment 2) has shown that the retardation effect is alleviated by a context-extinction manipulation. That is, interpolating nonreinforced context exposure between US-only pretraining and testing (i.e., extinguishing the context) reduces the magnitude of the retardation effect.

In summary, the data indicate that the magnitude of the retardation effect induced by US-only pretraining is directly related to the excitatory strength of the test context, which is manipulated in a manner specified by straightforward conditioning considerations. That is, the excitatory strength of the context is increased by the pairing of the context with food, whereas the presentation of the context in the absence of food extinguishes its excitatory properties.

If the retarding properties of the context are a byproduct of straightforward conditioning considerations, then the degree of retardation of autoshaping should be directly related to the density of US-only presentations during pretraining. Denser schedules of unpredictable US presentations would maximize the number of context-food pairings per unit time, while simultaneously minimizing nonreinforced context-extinction effects during the interreinforcement time. The present experiment investigates the effects of pretraining US density upon the acquisition of autoshaping.

METHOD

Subjects

The subjects were 32 experimentally naive adult pigeons obtained from a local supplier and maintained at 70%-75% of their ad-lib weights throughout the experiment. Subjects were housed in individual metal cages and given free access to grit and water.

Apparatus

Four standard pigeon chambers were used, with associated automatic programming and recording equipment. Each chamber measured 35 by 35 by 30 cm (length by width by height), with a metal intelligence panel on the front containing a 2.9-cm-diam pecking key centered 20 cm above a wire grid floor. Stimuli could be projected onto the response key by industrial Electronics Engineers in-line display cells equipped with GE 1815 miniature lamps and Kodak Wratten Filter 99, which provided chromatic light with peak wavelength transmission at 555 nm (green). The food-hopper aperture was located directly below the pecking key. A houselight was mounted behind a 2.4-cm-wide strip of white Plexiglas located above the intelligence panel; it provided ambient illumination of the conditioning chamber. Eighty-two decibels (SPL) of masking noise was provided by the exhaust fans, which were continuously operative during all phases of the experiment.

Procedure

Prior to the initiation of the experiment, the 32 pigeons were unsystematically divided into four groups of eight pigeons each. On Day 1, all subjects were trained to approach and eat from the food hopper. On Day 2, the eight pigeons in each group received the first of 30 daily sessions of pretraining, consisting of 60 presentations of 5-sec access to a tray of mixed pigeon grain (US). Two of the groups received US presentations of a variable-time (VT) 30-sec schedule. The remaining two groups were given grain on a VT 90-sec schedule.

Following 30 days of pretraining, the 32 pigeons were tested for the acquisition of autoshaping. Autoshaping trials consisted of the illumination of the response key by a light of 555 nm for the 7.5 sec immediately preceding response-independent 5-sec access to grain. Sixty autoshaping trials were administered per session. Subjects were run for eight sessions. Half of the 16 pigeons that received US-only pretraining with the VT 30-sec schedule were administered autoshaping trials according to a VT 30-sec schedule (Group 30-30); the remaining half of those subjects were administered autoshaping trials according to a VT 90-sec schedule (Group 30-90). In a parallel fashion, half of the 16 pigeons that received US-only pretraining with the VT 90-sec schedule were administered autoshaping trials according to a VT 30-sec schedule (Group 90-30), and the remaining half of those subjects were administered autoshaping trials according to a VT 90-sec schedule (Group 90-90).

RESULTS

The mean acquisition functions for each of the four groups of subjects are presented in Figure 1. As the figure reveals, acquisition was more rapid when autoshaping trials were administered according to a VT 90-sec schedule than when they were administered according to a VT 30-sec schedule. Furthermore, the ordinal relationship among the four groups revealed in acquisition rate was retained in the acquisition asymptote. The evidence for an effect of the pretraining schedule was less impressive. Groups administered US-only pretraining according to a VT 30-sec schedule were retarded relative to the groups pretrained on a VT 90-sec schedule; however, the differences were small and the degree of overlap among the functions was considerable.

The data from Figure 1 were entered into a 2 by 2 by 48 mixed-design analysis of variance, with pretraining schedule (VT 30 sec vs. VT 90 sec), testing schedule (VT 30 sec vs. VT 90 sec), and blocks of 10 trials as factors. The analysis revealed no main effect of pretraining schedule upon acquisition ($F < 1$), no interaction effect between pretraining schedule and blocks ($F < 1$), and no interaction effect between pretraining

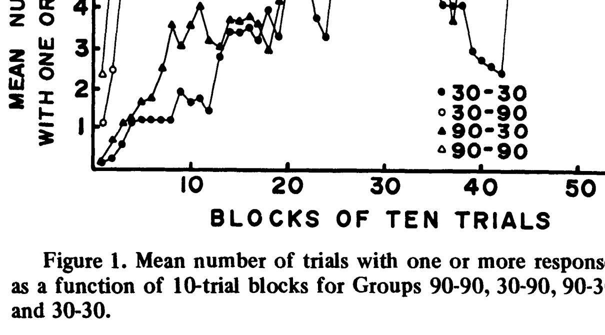

Figure 1. Mean number of trials with one or more responses as a function of 10-trial blocks for Groups 90-90, 30-90, 90-30, and 30-30.

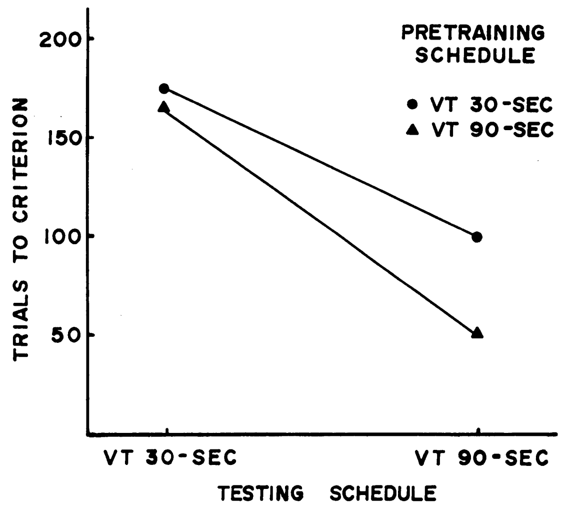

Figure 2. Mean number of trials to attain an autoshaping acquisition criterion of responding on five consecutive trials as a function of pretraining and testing schedules.

schedule and testing schedule ($F < 1$). Thus, the analysis reveals no statistical support for an effect of US-only density during pretraining upon the subsequent acquisition of autoshaping. The analysis does, however, indicate that the parameter of the testing schedule had a reliable effect upon the acquisition of autoshaping, in that there was a reliable main effect of testing schedule [$F(1,28) = 6.64$, $p < .05$] and a reliable Testing Schedule by Blocks interaction [$F(47,1316) = 2.68$, $p < .01$].

An additional assessment of the speed of acquisition of autoshaping was provided by a measure of the number of trials required by each of the subjects to attain a criterion of responding on five consecutive trials. The mean numbers of trials to criterion for each of the four groups of subjects are presented in Figure 2, which reveals faster acquisition under the VT 90-sec testing schedule. The data were entered into a 2 by 2 analysis of variance with two levels of pretraining schedule (VT 30 sec vs. VT 90 sec) and two levels of testing schedule (VT 30 sec vs. VT 90 sec). The analysis revealed no main effect of pretraining schedule ($F < 1$) and no interaction effect between pretraining and testing schedules ($F < 1$); however, there was a reliable main effect of testing schedule [$F(1,28) = 6.89$, $p < .925$]. Thus, the pattern of results identified by the analysis of the acquisition functions was precisely corroborated by the analysis of the trials-to-criterion data.

To determine whether the observed differences in acquisition asymptote (see Figure 1) were statistically reliable, a 2 by 2 by 12 mixed-design analysis of variance was performed on the data from the last two sessions (12 blocks of 10 trials). The analysis revealed no main effect of pretraining schedule ($F < 1$), but the main effect of testing schedule approached statistical significance [$F(1,28) = 3.50$, $.05 < p < .10$], providing some support for the observation that the pigeons tested with a VT 90-sec schedule attained a higher acquisition asymptote than did the pigeons tested with a VT 30-sec schedule.

DISCUSSION

The results support the following conclusion. Pigeons autoshape more rapidly when trials are programmed according to a VT 90-sec schedule than when trials are programmed according to a VT 30-sec schedule, and there is a tendency for the differences in acquisition rate to carry over into asymptotic performance. There are no reliable effects upon subsequent acquisition of the density of unpredictable feedings administered via US-only pretraining, nor are there any reliable interaction effects between pretraining and testing schedules.

The more rapid acquisition of autoshaping with the longer intertrial interval (ITI) is consistent with the results of parametric investigations of ITI effects in Pavlovian conditioning (cf. Gormezano & Moore, 1969; Kimble, 1961) and in autoshaping (cf. Gibbon, Baldock, Locurto, Gold, & Terrace, 1977; Gibbon, Farrell, Locurto, Duncan, & Terrace, 1980; Perkins, Beavers, Hancock, Hemmendinger, Hemmendinger, & Ricci, 1975; Terrace, Gibbon, Farrell, & Baldock, 1975). The direct relationship between test ITI and asymptotic probability of keypecking has been previously reported by Gibbon et al. (1980) and Terrace et al. (1975). This pattern of results is consistent with a number of different theoretical formulations of the Pavlovian acquisition process (cf. Gibbon & Balsam, in press; Gibbon, Berryman, & Thompson, 1974; Rescorla & Wagner, 1972). Unfortunately, however, these data provide ineffective leverage in discriminating among the theories.

The absence of an effect of the pretraining schedule is contrary to predictions derived from the context-blocking hypothesis, although it should be noted that the obtained results were in the predicted direction. Sharing in the embarassment are theoretical formulations of Pavlovian conditioning that predict a direct relationship between the excitatory associative strength of the context and the density of US presentations during pretraining (cf. Gibbon & Balsam, in press; Rescorla & Wagner, 1972).

One may argue that there is an effect of the pretraining schedule, but that the effect is simply less robust than that produced by the testing schedule manipulation. How does one account for the differential robustness of the pretraining and testing schedule manipulations? If the effect of the testing schedule upon acquisition is mediated by differences in the conditioning of the context during acquisition (cf. Gibbon & Balsam, in press; Rescorla & Wagner, 1972), these context effects should be at least as large when there is no discrete-trial CS present (i.e., as during US-only pretraining). The failure to observe the expression of differential context control as a function of pretraining schedules makes it difficult to attribute test ITI effects to that same factor. It is important to note that the Pavlovian literature, to our knowledge, contains no studies that investigate the density of unpredictable US presentations upon subsequent acquisition and that the results observed in this experiment are novel as well as unexpected.

The data reveal no evidence of an interaction between pretraining and testing schedules. That is, Groups 30-30 and 90-90 acquired keypecking at about the same rate as did Groups 30-90 and 90-30. This implies that changing the schedule parameter between pretraining and testing does not systematically influence the acquisition of autoshaping. There is some evidence from the instrumental conditioning literature that the ITI is an important contextual feature (cf. Neely & Wagner, 1974; Sheffield, 1949), in which case one might expect greater context blocking effects in groups that experience no change in the schedule parameter. On the other hand, studies that have demonstrated control by the ITI have invariably utilized a fixed value, whereas, in the present experiment, the ITI parameter represents a mean value, with a great range of variability about that mean. It is not particularly surprising, therefore, to find little evidence of control by ITI in this experiment.

The acquisition rates observed for the groups tested under the 30-sec schedule in this experiment are comparable to those reported previously for subjects administered pretraining with unpredictable food (cf. Engberg et al., 1972; Tomie et al., 1980) and retarded relative to rates typically observed for subjects tested under similar circumstances without such pretraining (cf. Engberg et al., 1972; Terrace et al., 1975; Tomie et al., 1980). On the other hand, the acquisition rates observed for the groups tested under the 90-sec schedule in this experiment are similar to those reported for subjects with no US-only pretraining that are tested for acquisition with a 90-sec ITI (Terrace et al., 1975). That is, US-only pretraining appears to retard acquisition on a VT 30-sec schedule, but not on a VT 90-sec schedule. Since the 90-sec ITI exposes the pigeon to extensive context extinction during acquisition, the absense of a retardation effect is not inconsistent with the context-blocking hypothesis (cf. Tomie, 1976, Experiment 2). The hypothesis, in fact, predicts the inverse relationship between test ITI and degree of retardation following US-only pretraining observed here.

In summary, the data provide mixed support for the context-blocking hypothesis. The effects of the test ITI and the relationship between test ITI and retardation are in accordance with the notions set forth by the hypothesis; however, the absence of a pretraining schedule effect is troublesome and questions the basic assumptions of that hypothesis.

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