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Magazine Training Trials and Context Effects on Autoshaping

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MAGAZINE TRAINING TRIALS
AND CONTEXT EFFECTS
ON AUTOSHAPING

by

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Fernando G. Oberdieck

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ABSTRACT

Magazine Training Trials
and Context Effects
on Autoshaping

by

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In the autoshaping preparation subjects are exposed to magazine training (US-only trials) prior to the conditioning phase in which a stimulus (conditioned stimulus, CS) predicts the delivery of a response independent reinforcer (unconditioned stimulus, US). Two experiments examined the hypothesis that irrespective of the number of US-only trials administered the magazine training and autoshaping contexts interact to determine conditioning, as measured by contact responses to the CS. The contexts employed were houselight on (light, L) and houselight off (dark, D).

In Experiment I pigeons were exposed to 1, 20, 100, or 900 US-only trials in a D, or L, context prior to autoshaping in the D, or L. The results indicated that first, autoshaping in the L was superior to autoshaping in the D. Second, irrespective of the autoshaping context performance was better following magazine training in the different

context. Third, the function relating performance to the number of US-only trials was an inverted U if magazine training occurred in the D and biphasic if it occurred in the L, irrespective of the autoshaping context.

In Experiment II pigeons were exposed to 900 US-only trials in a D, or L, context. Prior to autoshaping in the D, or L, they were exposed to either the magazine training, or a novel, context; this constituted extinction of the US-only context. The results demonstrated that when magazine training and autoshaping occur in the D extinction in the magazine training context results in superior performance relative to extinction in a novel context. However, extinction in a novel context results in better performance, relative to extinction of the magazine training context, if magazine training and autoshaping proceed in the L.

In summary, conditioning in the autoshaping paradigm is determined by the magazine training and autoshaping contexts and their interaction. The development of conditioning is therefore dependent on both the associative value of the CS and the background stimuli.

(99 pages)

CHAPTER I

INTRODUCTION

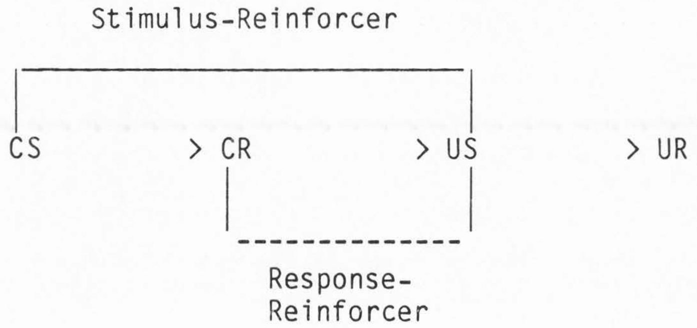
Although the study of learning has a relatively short history, it has experienced a number of theoretical and procedural reorientations. In spite of these changes, however, it has generally been assumed that learning, or conditioning, can be neatly categorized into two distinct types: classical and instrumental. This distinction is maintained both at the procedural and at the theoretical level (Mackintosh, 1974). Procedurally, instrumental, or operant, conditioning entails the arrangement of a particular contingency between the subject's behavior and an outcome (reinforcer). On the other hand, classical, or Pavlovian, conditioning arranges a particular contingency between a stimulus and an outcome (reinforcer) regardless of the subject's behavior. Simply put, the former entails a response-reinforcer contingency and the latter a stimulus-reinforcer contingency.

The procedural distinctions are parallelled on the theoretical level by statements concerned with the nature of reinforcement in conditioning. In the instrumental paradigm, reinforcement is said to strengthen the link between the response and the stimulus complex in which it occurs, thereby increasing the probability of that response in that situation (Thorndike's law of effect, Mackintosh, 1974). In the classical paradigm, reinforcement is believed to elicit a pattern of behavior which will, by association, come to be elicited by stimuli preceding the reinforcer (Pavlov's principle of stimulus substitution, Mackintosh, 1974).

It should be noted, however, that although Pavlovian conditioning arranges an explicit stimulus-reinforcer correlation, it also contains an implicit response-reinforcer connection. Since the conditioned response occurs in close temporal conjunction to the reinforcer, Pavlovian conditioning may be regarded as containing the essential feature of instrumental conditioning. Conversely, instrumental conditioning, which has an explicit response-reinforcer correlation, brings the discriminative stimulus into close temporal conjunction with the reinforcer. The implicit stimulus-reinforcer correlation makes instrumental conditioning procedurally similar to classical conditioning (Jenkins, 1973) (see Figure 1). Obviously the Pavlovian and instrumental paradigms do not clearly segregate the relations that occur between stimulus, response and reinforcer. Since both procedures entail a stimulus-response-reinforcer temporal sequence, it becomes questionable whether the two procedures actually distinguish between two simple forms of conditioning as was previously thought (Jenkins, 1973; Hearst & Jenkins, 1974).

The basic distinction made between classical and instrumental conditioning is further questioned by the autoshaping phenomenon. Since autoshaping involves both a stimulus-reinforcer and response-reinforcer relation, one is forced to consider the joint action of classical and instrumental conditioning. An examination of autoshaping may therefore lead to the abandonment of the traditional classical -instrumental conditioning dichotomy and result in a more unified view of learning (Jenkins, 1973). Furthermore, an understanding of autoshaping may help

Pavlovian Conditioning:



Operant Conditioning:

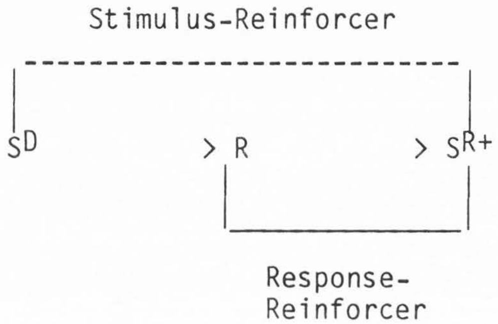


Figure 1: A schematic of Pavlovian and operant conditioning paradigms indicating the stimulus-reinforcer and response-reinforcer correlations.

Dashed lines signify an implicit correlation; solid lines an explicit correlation.

CS = conditioned stimulus S^D = discriminative stimulus

CR = conditioned response R = instrumental response

US = unconditioned stimulus S^{R+} = reinforcer

UR = unconditioned response

explain behavioral effects that arise in operant conditioning (e.g., behavioral contrast, positive conditioned suppression, response reduction to the negative stimulus in discrimination learning).

CHAPTER II

AUTOSHAPING

Brown and Jenkins (1968) found that if a response key is briefly transilluminated prior to response independent grain presentations, hungry pigeons will soon begin to peck the key during periods of key illumination. The behavior of the pigeons prior to the first peck follows a set sequence. During pairings of keylight and grain the subjects initially exhibit an increase in activity that orients them toward the lighted key, they begin to approach it, and finally peck at it. The first peck occurs, on the average, after approximately 40 keylight-grain pairings.

Procedurally, autoshaping is Pavlovian in nature since it arranges a response-independent contingency between a signalling stimulus and a reinforcer. In classical conditioning terminology, the keylight is a conditioned stimulus (CS) and the grain an unconditioned stimulus (US). The behavior, keypecking, may also be accounted for within the classical conditioning paradigm; the CS comes to elicit keypecking, a conditioned response (CR), that is similar in nature to the pecking elicited by the US (stimulus substitution). However, the skeletal movements engendered by the autoshaping procedure, approaching and contacting the keylight, are no different than those behaviors that may be selected for in an instrumental paradigm. Since approach and contact responses may also be engendered by arranging a response-reinforcer contingency, autoshaping confronts us with a Pavlovian procedure resulting in a typical instrumental behavior.

The following section presents some essential information about autoshaping that indicates the critical variables concerning this phenomenon and establishes a context for the research to be reported.

Facts on Autoshaping

The autoshaping literature has been exhaustively reviewed by Moore (1973), Jenkins (1973), Hearst and Jenkins (1974), Schwartz and Gamzu (1976) and Locurto, Terrace and Gibbon (1981); it would therefore be redundant to include a complete literature review in the present paper. However, a treatment of pertinent studies will be presented.

Experiments on autoshaping have revealed certain significant facts that must be accommodated within any systematic formulation of the phenomenon (Hearst & Jenkins, 1974). It should be noted, however, that these facts are based largely on experiments with pigeons.

(1) A majority of pigeons exposed to the autoshaping procedure consistently approach and contact the signal source after approximately 40 keylight-food pairings (Brown & Jenkins, 1968).

(2) The variable responsible for the first complete approach and contact response with the signalling stimulus is the positive correlation between the signalling stimulus and a reinforcer (Gamzu & Williams, 1971; Gamzu & Williams, 1973; Gamzu & Schwartz, 1973).

(3) Contact responses to the signal often persist even if such a response actually prevents the delivery of a scheduled reinforcer (omission procedure) (Williams & Williams, 1969).

(4) If a pigeon is allowed to view a positive stimulus-reinforcer correlation but is prevented by means of a barrier, from contacting the stimulus, or reinforcer, it will approach and contact the signalling stimulus when the barrier is removed (Moore, 1973; Hearst & Jenkins, 1974)

(5) A pigeon may be autoshaped with grain or water as the reinforcer; in a thirsty bird the contact response resembles drinking and in the hungry bird the contact response resembles pecking (Jenkins & Moore, 1973).

(6) Contact responses will shift from a less predictive signal to a more predictive one even if responses to the less predictive signal are the only ones that result in reinforcer delivery (Hearst & Jenkins, 1974).

Critical for an understanding of autoshaping is fact 2; it is the contingent pairing of keylight and food that results in the first keypeck. Little keypecking occurs with a) keylight only trials (no food is presented), b) exposure to a continuously illuminated key, and c) backward pairings of keylight and food (Brown & Jenkins, 1968). Subsequent experiments using Rescorla's (1967) random control procedure have shown quite clearly that the forward pairing of keylight and food engendered autoshaped keypecking (e.g., Gamzu & Williams, 1971; Wasserman, Franklin, & Hearst, 1974).

The parallels between autoshaping and Pavlovian conditioning, both procedurally and in terms of controlling relations are so striking that the difference between the two is often overlooked. A prerequisite for the emergence of autoshaped keypecking is that the pigeon be magazine trained, or at least that it eat from the food tray. [Autoshaping will, however, also emerge if a water US is delivered directly into the pigeons mandible, thereby precluding magazine training (Woodruff & Williams, 1976)]. The obvious counterpart in Pavlovian conditioning is the control group that receives US trials only. However, whereas in Pavlovian conditioning the groups receiving US only trials and CS-US trials are usually different, in autoshaping the subjects receiving US-only trials (i.e., magazine training) are the same ones that receive CS-US trials later on (i.e., in the autoshaping procedure). The necessity of having US only trials implicates this pretraining procedure as a major controlling variable in the emergence of autoshaped keypecking. Furthermore, since the US-only trials take place in a specific stimulus context, there may be some conditioning to the contextual stimuli present and this conditioning may interact with subsequent autoshaping. The studies reported here deal explicitly with this question; however, before formally presenting the hypothesis, the literature on magazine training, blocking, and contextual conditioning will be examined.

The Role of Magazine Training

Hitzing and Safer (1970) indicated the importance of prior magazine training by presenting twelve pigeons with two 80-trial keylight-only (CS-only) sessions followed by two magazine training sessions (US-only) followed by two more CS-only sessions. Although no pecking was observed in the initial CS-only session, ten pigeons pecked the key during the second CS-only session. However, Hearst and Jenkins (1974) noted that Hitzing and Safer (1970) conducted their experiment in a nonstandard chamber without a houselight on and failed to assess the effect of the initial CS-only trials. In an attempt to overcome these objections, Steinhauer, Davol, and Lee (1976) replicated Hitzing and Safer's (1970) procedure with conventional apparatus and no initial CS-only trials. Pigeons were given two days of US-only trials (20 trials on Day 1, 25 on Day 2) followed by 80 CS-only trials on Day 3. They found, as did Hitzing and Safer (1970), that the pigeons pecked the key on CS-only trials but keypecking was not sustained. Downing and Neuringer (1976) also found that US-only trials would result in some keypecking in subsequent CS-only trials with chicks, although only 30 percent of the chicks did so. More relevant is Steinhauer et al.'s (1976) Experiment III in which pigeons were exposed to the standard autoshaping procedure without prior magazine training. Although autoshaped keypecking eventually emerged, it occurred only after the pigeons had begun to eat from the food magazine.

There is another factor involved in magazine training and that is the number of magazine training trials. Engberg, Hansen, Welker, and Thomas (1972) reported a retardation of autoshaping in birds previously given 900 US-only trials. Wasserman (1972) (cited by Hearst and Jenkins, 1974) found a similar effect with 400 US-only trials. However, Mackintosh (1973) found no adverse effect of such pretraining, a result that is probably due to the relatively few (160) US-only trials, administered. More recently, Steinhauer et al. (1976) examined the relationship between number of magazine training trials and trials to first peck. They found that the greater the number of US-only trials, the fewer the number of autoshaping trials to the first peck. Unfortunately, they examined only 0, 3, 10, and 25 US-only trials and merely presented first peck data, not acquisition or overall performance data. As a whole, the preceding studies indicate that the function relating

US-only trials to trial to first peck is U-shaped with very few or very many US-only trials having a retarding effect. Downing and Neuringer (1976) have in fact shown such a function. They found that the first peck occurs significantly sooner after 100 US-only trials than after 1, 10, or 1000 such trials. Unfortunately, 3.5 day old Cornish chicks were used so it is not known how generalizable this function is.

In summary, certain significant facts about the role of magazine training in autoshaping can be stated.

(1) If US-only trials precede CS-only trials, some keypecking is generated but not sustained, suggesting that some pseudoconditioning results from US-only trials.

(2) Although autoshaped keypecking will emerge without prior magazine training, it occurs only after the pigeon has eaten from the magazine tray indicating that magazine training is a vital prerequisite for the emergence of autoshaped keypecking.

(3) The function relating US-only trials to trial to first peck is U-shaped with too few, or too many, US-only trials having a retarding effect on the emergence of autoshaped keypecking.

Magazine Training: Theoretical Considerations

That some magazine training trials, or at least eating from the food tray, is necessary prior to autoshaping intuitively makes sense and may be accounted for in the following way. Since the autoshaping procedure is Pavlovian in nature, the presentation of a US following a CS is required. However, without prior magazine training, the organism does not learn that a US is in fact being delivered. Consequently, the organism merely perceives a CS (keylight) followed by other neutral stimuli (i.e., hopper light and sound). Since the CS does not functionally predict reinforcement, no approach and contact responses to the CS would be expected. Magazine training, whether done by the experimenter, or the organism itself, effectively teaches the organism that a US is being delivered and that the food hopper light and sound signal US availability. Having learned that a US is periodically delivered, the CS now becomes predictive of reinforcement and approach and contact responses to the CS are expected.

This problem does not arise in Pavlovian conditioning since the organism is usually restrained and the US is delivered directly to the subject. In the autoshaping procedure, however, the subject has a relatively large area to move about in and so must learn where the US is being delivered.

Of particular present concern, and more problematic, is the relation between US-only trials and subsequent autoshaping. Although there has been relatively little theorizing on the role of magazine training and the effect of number of US-only trials, several investigators have put forth potential explanations.

Logan (1971) suggested that autoshaped keypecking to the CS occurs as generalized keypecking to the lighted grain hopper. Since US-only trials can initiate but not sustain some keypecks on CS-only trials, generalization may account for the initial autoshaped keypecks. The maintenance of autoshaped keypecking may then be accounted for within an operant framework. Although response-independent from the experimenter's viewpoint, the autoshaping procedure allows for the occurrence of a keypeck to be followed immediately, or with a short delay, by reinforcement. Consequently, the autoshaping procedure may be functionally response-dependent if seen from the organism's viewpoint. If initial pecks are a function of generalization, this would account for the facilitating effect of increased magazine trials on subsequent autoshaping; increasing magazine trials enhances stimulus control by the hopper light. Unfortunately, such an analysis cannot account for the fact that hundreds of magazine training trials substantially retard the acquisition of autoshaped keypecking.

An alternative explanation has been put forward by Downing and Neuringer (1976). These investigators account for the U-shaped function relating US-only trials to trial to first peck by postulating a motivational process which facilitates the learning of new responses with an optimal number of prior reinforcements. The problem with this analysis is the inability to define optimal number of prior reinforcements independent of a particular experiment. If a given number of magazine training trials facilitates the emergence of autoshaped keypecks, one is inclined to say that is the optimal number of prior reinforcements for the underlying motivational process.

The finding that some keypecking will occur on CS-only trials that are preceded by US-only trials is accounted for in terms of pseudoconditioning. Pseudoconditioning is a classical conditioning term that refers to the occurrence of a conditioned response to a CS after the subject has experienced US-only trials but prior to the pairing of the CS and the US. Although pseudoconditioning may account for the initial keypecks in autoshaping, it is difficult to imagine how such a concept can account for the detrimental effect of repeated US-only trials. It may be argued, however, that in pseudoconditioning, the UR is elicited by stimuli other than the US in spite of the lack of association between them. Continued US-only trials would therefore strengthen this adventitious association and proactively interfere with the learning of the CS-US association in autoshaping.

Wasserman (1972) and Schwartz, Reisberg, and Vollmecke (1974) attributed the proactive interference effect of repeated US-only trials to competition between responses conditioned in this pretraining phase and responses that would normally occur in the autoshaping procedure without this pretraining phase. Observation of the pigeons during US-only trials revealed that in this phase, they paced in front of the intelligence panel and oriented toward the houselight or unlit key. In the autoshaping, or test, phase such behaviors continued and although the behaviors were centered around the key area, pecking movements occurred infrequently.

Intuitively, the response competition formulation seems weak since the behaviors observed in the pretraining phase would appear to bring the pigeon into the vicinity of the key area. It is also difficult to imagine how the behaviors noted would interfere with keypecking. Furthermore, the assumption that certain responses compete with autoshaped keypecking is questioned by several recent studies (e.g., Tomie, 1976a (Note 1); Engberg et al., 1972). These investigators specifically trained an incompatible response (treadle pressing) prior to autoshaping and failed to find a retarding effect. Engberg et al. (1972) concluded that a response competition formulation was inadequate and proposed instead the concepts of "learned laziness" and "learned industriousness." A "lazy" organism learns that there is no correlation between its behavior and reinforcement and as a result this expectancy retards the acquisition of autoshaped keypecking. On the other hand, the "industrious" organism (treadle-trained subjects) learns that there is in fact a positive relation between its behavior and reinforcement, an expectancy which facilitates acquisition of keypecking.

Engberg et al.'s (1972) experiment is, however, open to major criticisms that cast doubt on their conclusions (Gamzu, Williams, & Schwartz, 1973). First, Engberg et al. (1972) failed to present maintenance data; therefore, it is difficult to determine if their treatment had an effect on the acquisition or maintenace of autoshaped keypecking. Second, when the treadle trained group was exposed to the autoshaping procedure, the treadle was removed from the chamber, a detail which explicitly precludes the competing response from occurring. Since the explicitly pretrained incompatible response (i.e., treadle pressing) cannot occur, the effect of this pretraining is minimal in the autoshaping phase. The free-food group, however, develops a superstitious response that may still occur during autoshaping; consequently, more interference is expected, which would result in the retardation of autoshaped keypecking.

In an attempt to disentangle these confounding factors, Schwartz, et al. (1974) autoshaped pigeons following one of four pretraining treatments. One group (naive) was exposed to the autoshaping procedure immediately following magazine training. Two groups were initially trained to treadle press and were then exposed to the autoshaping procedure with the treadle present, or absent. A fourth group (free food) received over 600 US-only trials prior to autoshaping. Trials to first peck data revealed that naive pigeons pecked after fewer trials, with treadle and free food subjects being equally retarded. Trial on which a criterion of one peck in eight of ten successive trials was reached revealed that free food subjects were retarded in comparison to the treadle group (data consistent with Engberg et al., 1972). Surprisingly, little difference was found between treadle trained subjects with the treadle present, or absent, during autoshaping. However, maintenance of keypecking was affected by the presence, or absence, of the treadle. When present, treadle and free food subjects were indistinguishable; when absent, more pecking occurred in the treadle group than in any other group.

Unfortunately, the groups were too small (N = 3) for adequate statistical evaluation. Equally unfortunate is that either the response competition or the "learned laziness" (or "industriousness") formulation may be supported depending on the response measure employed. Both US-only trials and treadle training with treadle present, or absent, are detrimental with respect to trials to first peck. The trials to criterion data implies that treadle training has a facilitative effect (support for learned "laziness" and "industriousness"). Maintenance data shows that with the treadle absent, treadle trained subjects respond at a greater rate and on more trials than free food subjects. This may be construed as support for Engbert et al., 1972, that is, treadle trained subjects learned "industriousness." However, with the treadle present, so that the competing responses could occur in both the treadle and free food group, there was no difference in maintenance data, support for the response competition view since both groups were retarded relative to the naive subjects.

The fact that both the response competition and learned "laziness" explanations may be supported, depending on what measures are employed, suggests that both formulations are inadequate. The overwhelming logical problem with either analysis is that there is no independent method for assessing whether or not a particular pretreatment has interacted with subsequent autoshaping via response competition, or learned "laziness" (or "industriousness"). If one presumes a response competition view, the effects of pretreatment may be accounted for in the following way. If the pretraining has a facilitative effect, the response pretrained was either weak or the response system did not effectively preclude the occurrence of keypecking. The facilitative effect may simply be due to the fact that learning one thing aids in learning another. If autoshaping is retarded, the competing response effectively interfered with keypecking. Similarly, one may argue that in pretraining a subject did, or did not, learn "laziness" (or "industriousness") and thus account for the retarding or facilitating effects on subsequent autoshaping. The ease with which findings can be accommodated, the inability to define "laziness" or response competition independent of a particular experiment, and the failure of various measures to consistently support one view suggest that neither conceptualization is presently worth maintaining.

Another theoretical interpretation of the retarding effects of massive US-only trials may be made employing Thomas' (1970) concept of "general attentiveness." Although Thomas' (1970) original conceptualization was formulated to account for certain discrimination learning phenomena, Hall and Honig (1974) have mentioned it as a possible explanation for the detrimental effects of US-only trials. Essentially, Thomas (1970) postulated that a true discrimination training procedure, in which the presence or absence of certain stimuli is correlated with reinforcement, heightens attentiveness to all stimuli thereby facilitating the acquisition of a subsequent discrimination. True

discrimination training results in the formation of discrimination learning sets. On the other hand, pseudodiscrimination training, in which stimuli and reinforcement are uncorrelated, would have a detrimental effect on subsequent discrimination learning.

Such an explanation may account for the finding that pigeons exposed to a zero correlation between CS and US autoshaped more slowly when the CS became predictive of the US relative to a non-preexposed control group (Gamzu & Williams, 1971, 1973; Mackintosh, 1973). Mackintosh suggested that this reflects "learned irrelevance"; that is, learning that the CS and US are uncorrelated retards subsequent association of the two stimuli; an explanation compatible with Thomas' (1970). However, Thomas' (1970) explanation is broader, suggesting that any prior discrimination training, not merely learning that the CS and US are uncorrelated, will have a facilitative or detrimental effect on a subsequent discrimination.

Hall and Honig (1974) magazine trained two groups of pigeons and then exposed them to a discrimination training situation with the response key unlit. Discrimination trials were 90 sec long and separated by 10 sec intertrial intervals during which the houselight was darkened. The true discrimination group received reinforcement on a VT-60 sec schedule with a green houselight signalling reinforcement and a red houselight signalling extinction. Pseudodiscrimination subjects experienced an equivalent reinforcement schedule with half of the reinforcers being signalled by the green househeight and half by the red one. After seven discrimination training sessions, all subjects were given three autoshaping sessions with a white houselight on and three white vertical lines on a black background as the CS.

Although the true discrimination group learned to peck the key more readily, no acquisition data were presented to determine when acquisition occurred and not enough maintenance sessions were run to determine if the group differences persisted. Furthermore, the data are not conclusive, because an untrained control group was not available to demonstrate that the discrimination pretraining actually had enhancing, or debilitating effects. However, the data do provide some evidence for the view that discrimination training aids in subsequent discrimination learning and that uncorrelated training retards the acquisition of a subsequent discrimination. If pseudodiscrimination training and US-only trials are viewed as functionally equivalent, the detrimental effects of the latter may be accounted for. The problem with such a consideration is that it is difficult to determine what the uncorrelated environmental stimuli are in the US-only situation. Since the environment is relatively constant, except for aperiodic US presentations, such stimuli must reside within the organism. Unfortunately, organismic variables and concepts seem to evaporate just when they are about to be grasped, much like Cheshire cats. The necessity of having to postulate uncorrelated organismic stimuli and the current inability to manipulate such stimuli appears to weaken the "general attentiveness" view of the effect of US-only trials.

In summary, all of the conceptualizations viewed that seek to account for the detrimental effect of certain pretraining manipulations on autoshaping either cannot account for the data or are formulated in such a way that they cannot be conclusively proven, or disproven. The major problem appears to be the use of concepts such as "learned" laziness, irrelevance, etc., which cannot be measured independently of a particular experiment. Consequently, there is no way of determining a priori if these factors will have a detrimental effect. Furthermore, if there is no retarding effect, it is always possible to argue that irrelevance, laziness, etc., were not learned in pretraining. Although the particulars of the account differ, all except Logan's (1971) generalization view, share a common premise; namely, that the retarding effect of certain pretraining techniques on autoshaping is a general transfer of training effect. Learning, in pretraining, that the US is unrelated to stimuli, or responses, proactively interferes with subsequent autoshaping. Massive US-only trials would therefore be expected to retard autoshaping.

Although the proactive interference interpretation is compatible with the data, an alternative is that blocking causes the retardation. A complete statement of a blocking interpretation must, however, be preceded by a brief review of the blocking literature.

CHAPTER III

BLOCKING

Kamin (1968; 1969) examined blocking using a conditioned suppression (or CER) paradigm. In the basic CER procedure, developed by Estes and Skinner (1941), a rat is trained to press a bar for reinforcement in an operant chamber. Once stable bar-pressing rates are established, CER conditioning is instigated. A CS (light, tone or white noise) is presented for up to three minutes with CS termination coincident with the delivery of a brief electric shock (US). For each CER trial (CS-US sequence), the CR measured is a reduction in the rate of lever pressing. This suppression ratio is measured in the form B/A+B, where B represents the number of bar presses during the CS and A is the number of lever responses in an equivalent period preceding the CS. If the ratio has a value of 0.50 then the CS has no effect on responding; a ratio of 0.00 indicates complete suppression of responding during the CS.

Blocking simply means that if sufficient training is given on CS1 alone before conditioning to a CS1CS2 compound, there may be virtually no conditioning to CS2. The prior training on CS1 blocks conditioning to the CS2 part of the compound stimulus. In the CER procedure employed by Kamin (1968, 1969), the stimuli were light (L), noise (N), and a light-noise (LN) compound. If conditioning to the LN compound is preceded by prior conditioning to L, test procedures in which N is presented alone resulted in virtually no suppression. Similarly, prior conditioning to N alone resulted in no conditioning to L of the NL compound. However, if conditioning is only to the LN compound, the presentation of each element separately results in some suppression. Furthermore, groups conditioned to L, N, or the LN compound without prior training will approach asymptotic suppression to their respective CS after a few trials although some differences can be noted in the acquisition of the CER. The LN group acquires most rapidly followed by the L group and finally the N group. The blocking effect does not therefore seem to be specific to any particular stimulus, or sequence of stimuli employed, it depends on prior conditioning to one element of a compound.

Blocking does not occur if reinforcement is changed on compound trials. If reinforced (i.e., US is presented) trials are presented with N alone and subsequent LN trials are nonreinforced (i.e., no US is presented), some inhibitory conditioning occurs to L. Excitatory conditioning (supression of responding) may also occur to the added element of a compound, in spite of prior training, if shock intensity is increased from 1 ma to 4 ma on compound trials. If the CS1CS2 compound predicts a change in reinforcement, conditioning may occur to CS2 even though there was prior exposure to CS1 alone. The blocking effect may also be attenuated if conditioning to the compound is initiated before conditioning to the single element is complete, that is before suppression is asymptotic. Amount of blocking is therefore a function of the amount of initial conditioning to an element of the compound. Elimination of the block may also occur if suppression to the initial element is extinguished prior to compound conditioning.

Blocking is also a function of the intensity of the CS; more blocking occurs to the CS1CS2 compound if CS1 is intense than if CS1 is weak.

In classical conditioning, the underlying stimulus-reinforcer association may be blocked. If the response-reinforcer association underlying instrumental conditioning is seen as containing an implicit stimulus-reinforcer association, it may be possible for a stimulus-reinforcer association to block a response-reinforcer association and prevent the appearance of instrumental learning; St. Claire-Smith (1970; cited by Mackintosh, 1974) has shown just this. Rats were initially trained to bar press for food and then exposed to a classical conditioning procedure in which a CS was paired with shock. The animals were then exposed to a shock, contingent on lever pressing, every five minutes. For the blocking group, the CS previously paired with shock was presented coincidently with each punished response. An overshadowing group was presented with a CS not paired with shock coincident with each punished response and a control group was punished without any accompanying external stimulus. Suppression ratios indicated that response contingent shock suppressed responding in the control group, had some effect on the overshadowing group, and had very little effect on the blocking group. Suppression ratios after 10 punishment trials were approximately 0.09 (control), 0.35 (overshadowing), and 0.42 (blocking). The implication is that learning the stimulus-reinforcer association during pretraining blocked learning of the response-reinforcer association in the punishment procedure.

The preceding studies would lead one to suspect that learning one response-reinforcer association may block the subsequent learning of another response-reinforcer association. Several studies have, in fact, shown that blocking occurs in instrumental discrimination learning. For example, Miles (1970) demonstrated that if pigeons are trained on a successive visual discrimination between L1 and L2, and then switched to a discrimination involving TL1 and L2, they show less learning to the tone than a control group that only learned the TL1/L2 discrimination. Pretraining did not completely block learning about the tone, it merely reduced it. Similar findings have been reported with simultaneous discrimination learning in rats (Mackintosh, 1965). Although blocking may occur in discrimination learning, the effect is typically small and may often not occur (Farthing & Hearst, 1970). There are, however, no studies which attempt to determine why complete blocking is shown in the CER procedure and only partial blocking is exhibited in discrimination learning.

Wasserman (1972, 1973) has also shown that blocking may occur in an autoshaping paradigm. After magazine training, one group of pigeons was exposed to 400 trials of food delivery predicted by an auditory cue. This group then experienced autoshaping in which the CS was the auditory cue plus the keylight. Acquisition of autoshaped keypecking was retarded; however, it is not certain if this was due to blocking or simply to the retarding effect of the US-only trials since a group receiving US-only trials was similarly retarded.

In summary, blocking is a robust behavioral phenomenon that occurs in both classical and instrumental conditioniong although its effects seem to be more durable in the classical paradigm. Furthermore, a classical stimulus-reinforcer association may be used to block a subsequent response-reinforcer correlation. The blocking of a stimulus-reinforcer association by prior conditioning of a response-reinforcer association has not been demonstrated. Of particular present concern are the rules that appear to control blocking, at least within the CER procedure employed by Kamin. They are as follows:

1. Blocking remains total even if compound conditioning trials are greatly increased.
2. The amount of blocking is systematically related to the amount of prior conditioning to CS1.
3. More blocking will occur if CS1 is physically intense.
4. The blocking effect may be negated if:
    a. prior conditioning to CS1 is extinguished before exposure to the CS1CS2 complex.
    b. the CS1CS2 complex predicts a change in reinforcement.

Although it is not known how generalizable the preceding rules are, it is best to assume for the moment that they are generally valid. A problem that remains, however, is to account for blocking theoretically.

Blocking: Theoretical Interpretations

One approach to the blocking phenomenon is that it reveals an underlying mechanism of selective attention (e.g., Sutherland & Mackintosh, 1971). The primary assumption is that there is a limit to the number of stimuli that can be simultaneously attended to and that may be used to form new associations. Within any experimental situation, the probabilities of strengths of attention to various stimuli sums to 1.0. Consequently, an increase in the probability of attention to one stimulus will entail a concomitant decrease in the probability of attention to other stimuli ("inverse hypothesis").

Blocking would therefore be a result of complete attention to CS1 resulting from pretraining. Although the idea that organisms have limited channel capacity is informative their information processing system is not likely so limited that it cannot handle the restricted salient stimuli employed in Kamin's (1968, 1969) CER procedure. Furthermore, recall that if the CS1CS2 complex signals a change in reinforcement, there is no blocking, suggesting that CS2 is in fact attended to. It is difficult for the "inverse hypothesis" to account for this since it would predict that prior conditioning to CS1 would essentially employ nearly all of the attention capabilities of the organism.

Kamin (1969) suggested that blocking occurs because the US is fully predicted by CS1. By implication, only surprising, or nonpredictable, reinforcers are effective. The initial conditioning to CS1 occurs because the reinforcer is surprising. On the CS1CS2 compound trial, the reinforcer is moderately surprising but not enough to sustain conditioning to the stimulus complex. If, however, the complex signals a change in reinforcement, the reinforcers are again surprising and may sustain conditioning. Rescorla and Wagner (1972) have proposed a similar idea, suggesting that a given US will only support a certain level of conditioning. As conditioning to a stimulus complex approaches this asymptote, there will be relatively less conditioning accruing to the individual elements forming the compound. If the conditioning asymptote is reached by one element, there can be no further conditioning to any new element. Blocking is therefore a result of reaching the conditioning asymptote by CS1. If there is a change in reinforcement, then conditioning may occur to CS2 because the new US can support a different level of conditioning. If the CS1CS2 complex signals the omission of reinforcement, inhibition is conditioned to CS2 because the inhibitory conditioning asymptote has not been reached. Inhibitory conditioning occurs when an expected reinforcer is omitted (i.e., there is "surprise" value). Similarly, excitatory conditioning occurs when a reinforcer is unexpected but occurs (is "surprising"); in the limiting case, a completely expected reinforcer results in no more excitatory conditioning, asymptotic conditioning is reached.

Unfortunately, data exists which are contrary to the Rescorla-Wagner model of conditioning. Mackintosh and Turner (1971) found that following conditioning to CS1, and then conditioning to a CS1CS2 complex in which there was no change in reinforcement, later conditioning to CS2 was retarded. Conditioning to CS2 was therefore affected by prior exposure to a context in which CS2 signalled no change in reinforcement. The Rescorla-Wagner model would not have predicted such a retarding effect since theoretically no association could have been formed to CS2 when the CS1CS2 complex predicted no change in reinforcement.

A final difficulty with both models is their inability to account for the small blocking effect encountered in discrimination learning compared to the large effect found in the CER procedure. The difficulties encountered by both models suggest that stimulus selection should not be viewed as a direct consequence of either limited attention, or limited associative strength (Mackintosh, 1974). Perhaps it is easier to assume that attention is primarily maintained to informative stimuli, that is, stimuli predictive of reinforcement.

Blocking occurs because the added stimulus is redundant and therefore partially ignored. The added stimulus is only partially ignored because if conditions change the added stimulus can be employed. It also seems reasonable that the organism can attend to more than one stimulus at a time. Reinforcement strengthens the associative strength of a predictive stimulus but this does not necessarily mean that attention to other stimuli is completely extinguished.

Although an adequate theoretical account of blocking does not presently exist blocking evidently is a well established behavioral phenomenon. The next task it to apply a blocking interpretation to the retarding effects of US-only trials on subsequent autoshaping. Such an interpretation, however, requires the initial identification of a blocking stimulus present during pretraining that is compounded with the keylight during autoshaping. A likely candidate is the environment itself. Contextual stimuli are present during pretraining and may be viewed as being compounded with the keylight during autoshaping.

CHAPTER IV

CONTEXT CONDITIONING

Rescorla and Wagner's (1972) theory of classical conditioning states that the effects of reinforcement, or nonreinforcement, on the associative strength of a stimulus element is a function of the total associative strength of the stimulus compound. Coupled with this is their assumption that any US will only support a certain amount of conditioning. Since any CS is invariably presented in compound with background stimuli an interaction presumably exists between the manipulated CS and static environmental stimuli. From this theory, one would predict that more conditioning occurs to the background stimuli if a US is presented in the absence of a CS. However, if a CS is introduced which reliably predicts a US then more conditioning should accrue to the CS and less to the background stimuli.

Odling-Smee (1975) tested this proposition by presenting rats with a tone CS followed by unavoidable shock as the US. Following conditioning, rats were tested for their reactions to the environment in which they were conditioned; CS and US were absent. Avoidance was simply measured by the amount of time spent in the conditioning half of a two-compartment chamber. Control groups that received CS-only and no CS, or US, did not avoid the environment. However, the US-only control group, in which more conditioning is expected to occur to the environment, avoided the conditioning part of the area. Groups exposed to the CS and varying US probabilities avoided the conditioning environment more the less predictive the CS was. When the CS was fully predictive of the US some conditioning still occurred to the context, as indicated by the fact that some avoidance occurred relative to the CS-only control.

Welker, Tomie, Davitt, and Thomas (1974) have also demonstrated that contextual stimuli are conditioned during simple discriminations. They exposed a group of pigeons to single stimulus training with a houselight (HL) and tone (T) present during all sessions. Subsequently discrimination training was instituted with 555 nm as S+ and a line as S-. For one group, the HL and T were paired with S+ (S+/context), for another with S- (S-/context), and for a third with both S+ and S- (no context change, NCC). Matched control groups received the same discrimination training without prior single stimulus training. The discrimination was acquired most rapidly by the S+/context group, then S-/context group and never by the NCC group. That the S-/context group learned the discrimination slowly indicates that prior context conditioning initially interfered with learning not to respond to S-. Failure of the NCC group to learn not to respond to S- suggests that prior context conditioning effectively blocked learning of the discrimination. Postdiscrimination generalization gradients indicated that all experimental groups yielded flatter gradients than their matched controls, suggesting that in all cases contextual stimuli had at least a mild blocking effect.

Blanchard and Honig (1976) demonstrated that prior context conditioning could interfere with the speed of acquisition of autoshaped keypecking. Naive pigeons were magazine trained and then exposed to a discrimination procedure in which a colored houselight signalled response-independent food presentations (S+), and a houselight of a different color signalled extinction (S-). Subsequently, the subjects were exposed to an autoshaping procedure in the context of the S+ houselight (positive), S- houselight (negative), or novel houselight. The negative group autoshaped the fastest, followed by the novel and positive groups respectively. The retarded effect exhibited by the positive group suggests that autoshaping may be blocked by embedding the CS in a context that has previously been associated with a US. The rapid acquisition of keypecking by the negative group may also be accounted for within a blocking interpretation since blocking may be negated if the added stimulus signals a change in reinforcement. In this instance, the keylight predicted reinforcement and thus effectively negated the inhibitory effect of the S- houselight. That this group autoshaped faster than the novel group may be explained by Kamin's (1969) suggestion that the effectiveness of a US depends on its surprise value. A US presented in a S- context is, predictably, very surprising.

Tomie (1976a) has also shown that random presentations of a tone CS and food proactively interferes with autoshaping only when pretraining and autoshaping occur in the same context. If autoshaping occurs in a different context, the pretraining has no detrimental effect.

Tomie (1976b) demonstrated that random presentations of a red keylight (CS) and food (US) retarded autoshaping to a green-key-CS only if the context remained unchanged. If the context was altered, no retarding effect was evidenced. Similarly, if the pretraining context was extinguished by exposing the pigeons to the context without the CS, or US, the retarding effect on subsequent autoshaping was also negated.

Although the area of context conditioning is relatively young and the experiments limited, the data unequivocally support the notion that conditioning can occur to contextual stimuli. The assumption that contextual conditioning occurs during magazine training is thereby bolstered.

Context Conditioning During Magazine Training

The introductory problem was to account for the retarding effect of too few, or too many, US-only trials on subsequent autoshaping. The blocking and context conditioning literature suggests that these two variables may account for the deleterious effect of the US-only trials. The result of US-only trials is to condition the contextual stimuli present to the US. If contextual stimuli are viewed as CS1 and the autoshaping keylight as CS2, during autoshaping CS1 and CS2 are compounded. Prior conditioning to CS1 (the context alone) thus blocks conditioning to CS2 (the keylight). Blocking is not total because CS2 is a more reliable predictor of the US than CS1; consequently conditioning to CS2 eventually occurs. If, however, CS1 is not present during autoshaping (i.e., the context is changed), no retarding effect is expected even after massive conditioning to CS1. The implication is that many US-only trials will not have a retarding effect on subsequent autoshaping if the context is changed, only if autoshaping and US-only trials occur in the same context. However, even if the context is not changed, the retarding effect of US-only trials may be dissipated if conditioning to the context is extinguished prior to autoshaping.

CHAPTER V

EXPERIMENT I

Introduction

The following series of experiments assessed the role of context conditioning and blocking, resulting from magazine training, on subsequent autoshaping. To make the contexts as distinct as possible, the two contexts employed were houselight on (light, L) and houselight off (dark, D). Four cases were possible: magazine training in the light or dark and subsequent autoshaping in the light or dark. Experiment I examined the blocking interpretation by systematically varying the number of US-only trials, magazine training context, and autoshaping context.

Subjects

Seventy-two experimentally naive wild pigeons maintained at approximately 75% of their free-feeding weight served. They were individually housed with water available in their home cages at all times.

Apparatus

Subjects were tested in a three-key operant conditioning chamber with internal dimensions of 40.64 cm by 40.64 cm by 40.64 cm. Response keys, 2.22 cm in diameter, were in line with their centers 25.4 cm above the floor. The center of the central key was located on the midline of the intelligence panel with the centers of the side keys

6.35 cm to either side of it. Only the center key was employed, side keys were accessible but nonfunctional. During CS presentations, the center key was transilluminated by a standard white 28 V-dc bulb (Sylvania 28ESB). When operated by a force of approximately 0.06N the response key produced an audible feedback click. Reinforcement was made available through a 6.35 cm by 5.08 cm (W by H) aperture centrally located on the intelligence panel with its upper edge 10.16 cm below the center of the central key. Illumination of the aperture by a white 28-V dc bulb (GE #757) always accompanied reinforcement; during nonreinforcement periods the aperture was dark. A 110-V, 7 1/2W white houselight centrally located in the ceiling provided general chamber illumination in the houselight on conditions. Extraneous sounds were masked by a sound-attenuating compartment in which the chamber was housed and white noise. Experimental events were controlled and data recorded by electromechanical components situated in an adjoining room.

Procedure

Subjects were randomly divided into groups of at least four pigeons; groups differed as to the number of magazine training trials, magazine training context, and autoshaping context. The four context conditions were:

1. Magazine training and autoshaping in the dark (D-D).
2. Magazine training with the houselight on and autoshaping in the dark (L-D).
3. Magazine training and autoshaping with the houselight on (L-L).

4. Magazine training in the dark and autoshaping with the houselight on (D-L) (see Table 1).

Table 1

The Design of Experiment 1

Group	No. of Subjects	Magazine Training Context	No. of Magazine Trials	Autoshaping Context
D-D	4	Dark	1	Dark
	7	Dark	20	Dark
	4	Dark	100	Dark
	4	Dark	900	Dark
L-D	4	Light	1	Dark
	7	Light	20	Dark
	4	Light	100	Dark
	4	Light	900	Dark
L-L	4	Light	1	Light
	6	Light	20	Light
	4	Light	100	Light
	4	Light	900	Light
D-L	4	Dark	1	Light
	4	Dark	20	Light
	4	Dark	100	Light
	4	Dark	900	Light

Magazine training trials varied between groups as follows:

1 Magazine trial. The D-D, L-D, D-L, and L-L groups in this condition received only one magazine trial prior to autoshaping. On Day 1, subjects were placed in the chamber with the key darkened and the houselight on, or off, as required. The illuminated magazine tray was in the elevated position and loaded to the brim with pigeon food. After the subject had eaten for 20 sec, the food tray was lowered (tray light extinguished) and the subject returned to its home cage. Autoshaping sessions began the following day.

20 Magazine trials. Conditions were similar to those for the previous group with the following changes. After eating for 20 sec, the food tray was lowered and immediately raised again until the pigeon had eaten for 10 sec. On the following three trials, the food tray was elevated at 15 sec intervals, remaining in this position for 5 sec. Subsequently, the food tray was operated for five trials each at 30, 45, and 60 sec intervals (in that order), remaining elevated for 5 sec/trial, for a total of 20 magazine trials. If the subject failed to eat on any three consecutive trials, the food magazine remained elevated on the third trial until the subject ate for 3 sec. Autoshaping began on Day 2.

100 Magazine trials. Magazine training on Day 1 was identical to that given to the group experiencing 20 magazine trials. On Days 2 and 3, the same context conditions were maintained and the pigeon received 40, 3-sec food-only trials daily.

Food presentations were governed by a variable time (VT) tape with an average interval of 60-sec (range: 5-216 sec). Autoshaping sessions began on Day 4.

900 Magazine trials. Day 1 training for these groups was similar to that of the previous group. After Day 1, these groups received 22 days of food-only trials, in the same context, prior to autoshaping. On food-only days the 60-sec VT tape governed food presentations.

Autoshaping protocol. After a pigeon received the appropriate number of food-only trials, autoshaping sessions began with the house-light on, or off, depending on the treatment. Autoshaping sessions took place seven days a week at approximately the same time and lasted for 15 days. Daily sessions consisted of 40, 8-sec CS presentations with each CS terminating coextensively with a 3-sec response independent feeder presentation. Intertrial intervals (ITI's), the interval between food termination and onset of the following CS, averaged 60 sec (range: 5-216 sec). Key pecks had no scheduled consequences. Responding during the CS was recorded on a trial by trial basis, and ITI responses were recorded cumulatively throughout the session.

Results

Under all conditions keypecking occurred primarily during the CS period. Some ITI responding was noted but it was infrequent and consisted mostly of runover pecks; keypecking that continued immediately after CS termination. The data analysis in both Experiments I and II focused on group means (all subjects were included) with the Mann-Whitney U test being employed to detect between-group differences. To assay overall between-group performance differences, in both experiments, consecutive sequences of five sessions were collapsed into blocks and between-group comparisons made within blocks. This allows one to determine in which third of the autoshaping sessions differences emerged and if these differences remained stable. For a data analysis in which sessions are blocked and a non-parametric statistic is employed to detect significant between-group differences within performance blocks, see Oberdieck, Cheney, and Mueller (1978). Also, see Hearst, Bottjer, and Walker (1980) for an additional example of statistical analysis based on session blocks. In an attempt to make the text more readable and concise only statistically significant group differences are noted, that is, Mann-Whitney *Us* $\leq$ 4 and *ps* $\leq$ .048. Moreover, in instances involving numerous paired comparisons only the range of U and p values is presented. The exact values of U and p for any statistically significant paired comparison are listed in Tables 2 through 27 which summarize the comparisons made.

1 Magazine trial. (N = 4 for all groups.) The D-D, L-D, D-L, and L-L groups respectively emitted their first CS peck on mean trials 28.2, 33.7, 12.0, and 46.5. The D-L group required significantly fewer trials than the L-L group ($U = 0$, $p = .01$). The second peck emerged on mean trials 34.5, 40.2, 25.2, and 48.7 for groups D-D, L-D, D-L, and L-L, in that order. Fewer trials were required for the D-L group to emit its second peck relative to the L-L group ($U = 2$, $p = .02$). Groups D-D, L-D, D-L, and L-L achieved acquisition criterion (the first of five consecutive trials with at least one response in each trial, Newlin & LoLordo, 1976) on mean trials 103.7, 194.0, 46.7, and 69.5 respectively. Group D-L reached acquisition criterion sooner than groups L-L and D-L (Us = 1, ps = .029).

Figure 2 depicts the mean trials with a peck (TWP) (top) and mean total CS pecks (TCSP) (bottom) as a function of consecutive autoshaping sessions. Performance is stable after approximately four sessions for all groups except D-D. Note, however, the between-group differences (Us $\leq$ 4, ps $\leq$ .048). The TWP measure showed the D-L group outperformed the D-D group in Block 1. In Block 2, the D-L group performed better than groups D-D and L-D with group D-D also responding on more trials than group L-D. Also the L-L group outperformed the L-D group. Group D-L remained superior to groups L-L, L-D, and D-D in Block 3. In Block 3, group L-L outperformed groups L-D and D-D with group L-D also responding on more trials than group D-D (see Table 2).

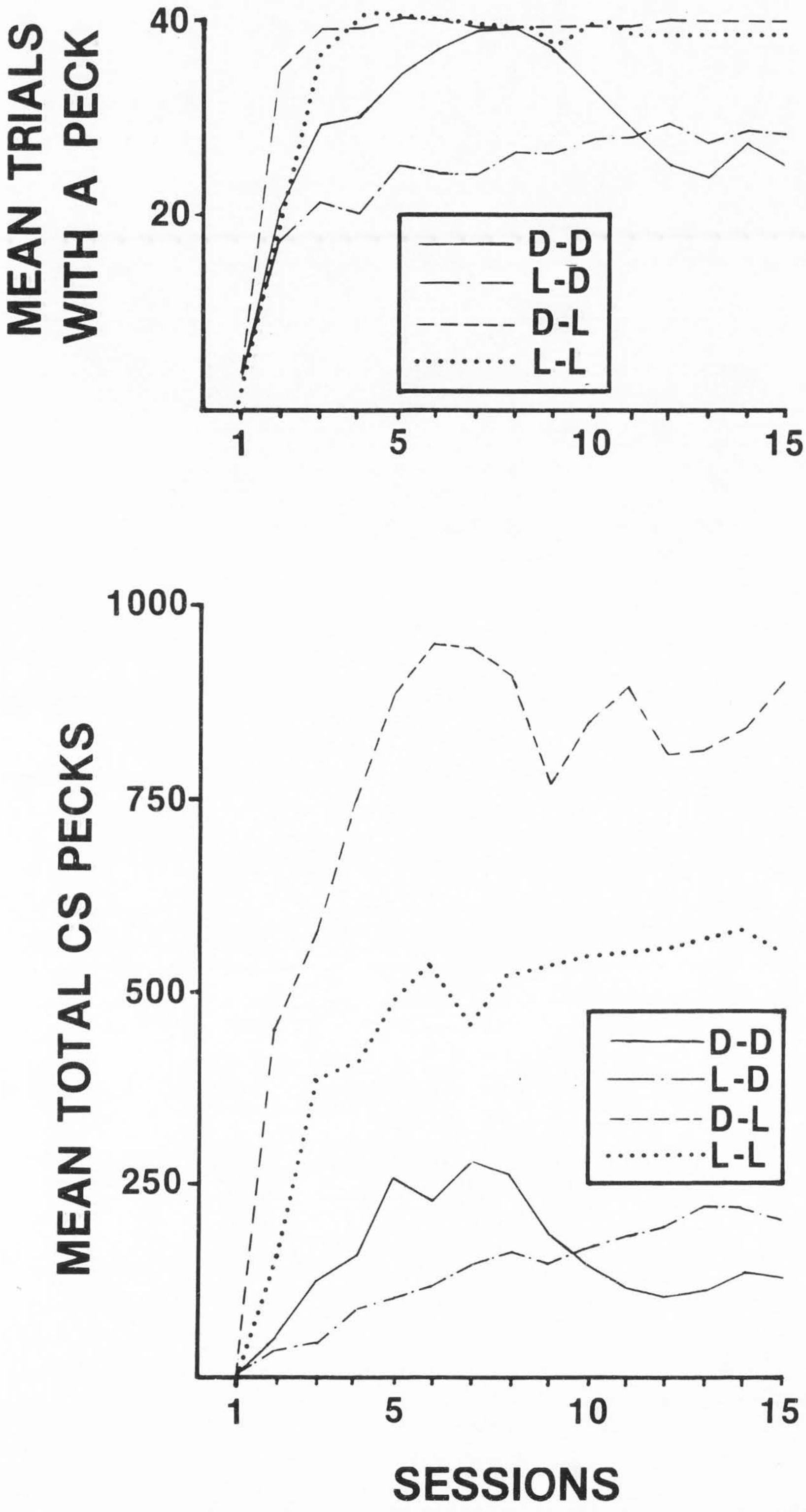


Figure 2. Mean trials with a peck (top) and mean total CS pecks (bottom) for all groups exposed to 1 US-only trial prior to autoshaping as a function of sessions.

Table 2

Between-Group Comparisons Based on Mean TWP for

Groups Administered 1 US-only Trial

Block 1	Block 2	Block 3
D-D=L-D	D-D>L-D [1]	D-D<L-D [3]
D-D<D-L [3]	D-D<D-L [2]	D-D<D-L [1]
D-D=L-L	D-D=L-L	D-D<L-L [1]
L-D=D-L	L-D<D-L [1]	L-D<D-L [1]
L-D=L-L	L-D<L-L [1]	L-D<L-L [1]
D-L=L-L	D-L=L-L	D-L>L-L [1]

In this and all subsequent tables an equality sign indicates statistical indifference, an inequality sign a significantly higher performance level by one group. Additionally, in this and all subsequent tables numbers in brackets refer to exact U and p values: [1] $U = 0$, $p = .004$, [2] $U = .5$, $p = .008$, and [3] $U = 4$, $p = .048$.

As indexed by mean TCSP, in Block 1 group D-L responded more than groups D-D and L-D. In Block 2, group D-L performed better than groups L-L, D-D, and L-D. Also group L-L emitted more pecks than groups D-D and L-D with group D-D also outperforming group L-D. The only change in Block 3 was that group L-D responded more than group D-D (see Table 3).

Although differences emerged in Block 1, groups clearly segregated in Block 3. On the basis of Block 3 performance both metrics ranked the groups in the following descending order, D-L, L-L, L-D, and D-D with all between-group differences being significantly different.

Table 3

Between-Group Comparisons Based on Mean TCSP for

Groups Administered 1 US-only Trial

Block 1	Block 2	Block 3
D-D=L-D	D-D>L-D [2]	D-D<L-D [1]
D-D<D-L [2]	D-D<D-L [2]	D-D<D-L [1]
D-D=L-L	D-D<L-L [1]	D-D<L-L [1]
L-D<D-L [2]	L-D<D-L [2]	L-D<D-L [1]
L-D=L-L	L-D<L-L [1]	L-D<L-L [1]
D-L=L-L	D-L>L-L [1]	D-L>L-L [1]

[1] *U* = 0, *p* = .004 and [2] *U* = 4, *p* = .048.

20 Magazine trials. Groups D-D (N = 7), L-D (N = 7), D-L (N = 4), and L-L (N = 6) respectively emitted their first peck after a mean of 66.2, 63.1, 30.5, and 68.6 trials and their second peck after a mean of 161.0, 70.7, 32.3, and 72.1 trials. First peck data, being highly variable, revealed no significant between-group differences. Second peck comparisons showed that the D-L group pecked sooner than the L-D group (*U* = 4, *p* = .036). Acquisition criterion was reached after a mean of 421.8, 280.5, 35.7, and 86.3 trials for groups D-D, L-D, D-L, and L-L in that order. Planned comparisons revealed that groups D-L and L-L reached criterion sooner than the D-D (*Us* $\leq$ 3.5, *ps* $\leq$ .007) and L-D (*Us* $\leq$ 6, *ps* $\leq$ .017) groups.

Figure 3 shows the overall performance of these groups as indexed by mean TWP (top) and mean TCSP (bottom) as a function of consecutive autoshaping sessions. Although all groups autoshaped, visible performance differences between groups may be noted.

A blocking of sessions and between block comparisons revealed the following significant differences (Us $\leq$ 4, ps $\leq$ .048). In Block 1, as indexed by mean TWP, group D-L outperformed groups L-L, D-D, and L-D and group L-L performed better than groups D-D and L-D. In Block 2, group D-L ranked higher than groups L-L, L-D, and D-D; Group L-L responded on more trials than groups L-D and D-D and group L-D ranked higher than group D-D. This pattern of differences persisted in Block 3 (see Table 4).

Table 4

Between-Group Comparisons Based on Mean TWP for

Groups Administered 20 US-only Trials

Block 1	Block 2	Block 3
D-D=L-D	D-D<L-D [2]	D-D<L-D [1]
D-D<D-L [1]	D-D<D-L [1]	D-D<D-L [1]
D-D<L-L [3]	D-D<L-L [1]	D-D<L-L [1]
L-D<D-L [4]	L-D<D-L [1]	L-D<D-L [1]
L-D<L-L [5]	L-D<L-L [1]	L-D<L-L [1]
D-L>L-L [5]	D-L>L-L [1]	D-L>L-L [1]

[1] U = 0, p = .004, [2] U = 1, p = .008, [3] U = 2, p = .016, [4] U = 3, p = .028, and [5] U = 4, p = .048.

As indexed by mean TCSP, in Block 1 group D-L responded more than groups L-L, D-D, and L-D. Group L-L emitted more pecks than groups D-D and L-D. Block 2 revealed the same pattern of differences. In Block 3, the only change was that group L-D responded more than group D-D (see Table 5).

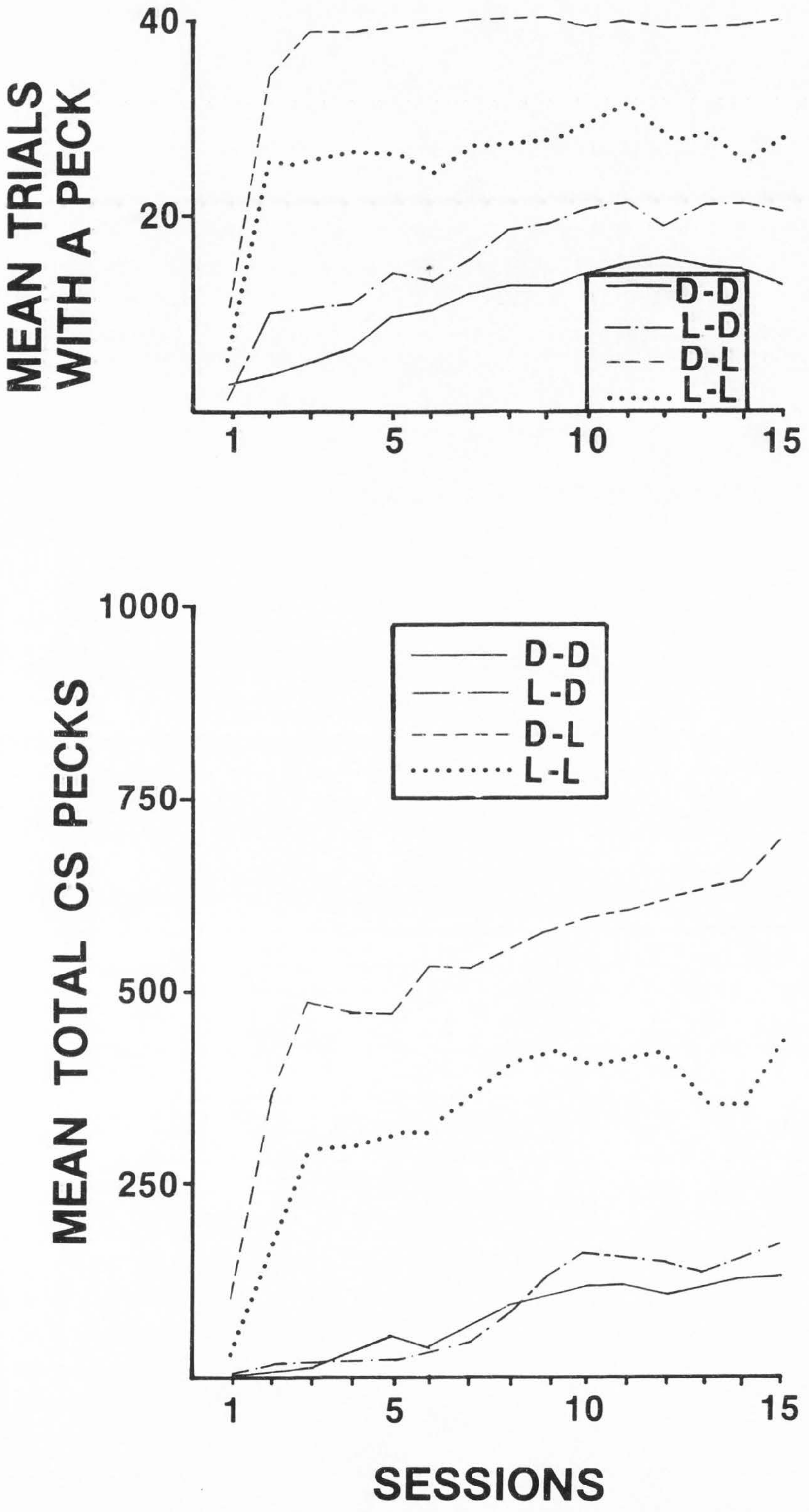


Figure 3. Mean trials with a peck (top) and mean total CS pecks (bottom) for all groups exposed to 20 US-only trials prior to autoshaping as a function of sessions.

Table 5

Between-Group Comparisons Based on Mean TCSP for

Groups Administered 20 US-only Trials

Block 1	Block 2	Block 3
D-D=L-D	D-D=L-D	D-D<L-D [1]
D-D<D-L [1]	D-D<D-L [1]	D-D<D-L [1]
D-D<L-L [2]	D-D<L-L [1]	D-D<L-L [1]
L-D<D-L [1]	L-D<D-L [1]	L-D<D-L [1]
L-D<L-L [1]	L-D<L-L [1]	L-D<L-L [1]
D-L>L-L [3]	D-L>L-L [1]	D-L>L-L [1]

[1] $U = 0$, $p = .004$, [2] $U = 2$, $p = .016$, and [3] $U = 4$, $p = .048$.

Although differences emerged in Block 1, it was Block 2 performance that clearly segregated these groups. As indexed by both metrics on the basis of terminal performance levels groups D-L, L-L, L-D, and D-D respectively may be ranked first, second, third, and fourth.

100 Magazine trials. (N = 4 for all groups.) Groups D-D, L-D, D-L, and L-L respectively emitted their first CS peck on mean trials 17.0, 5.7, 23.5, and 39.2. No significant between-group differences were noted. The second peck emerged after a mean of 26.0, 7.2, 26.5, and 48.7 trials for groups D-D, L-D, D-L, and L-L, in that order. Group L-D emitted its second peck sooner than groups D-D and L-L (Us = 0, ps = .014). Acquisition criterion was reached after 245.0, 20.7, 33.5, and 52.7 mean trials for groups D-D, L-D, D-L, and L-L respectively. This measure revealed no statistically significant group differences.

Figure 4 presents overall performance for these groups as indexed by mean TWP (top) and mean TCSP (bottom). Performance levels were high for all groups except group D-D. Again, between-group differences in performance are readily noted.

Blocking sessions revealed the following pattern of differences (Us $\leq$ 4, ps $\leq$ .048). As indexed by mean TWP in Block 1 groups D-L, L-D, and L-L pecked on more trials than group D-D. In Block 2, group L-L outperformed groups D-L, L-D, and D-D and group D-L performed better than groups L-D and D-D. Finally, group L-D responded on more trials than group D-D. The same pattern of differences existed in Block 3 (see Table 6).

In Block 1, as indexed by mean TCSP, groups L-L and D-L responded more than groups L-D and D-D, with L-D also outperforming D-D. In Block 2, group L-L pecked more than groups D-L, L-D, and D-D. Group D-L responded more than groups L-D and D-D and group L-D outperformed group D-D. The same pattern of differences was maintained in Block 3 (see Table 7).

Table 6

Between-Group Comparisons Based on Mean TWP for

Groups Administered 100 US-only Trials

Block 1	Block 2	Block 3
D-D<L-D [1]	D-D<L-D [3]	D-D<L-D [1]
D-D<D-L [1]	D-D<D-L [1]	D-D<D-L [1]
D-D<L-L [1]	D-D<L-L [1]	D-D<L-L [1]
L-D=D-L	L-D<D-L [1]	L-D<D-L [1]
L-D=L-L	L-D<L-L [1]	L-D<L-L [1]
D-L=L-L	D-L<L-L [2]	D-L<L-L [1]

[1] U = 0, p = .004, [2] U = .5, p = .005, and [3] U = 1, p = .008.

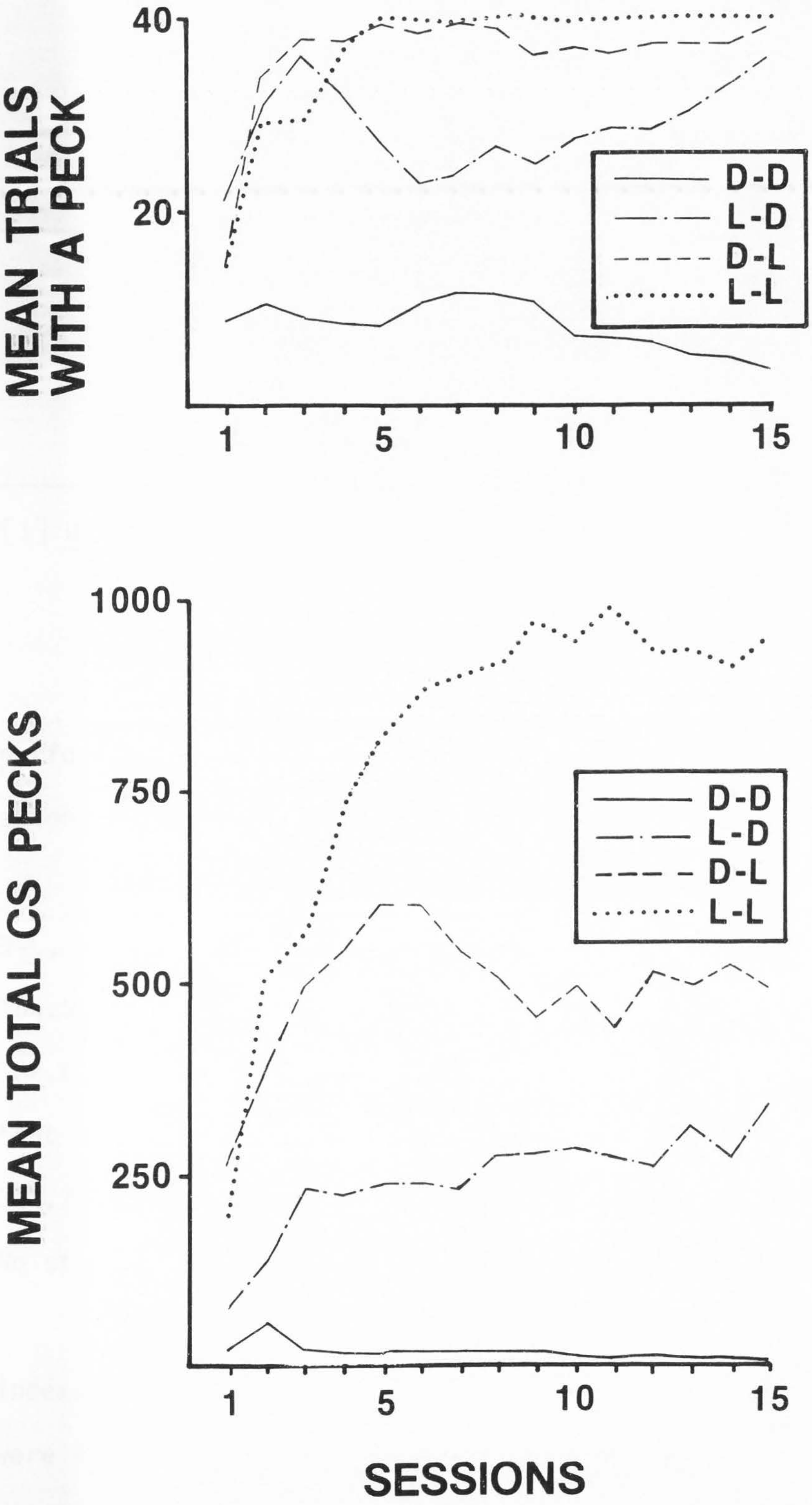


Figure 4. Mean trials with a peck (top) and mean total CS pecks (bottom) for all groups exposed to 100 US-only trials prior to autoshaping as a function of sessions.

Table 7

Between-Group Comparisons Based on Mean TCSP for Groups Administered 100 US-only Trials

Block 1	Block 2	Block 3
D-D<L-D [1]	D-D<L-D [1]	D-D<L-D [1]
D-D<D-L [1]	D-D<D-L [1]	D-D<D-L [1]
D-D<L-L [1]	D-D<L-L [1]	D-D<L-L [1]
L-D<D-L [1]	L-D<D-L [1]	L-D<D-L [1]
L-D<L-L [2]	L-D<L-L [1]	L-D<L-L [1]
D-L=L-L	D-L<L-L [1]	D-L<L-L [1]

[1] $\underline{U} = 0$, $\underline{p} = .004$, and [2] $\underline{U} = 3$, $\underline{p} = .028$.

Clear between-group differences emerged in Block 2 with both performance measures ranking groups L-L, D-L, L-D, and D-D first, second, third, and fourth.

900 Magazine trials. (N = 4 for all groups.) Groups D-D, L-D, D-L, and L-L respectively emitted their first CS peck on mean trials 155.5, 160.0, 34.7, and 51.0. The second peck emerged after 160.7, 162.0, 38.2, and 55.7 mean trials for groups D-D, L-D, D-L, and L-L, in that order. Acquisition criterion was reached on mean trials 303.5, 312.7, 48.7, and 181.0 for groups D-D, L-D, D-L, and L-L respectively. No statistically significant between-group differences were noted.

Figure 5 depicts mean overall performance of these groups as indexed by TWP (top) and TCSP (bottom). Although performance levels were not very high differences may be noted between groups autoshaped in the light and groups autoshaped in the dark.

Between block comparisons revealed the following pattern of between-group differences (Us $\leq$ 4, ps $\leq$ .048). As indexed by mean TWP, in Block 1 group D-L pecked on more trials than groups L-D and L-L. In Block 2, group D-L outperformed groups L-L, D-D, and L-D with group L-L also responding more than groups D-D and L-D. In Block 3, the same pattern of differences was maintained with the addition that group D-D now outperformed group L-D (see Table 8).

As measured by mean TCSP, in Block 1, group D-L responded more than groups L-L and L-D with groups D-D and L-L also outperforming

Table 8

Between-Group Comparisons Based on Mean TWP for

Groups Administered 900 US-only Trials

Block 1	Block 2	Block 3
D-D=L-D	D-D=L-D	D-D>L-D [1]
D-D=D-L	D-D<D-L [1]	D-D<D-L [1]
D-D=L-L	D-D<L-L [1]	D-D<L-L [1]
L-D<D-L [2]	L-D<D-L [1]	L-D<D-L [1]
L-D=L-L	L-D<L-L [1]	L-D<L-L [1]
D-L>L-L [2]	D-L>L-L [1]	D-L>L-L [1]

[1] U = 0, p = .004, and [2] U = 4, p = .048.

group L-D. In Block 2, groups D-L and D-D pecked more than groups L-L and L-D. Group L-L also responded more than group L-D. In Block 3, group D-L performed at a higher level than groups D-D, L-L, and L-D. Group D-D responded more than groups L-L and L-D and group L-L pecked more frequently than group L-D (see Table 9).

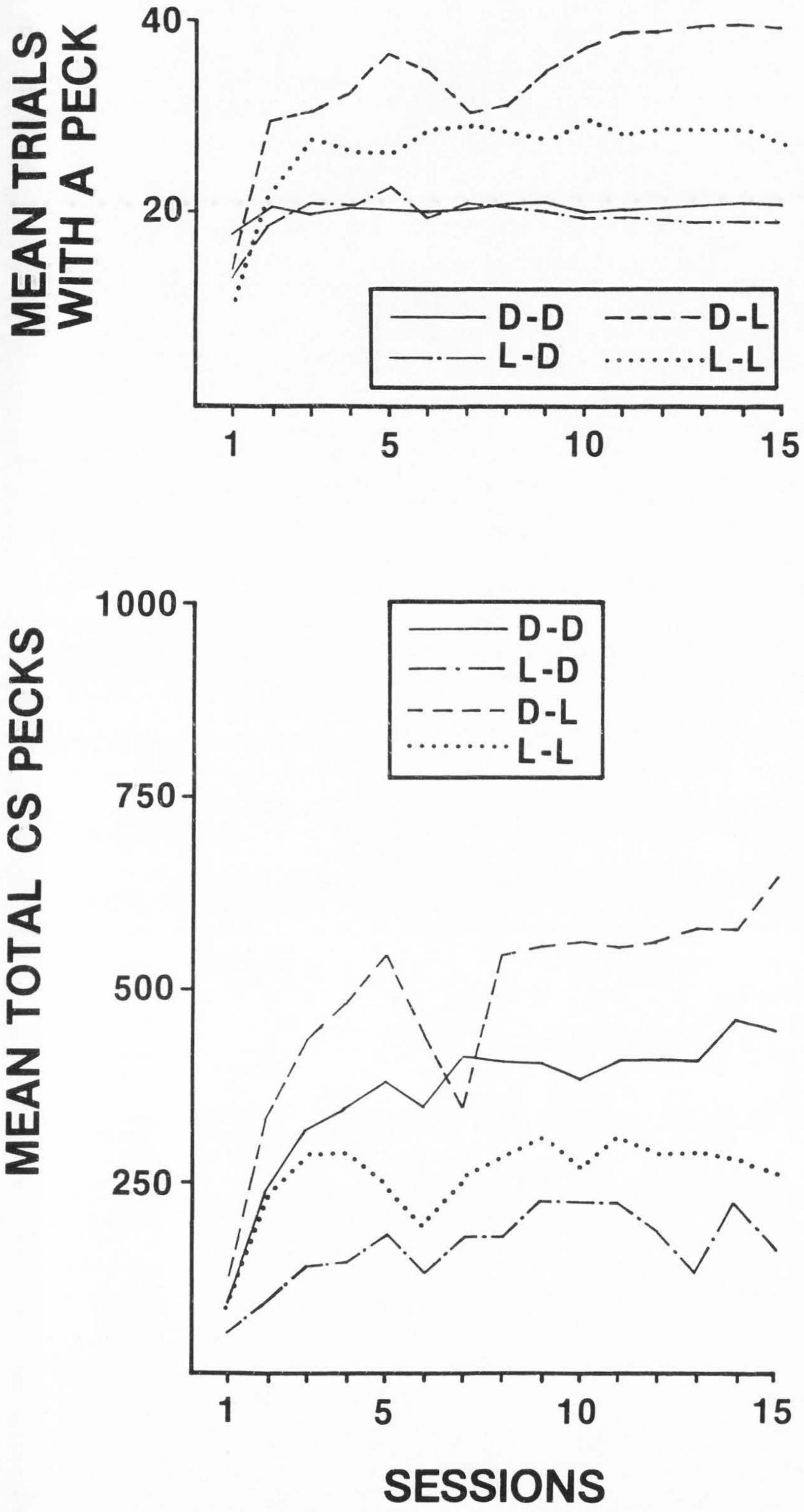


Figure 5. Mean trials with a peck (top) and mean total CS pecks (bottom) for all groups exposed to 900 US-only trials prior to autoshaping as a function of sessions.

In this case, both metrics did not rank the groups similarly in Block 3. The mean TWP metric assigns first, second, third, and fourth rank to groups D-L, L-L, D-D, and L-D respectively. However, the mean TCSP index ranks groups D-D second and group L-L third.

Table 9

Between-Group Comparisons Based on Mean TCSP for Groups Administered 900 US-only Trials

Block 1	Block 2	Block 3
D-D>L-D [4]	D-D>L-D [1]	D-D>L-D [1]
D-D=D-L	D-D=D-L	D-D<D-L [1]
D-D=L-L	D-D>L-L [1]	D-D>L-L [1]
L-D<D-L [3]	L-D<D-L [1]	L-D<D-L [1]
L-D<L-L [4]	L-D<L-L [2]	L-D<L-L [1]
D-L>L-L [3]	D-L>L-L [1]	D-L>L-L [1]

[1] $\underline{U} = 0$, $\underline{p} = .004$, [2] $\underline{U} = 2$, $\underline{p} = .016$, [3] $\underline{U} = 3$, $\underline{p} = .028$, and [4] $\underline{U} = 4$, $\underline{p} = .048$.

To assess the effects of varying the number of US-only trials on subsequent autoshaping, groups experiencing similar context conditions but different numbers of US-only trials may be compared. Visually, this may be done by examining Figures 2, 3, 4, and 5 which depict the performance of groups exposed to similar contexts but a varying number of US-only trials.

D-D groups. Groups experiencing dark contexts and exposed to 1, 20, 100, and 900 US-only trials respectively emitted their first CS peck on mean trials 28.2, 66.2, 14.0, and 155.5, and the second CS peck on mean trials 34.5, 161.0, 26.0, and 160.7. Acquisition criterion was reached after 103.7, 421.8, 245.0, and 303.5 mean trials for groups exposed to 1, 20, 100, and 900 US-only trials, in that order. The group exposed to 1 US-only trial achieved acquisition criterion sooner than the group given 20 US-only trials ($U = 3$, $p = .021$); all other comparisons were not significantly different.

Between-group comparisons of session blocks revealed the following pattern of differences ($Us = 4$, $ps \leq .048$). As indexed by mean TWP, in Block 1 groups given 1 and 900 US-only trials pecked on more trials than groups exposed to 20 or 100 US-only trials. Also, the 100 US-only group performed better than the 20 US-only group. In Block 2, the 1 US-only group outperformed all other groups. The group exposed to 900 US-only trials responded on more trials than groups administered 20 and 100 US-only trials. The 20 US-only group performed better than the 100 US-only group. Block 3 showed the same pattern of differences (see Table 10).

In Block 1, as measured by mean TCSP, 900 US-only trials resulted in more pecking than 1, 20, or 100 US-only trials. The 1 US-only group pecked more than the 20 US-only group. In Block 2, the only changes were that the 1 and 20 US-only groups now also responded more than the 100 US-only group. The only change in Block 3 was that the 1 and 20 US-only groups were equivalent (see Table 11).

This is another instance where the mean TWP and TCSP measures do not give similar group rankings. The mean TWP index ranks the 1, 900, 20, and 100 US-only groups first, second, third, and fourth respectively. However, the mean TCSP measure ranks the 900 US-only group first and both the 1 and 20 US-only groups second.

Table 10

Between-Group Comparisons Based on Mean TWP

for All D-D Groups

Block 1		Block 2		Block 3	
1>20	[2]	1>20	[1]	1>20	[1]
1>100	[2]	1>100	[1]	1>100	[1]
1=900		1>900	[1]	1>900	[1]
20<100	[1]	20>100	[2]	20>100	[1]
20<900	[1]	20<900	[1]	20<900	[1]
100<900	[1]	100<900	[1]	100<900	[1]

[1] _U_ = 0, _p_ = .004 and [2] _U_ = 4, _p_ = .048.

Table 11

Between-Group Comparisons Based on Mean TCSP

for All D-D Groups

Block 1		Block 2		Block 3	
1>20	[2]	1>20	[1]	1=20	
1=100		1>100	[1]	1>100	[1]
1<900	[2]	1<900	[1]	1<900	[1]
20=100		20>100	[1]	20>100	[1]
20<900	[1]	20<900	[1]	20<900	[1]
100<900	[1]	100<900	[1]	100<900	[1]

[1] _U_ = 0, _p_ = .004 and [2] _U_ = 4, _p_ = .048.

L-D groups. Groups experiencing these context conditions and exposed to 1, 20, 100, and 900 US-only trials emitted their first CS peck on mean trials 33.7, 63.1, 5.7, and 160.0 respectively. The second peck occurred on mean trials 40.2, 70.7, 7.2, and 162.0 for the

1, 20, 100, and 900 US-only groups, in that order. Finally, acquisition criterion was achieved on mean trials 194.0, 280.5, 20.7, and 312.7 respectively for the 1, 20, 100, and 900 US-only groups. The 100 US-only group emitted its first peck, second peck, and reached criterion sooner than the 20 US-only group ($\underline{U}s = 0$. $\underline{p}s = .003$). The 100 US-only group also emitted its second peck and reached criterion sooner than the 1 US-only group ($\underline{U}s \leq 1$, $\underline{p}s \leq .029$).

Between-block comparisons revealed the following differences as indexed by mean TWP ($\underline{U}s \leq 4$, $\underline{p}s \leq .048$). In Block 1, the 100 US-only group pecked on more trials than all other groups. The 1 and 900 US-only groups also responded on more trials than the 20 US-only group. In Block 2, both the 1 and 100 US-only groups outperformed the 900 and 20 US-only groups and the 900 US-only group ranked better than the 20 US-only group. The same pattern of differences was exhibited in Block 3 (see Table 12).

As indexed by the mean TCSP in Block 1 both the 100 and 900 US-only groups emitted more responses than the 1 US-only group. However, the 1, 100, and 900 US-only groups outperformed the 20 US-only group. In Block 2 the 100 US-only group pecked more frequently than all other groups and both the 1 and 900 US-only groups performed better than the 20 US-only group. The 100 US-only group performed best in Block 3 and the 1 US-only group pecked more than the 20 US-only group (see Table 13).

Table 12

Between-Group Comparisons Based on Mean TWP

for All L-D Groups

Block 1		Block 2		Block 3	
1>20	[5]	1>20	[1]	1>20	[1]
1<100	[2]	1=100		1=100	
1=900		1>900	[1]	1>900	[1]
20<100	[1]	20<100	[1]	20<100	[1]
20<900	[1]	20<900	[4]	20<900	[4]
100>900	[3]	100>900	[1]	100>900	[1]

[1] $\underline{U} = 0$, $\underline{p} = .004$, [2] $\underline{U} = 1$, $\underline{p} = .008$, [3] $\underline{U} = 1.5$, $\underline{p} = .008$, [4] $\underline{U} = 3$, $\underline{p} = .028$, and [5] $\underline{U} = 4$, $\underline{p} = .048$.

Table 13

Between-Group Comparisons Based on Mean TCSP

for All L-D Groups

Block 1		Block 2		Block 3	
1>20	[4]	1>20	[4]	1>20	[1]
1<100	[2]	1<100	[1]	1<100	[1]
1<900	[3]	1=900		1=900	
20<100		20<100	[1]	20<100	[1]
20<900		20<900	[2]	20=900	
100=900		100>900	[1]	100>900	[1]

[1] $\underline{U} = 0$, $\underline{p} = .004$, [2] $\underline{U} = 2$, $\underline{p} = .016$, [3] $\underline{U} = 3$, $\underline{p} = .028$, and [4] $\underline{U} = 4$, $\underline{p} = .048$.

As indexed by the mean TWP metric in Block 3 the 1 and 100 US-only groups ranked first with the 900 and 20 US-only groups ranking second and third respectively. The mean TCSP measure ranked the 100, 1, and 20 US-only groups first, second, and third, in that order. Since the 900 US-only group was indifferent from the 1 and 20 US-only groups, it would be ranked second or third.

D-L groups. The first CS peck emerged on mean trials 12.0, 30.5, 23.5, and 34.7 respectively for the 1, 20, 100, and 900 US-only groups. The 1 US-only group pecked sooner than the 20 US-only group ($U = 1$, $p = .029$). The 1, 20, 100, and 900 US-only groups respectively emitted their second peck on mean trials 25.2, 32.2, 26.5, and 38.2 and reached acquisition criterion on mean trials 46.7, 35.7, 33.5, and 48.7. Both the second peck and acquisition measures failed to reveal significant group differences.

Within block comparisons revealed the following differences as indexed by mean TWP (Us ≤ 4, ps $\leq .048$). Block 1 showed no between-group differences. In Block 2 both the 1 and 20 US-only groups pecked on more trials than the 100 and 900 US-only groups. The 100 US-only group also responded on more trials than the 900 US-only group. The only change in Block 3 was that the 900 US-only group now outperformed the 100 US-only group (see Table 14).

Table 14

Between-Group Comparisons Based on Mean TWP

for All D-L Groups

Block 1	Block 2	Block 3
1=20	1=20	1=20
1=100	1>100 [2]	1>100 [1]
1=900	1>900 [1]	1>900 [1]
20=100	20>100 [2]	20>100 [1]
20=900	20>900 [1]	20>900 [1]
100=900	100>900 [3]	100<900 [4]

[1] $U = 0$, $p = .004$, [2] $U = .5$, $p = .004$, [3] $U = 1$, $p = .008$, and [4] $U = 4$, $p = .048$.

The mean TCSP measure also failed to reveal any significant between-group differences in Block 1. In Block 2, the 1 US-only group responded more than all other groups. In Block 3, the 1 US-only group ranked first and the 20 US-only group outperformed the 900 and 100 US-only groups. The 900 US-only group also pecked more than the 100 US-only group (see Table 15).

In Block 3, the mean TWP measure ranked the 1 and 20 US-only groups first and the 900 and 100 US-only groups second and third, in that order. The mean TCSP measure ranked the 1, 20, 900 and 100 US-only groups first, second, third, and fourth respectively.

L-L groups. First and second CS pecks respectively emerged after a mean of 46.5, 68.6, 39.2, and 51.0 trials and 48.7, 72.1, 48.7, and 55.7 trials for the 1, 20, 100, and 900 US-only groups, in that order. The 1, 20, 100, and 900 US-only groups, respectively reached

Table 15

Between-Group Comparisons Based on Mean TCSP

for All D-L Groups

Block 1	Block 2	Block 3
1=20	1>20 [1]	1>20 [1]
1=100	1>100 [1]	1>100 [1]
1=900	1>900 [1]	1>900 [1]
20=100	20=100	20>100 [1]
20=900	20=900	20>900 [2]
100=900	100=900	100<900 [1]

[1] $\underline{U} = 0$, $\underline{p} = .004$, and [2] $\underline{U} = 4$, $\underline{p} = .048$.

acquisition criterion on mean trials 69.5, 86.3, 52.7, and 181.0. No statistically significant between-group differences were noted.

The following differences were noted with respect to the mean TWP measure ($\underline{U}s \leq 4$, $\underline{p}s \leq .048$). In Block 1, the 100 US-only group pecked on more trials than the 20 or 900 US-only groups. In Block 2, the 100 US-only group performed better than all other groups and the 1 US-only group responded on more trials than the 20 and 900 US-only groups. There were no changes in Block 3 (see Table 16).

The mean TCSP metric showed the 100 US-only group responding more than all other groups in Block 1. In Block 2, the 100 US-only group remained superior and the 1 US-only group pecked more than the 20 and 900 US-only groups. Also, the 20 US-only group outperformed the 900 US-only group. The same pattern of differences persisted in Block 3 (see Table 17).

Table 16

Between-Group Comparisons Based on Mean TWP

for All L-L Groups

Block 1		Block 2		Block 3	
1=20		1>20	[1]	1>20	[1]
1=100		1<100	[2]	1<100	[1]
1=900		1>900	[1]	1>900	[1]
20<100	[2]	20<100	[1]	20<100	[1]
20=900		20=900		20=900	
100>900	[2]	100>900	[1]	100>900	[1]

[1] _U_ = 0, _p_ = .004, and [2] _U_ = 4, _p_ = .048.

Table 17

Between-Group Comparisons Based on Mean TCSP

for All L-L Groups

Block 1		Block 2		Block 3	
1=20		1>20	[1]	1>20	[1]
1<100	[2]	1<100	[1]	1<100	[1]
1=900		1>900	[1]	1>900	[1]
20<100	[3]	20<100	[1]	20<100	[1]
20=900		20>900	[1]	20>900	[1]
100>900	[3]	100>900	[1]	100>900	[1]

[1] _U_ = 0, _p_ = .004, [2] _U_ = 3, _p_ = .028, and [3] _U_ = 4, _p_ = .048.

In the final block the mean TWP measure ranks the 100 and 1 US-only groups first and second respectively with the 20 and 900 US-only groups tied for third. However, the mean TCSP metric ranks the 100, 1, 20, and 900 US-only groups first, second, third, and fourth, in that order.

Discussion

The data may be best discussed within the framework of two general questions. First, for a given number of US-only trials how do the various light-dark magazine training and autoshaping contexts interact? Second, given the various light-dark context combinations in magazine training and autoshaping, what is the effect of systematically varying the number of US-only trials?

Regarding the first question, trials to first peck, second peck, and acquisition failed to reveal a consistent pattern of significant differences. Presumably, initial peck data are not sensitive to context interaction effects. However, overall responding, as measured by mean TWP and mean TCSP, was affected by context interactions. Because clear between-group differences were evidenced in Block 3 only group rankings in this block will be discussed. Figure 6 summarizes the Block 3 between-groups rank for the groups exposed to the various combinations of magazine training and autoshaping contexts and experiencing 1, 20, 100, or 900 US-only trials. A rank of 1 indicates best performance, based on systematic paried comparisons, with each rank being significantly different ($\underline{U}s \leq 4$, $\underline{p}s \leq .048$) from all other ranks. Figure 6 shows that both response measures ranked groups similarly and that groups autoshaped with the houselight on generally ranked higher than groups autoshaped in the dark. An exception is at 900 US-only trials where the D-D group performed better than the L-L group with respect to the mean TCSP.

That pigeons autoshaped with the houselight off parallels the findings of Oberdieck, Mueller, and Cheney (1977) and Oberdieck et al. (1979). The weight of the data seriously weakens Wasserman's (1973) contention that autoshaped keypecking will not emerge in a dark chamber (a radical interpretation of the cue localization hypothesis). However, the cue localization hypothesis may be interpreted in a modified way to accommodate the general superiority of autoshaping with the houselight on. In short, this interpretation states that autoshaping with the houselight on results in higher performance levels than with the houselight off because in the former case CS onset produces fewer redundant (reflections off the walls) contextual cues. However, autoshaping in the dark is not precluded.

Figure 6 also shows that between groups autoshaped in the dark the group magazine trained with the houselight on performed better at 1, 20, and 100 US-only trials. At 900 US-only trials, however, performance was best following magazine training in the dark. Between groups autoshaped with the houselight on performance was best following magazine training in the dark, except at 100 US-only trials when a reversal is noted. In spite of these exceptions, however, the data strongly implicate the importance of the magazine training context in determining subsequent autoshaping performance.

With respect to the second question, increasing the number of US-only trials had variable effects depending on the combination of magazine training and autoshaping contexts. Initial peck data was

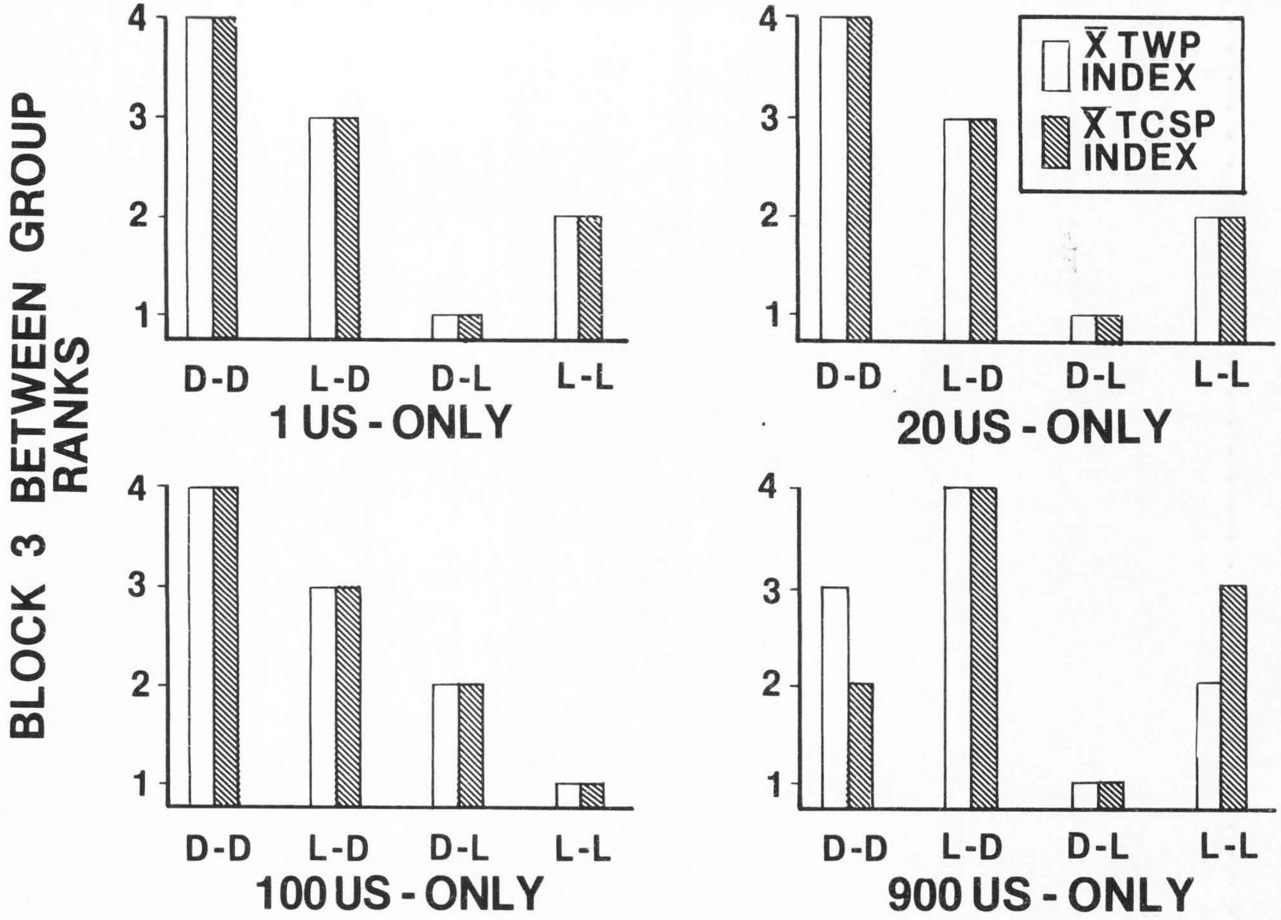


Figure 6. Block 3 between groups rank based on the mean trials with a peck and mean total CS pecks metrics for the various context combination groups exposed to 1, 20, 100, or 900 US-only trials prior to autoshaping. A rank of 1 signifies best relative performance and all ranks are significantly different (*Us* $\leq$ 4, *ps* $\leq$ .048) from all other ranks.

generally insensitive to varying the number of US-only trials given particular context combinations. However, overall performance levels were significantly affected by US-only trials. Figure 7 depicts Block 3 between-groups ranks for the various context combinations as a function of US-only trials. Although both the mean TWP and mean TCSP yield similar rankings discrepancies may be noted at 1 US-only trial for D-D and L-D groups and 900 US-only trials for L-L groups. Figure 7 reveals two general functions relating US-only trials and autoshaping performance. One, an inverted U-shaped function characteristic of the D-D and D-L contexts which shows a facilitating effect of few (1, 20) or many (900) US-only trials. The other function is biphasic, characteristic of the L-D and L-L context combinations, and shows performance to be best following 1 or 100 US-only trials. Balsam and Schwartz (1981), however, found that when the magazine training and autoshaping contexts were different four US-only trials accelerated acquisition and enhanced responding, as indexed by mean TWP and responses/second, relative to 64 US-only trials. Their findings are similar to the present data in that in both the L-D and D-L conditions overall performance, as measured by mean TWP and mean TCSP, was best following few US-only trials. However, they also found that if magazine training and autoshaping contexts were different, acquisition and maintained response measures were monotonically related to the number of US-only trials, that is, they found no biphasic function. This discrepancy is undoubtedly due to a variety of procedural differences. For instance, they employed ring doves, not pigeons, and the contexts they employed were a chamber lined with cardboard and the HL-on and a flat black chamber with the HL-on. Additionally, they habituated their subjects to the autoshaping context after feeder training but prior to autoshaping. The autoshaping context was therefore not novel which it was in the present study. In spite of the differences, however, Balsam and Schwartz (1981) underscore the importance of the magazine training and autoshaping contexts and their influence on performance.

The present data show that most of the existing literature relating number of US-only trials to autoshaping with the houselight on represents particular instances of these context combinations. For instance, Engberg et al. (1972) found that the trials to first peck were delayed significantly following 900 US-only trials. The present study found no delaying effect of 900 US-only trials on trials to first peck in any context. However, overall performance of the L-L group given 900 US-only trials was inferior relative to the L-L groups exposed to 1 or 100 US-only trials. Similarly, performance of the D-L group given 900 US-only trials was inferior to D-L groups administered 1 and 20 US-only trials (see Figure 7). Steinhauer et al. (1976) found that between 0 and 25 US-only trials the greater the number of US-only trials the fewer the number of trials to first peck. Neither the present study nor Downing et al. (1976) confirm that finding. In fact, the present study reveals overall performance levels to be typically higher following 1 US-only trial relative to 20 US-only trials, irrespective of magazine training and autoshaping contexts (see Figure 7). This parallels Balsam and Schwartz's (1981) finding that if magazine training and autoshaping contexts are similar 20 US-only trials retard acquisition relative to 2 US-only trials. Finally, Downing et al. (1976) found that subjects exposed to 100 US-only

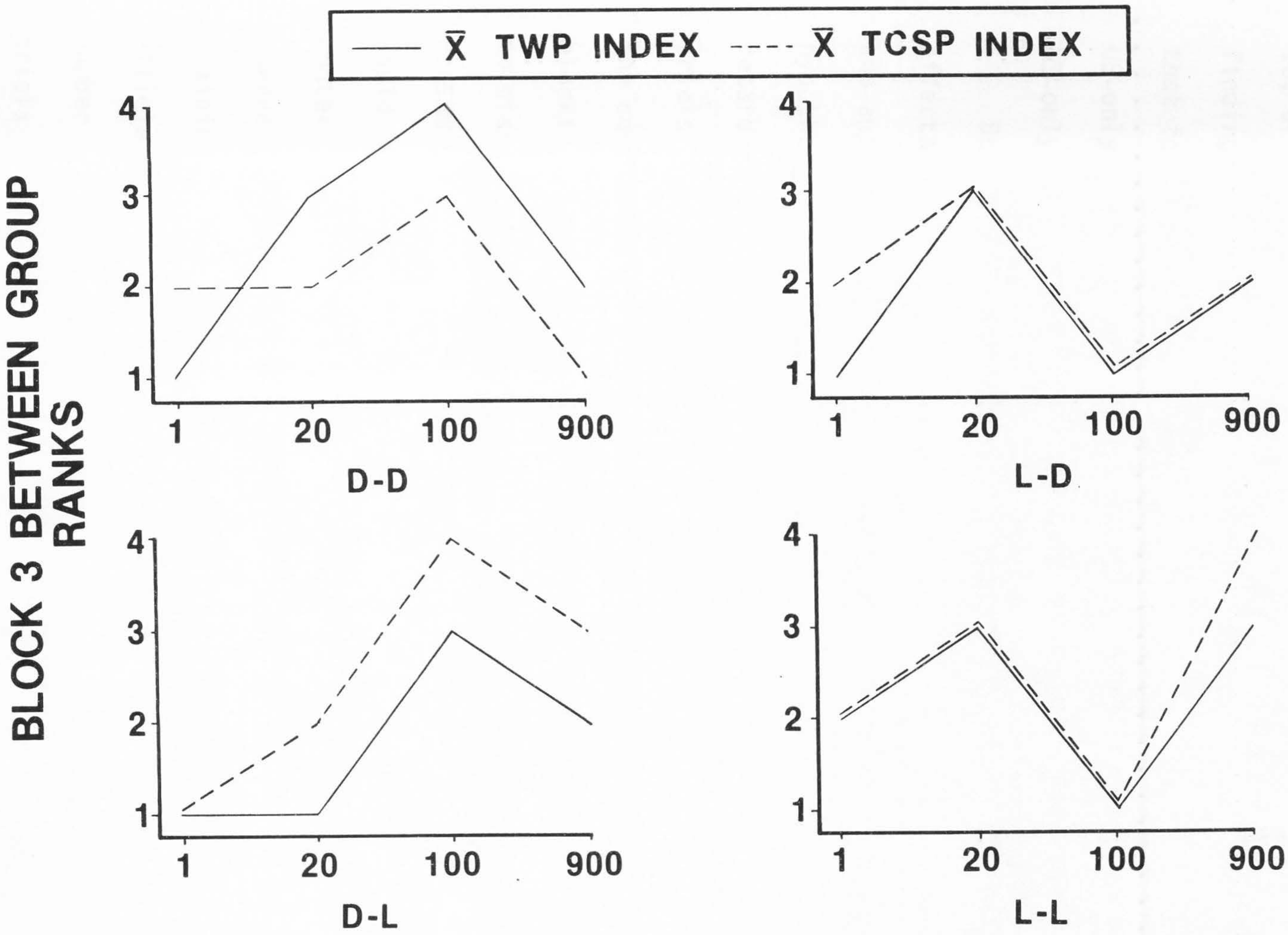


Figure 7. Block 3 between groups rank based on the mean trials with a peck and mean total CS pecks metrics for the groups exposed to various magazine training trials with the D-D, L-D, D-L, and L-L contexts held constant. A rank of 1 signifies best relative performance and all ranks are significantly different ($\underline{Us} \leq 4$, $\underline{ps} \leq .048$) from all other ranks.

trials emitted their first peck sooner than subjects administered 1, 10, or 1,000 US-only trials. The present study does not parallel this finding with respect to trials to first peck. However, it does show that for L-L context conditions overall performance following 100 US-only trials is better than performance following 1, 20, or 900 US-only trials (see Figure 7).

Because increasing the number of US-only trials had variable effects on subsequent autoshaping, depending on the magazine training and autoshaping contexts, the magazine training context blocking hypothesis is weakened. This hypothesis predicted an increasing retarding effect in the D-D and L-L groups as the number of US-only trials was increased. It was believed that increasing conditioning to the context, by increasing US-only trials, would enhance contextual blocking in autoshaping. However, the L-D and D-L groups were expected to display little change as the number of US-only trials increased. Presumably, increased conditioning to the magazine training context would have little or no blocking effect on autoshaping since the contextual cues were different. Neither prediction was borne out. However, the data revealed two important facts. First, the magazine training and autoshaping contexts are critical in determining efficiency of subsequent autoshaping performance, regardless of the number of US-only trials. That is, for a given number of US-only trials certain context combinations result in better overall performance (see Figure 6). Second, the function relating autoshaping performance to the number of US-only trials appears to be critically determined by the magazine training context (see Figure 7). This contention is derived from the finding that the functions relating performance to US-only trials are similar for the D-D and D-L groups and for the L-D and L-L contexts. Additionally, the particular contexts employed may critically determine performance (see Balsam & Schwartz, 1981).

CHAPTER VI

EXPERIMENT II

Introduction

Experiment I did not bear out all the predictions of the magazine training context blocking hypothesis. However, it was demonstrated that irrespective of the autoshaping context and number of US-only trials performance was best if magazine training and autoshaping occurred in different contexts. Presumably, at least some conditioning accrued to the magazine training context so that this context could have a proactive interfering effect on subsequent autoshaping. If contextual stimuli achieve their associative strength by Pavlovian conditioning, presentation of the US in a particular context, simple extinction should attenuate this effect. The interfering effect of the magazine training context should therefore be weakened by simply exposing the subjects to that context in the absence of US deliveries. Experiment II examined this prediction by extinguishing the magazine training context of D-D and L-L groups administered 900 US-only trials. Control groups were extinguished to a novel context.

Subjects

Sixteen experimentally naive feral pigeons maintained at approximately 75% of their free feeding weight served. Subjects were individually housed with water available in their home cages at all times.

Apparatus

The same as in Experiment I.

Procedure

Subjects were randomly divided into four groups of four. All groups were given 900 US-only trials as in Experiment 1. Two of the groups were magazine trained and autoshaped in the dark (D-D) and two in the light (L-L). Prior to autoshaping either the magazine training context or a novel context was extinguished. Extinction consisted of placing the subjects in the experimental chamber, in the appropriate context (D or L), for one hour per day for two consecutive days and withholding US deliveries. Experimental groups in which the magazine training context was extinguished experienced the following contexts, D-D-D, or L-L-L. Control groups experienced a novel context during extinction, D-L-D or L-D-L.

Magazine training, autoshaping, and data collection were similar to that of Experiment I.

Results

For all groups autoshaped keypecking was confined to the CS periods with occasional ITI pecks, mostly runover pecks. The group magazine trained, extinguished, and autoshaped in the dark (D-D-D) required 17.2, 20.0 and 171.0 mean trials respectively to emit the first CS peck, second CS peck, and to reach acquisition criterion (the same criterion was used as in Experiment I). The group extinguished to the houselight on context (D-L-D) emitted its first peck, second peck, and achieved acquisition criterion on mean trials 252.5, 277.5, and

370.2, in that order. Initial peck data failed to reveal any significant between-group differences.

Figure 8 presents the mean TWP (top) and TCSP (bottom) for all groups as a function of consecutive autoshaping sessions. A comparison of the D-D-D and D-L-D functions suggests that the former conditions resulted in higher performance levels. To assess differences consecutive five sessions were blocked and witin block comparisons made. As measured by both mean TWP and mean TCSP the D-D-D group outperformed group D-L-D in Blocks 1, 2, and 3 (Us $\leq$ 4, ps $\leq$ .048) (see Tables 18 and 19).

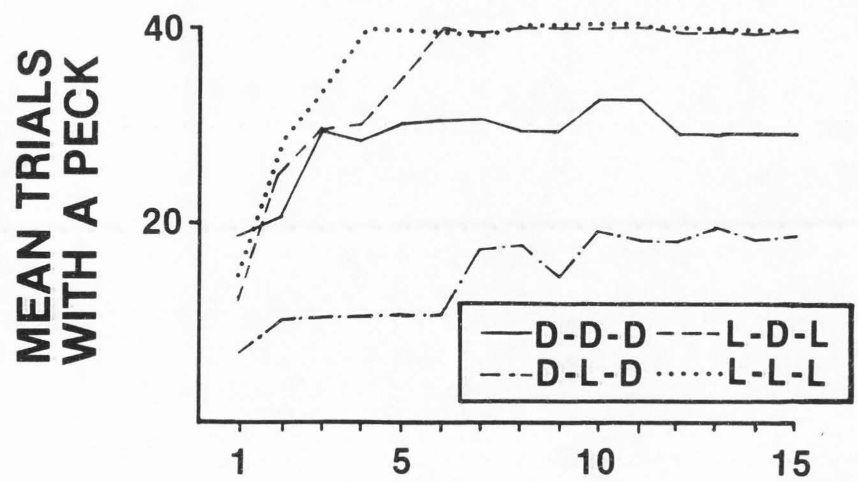
Table 18

Between-Group Comparisons Based on Mean TWP for the D-D-D Group Relative to All Dark Autoshaped Groups

Block 1	Block 2	Block 3
D-D-D>D-L-D [1]	D-D-D>D-L-D [1]	D-D-D>D-L-D [1]
D-D-D>D-D (900) [3]	D-D-D>D-D (900) [1]	D-D-D>D-D (900) [1]
D-D-D>D-D (100) [1]	D-D-D>D-D (100) [1]	D-D-D>D-D (100) [1]
D-D-D>D-D (20) [1]	D-D-D>D-D (20) [1]	D-D-D>D-D (20) [1]
D-D-D=D-D (1)	D-D-D<D-D (1) [1]	D-D-D>D-D (1) [1]
D-D-D=L-D (900)	D-D-D>L-D (900) [1]	D-D-D>L-D (900) [1]
D-D-D=L-D (100)	D-D-D>L-D (100) [1]	D-D-D=L-D (100)
D-D-D>L-D (20) [1]	D-D-D>L-D (20) [1]	D-D-D>L-D (20) [1]
D-D-D=L-D (1)	D-D-D>L-D (1) [1]	D-D-D>L-D (1) [2]

In Tables 18-25 numbers in parentheses indicate the number of magazine training trials received prior to autoshaping.

[1] U=0, p=.004, [2] U=2.5, p=.021, [3] U=4, p=.048.



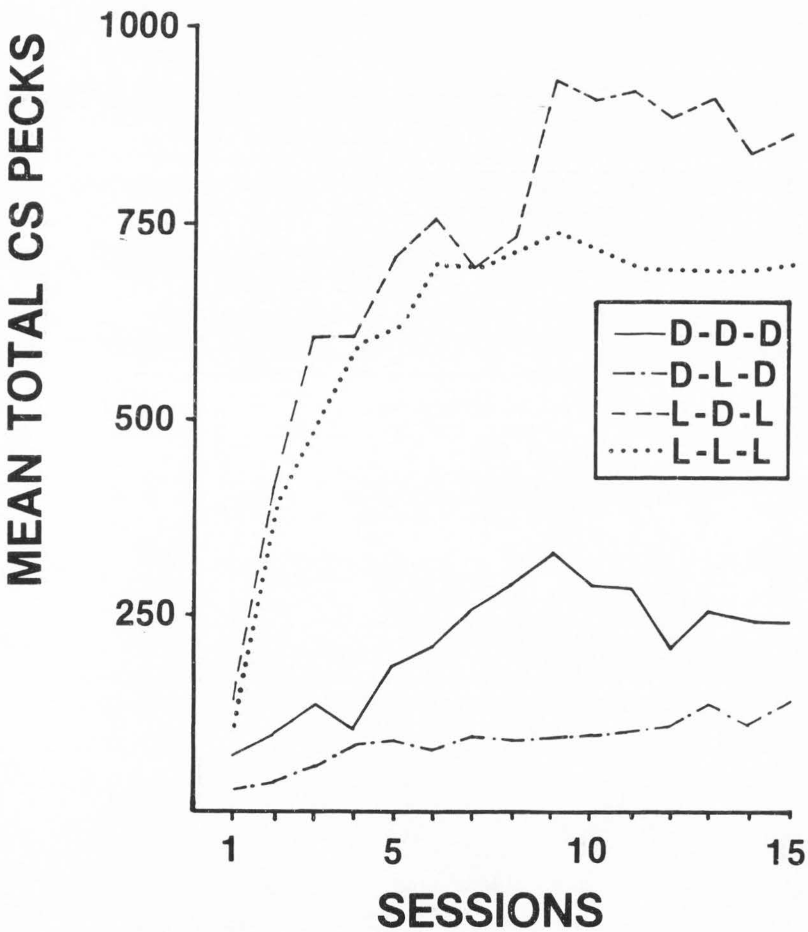


Figure 8. Mean trials with a peck (top) and mean total CS pecks (bottom) as a function of sessions for groups exposed to novel or familiar context extinction sessions in Experiment II.

Table 19

Between-Group Comparisons Based on Mean TCSP for the D-D-D Group Relative to all Dark Autoshaped Groups

Block 1		Block 2		Block 3	
D-D-D>D-L-D	[3]	D-D-D>D-L-D	[1]	D-D-D>D-L-D	[1]
D-D-D<D-D (900)	[4]	D-D-D<D-D (900)	[1]	D-D-D<D-D (900)	[1]
D-D-D>D-D (100)	[1]	D-D-D>D-D (100)	[1]	D-D-D>D-D (100)	[1]
D-D-D>D-D (20)	[1]	D-D-D>D-D (20)	[1]	D-D-D>D-D (20)	[1]
D-D-D=D-D (1)		D-D-D=D-D (1)		D-D-D>D-D (1)	[1]
D-D-D=L-D (900)		D-D-D>L-D (900)	[3]	D-D-D>L-D (900)	[2]
D-D-D=L-D (100)		D-D-D=L-D (100)		D-D-D<L-D (100)	[4]
D-D-D>L-D (20)	[1]	D-D-D>L-D (20)	[1]	D-D-D>L-D (20)	[1]
D-D-D>L-D (1)	[4]	D-D-D>L-D (1)	[1]	D-D-D>L-D (1)	[3]

[1] U=0, p=.004, [2] U=1, p=.008, [3] U=2, p=.016 and [4] U=3, p=.028.

To assess the general effects of extinction to the D or L context prior to autoshaping in the dark the D-D-D and D-L-D groups may be compared to all D-D and L-D groups of Experiment I. However, since Experiment I demonstrated clear group differences in Block 3 only terminal block comparison revealing statistically significant differences will be focused on, although Tables 18-27 contain all block comparisons.

Initial peck data failed to uniformly differentiate the D-D-D group from D-D and L-D groups exposed to 1, 20, 100, or 900 US-only trials. In Block 3, as indexed by mean TWP, the D-D-D group outperformed all the D-D groups (for all significant differences $Us \leq 4$, $ps \leq .048$, see Table 18). As indexed by mean TCSP, the D-D-D group ranked below the D-D 900 group but above the D-D 1, 20, and 100 groups (see Table 19). Relative to the L-D groups, and as ordered by mean

TWP, group D-D-D was equivalent to the L-D 100 group and superior to all other L-D groups (see Table 18). The mean TCSP metric ranked the L-D 100 group higher than the D-D-D group although the latter outperformed all other L-D groups (see Table 19).

The D-L-D group could not be statistically distinguished from the D-D and L-D groups of Experiment I by initial peck measures. As indexed by mean TWP, the D-L-D group ranked below the D-D 1 and 900 groups but above the D-D 20 and 100 groups, (for all significant differences $\underline{U}s \leq 4$, $\underline{p}s \leq .048$, see Table 20). The mean TCSP measure, revealed that the D-L-D group responded less than the D-D 900 group, more than the D-D 100 group, and was equivalent to the D-D 1 and 20 groups (see Table 21). Relative to L-D groups, and as indexed by mean TWP, the D-L-D group was equivalent to the L-D 900 group and inferior to all other L-D groups (see Table 20). As indexed by mean TCSP, the D-L-D group ranked below all L-D groups (see Table 21).

Figure 9 presents the between-groups ranks determined in Block 3 by paired comparisons of the mean TWP and mean TCSP measures. Figure 9 (top) depicts the ranks between D-D-D, D-L-D, and all D-D groups of Experiment 1. The ranks between D-D-D, D-L-D, and all L-D groups are presented at the bottom of Figure 9. The asterisk by the D-D-D and D-L-D groups for the mean TWP index (Figure 9, bottom) indicates a conservative rank for these groups. Group D-D-D ranked lower than group L-D 1 but equal to group L-D 100. But since L-D 1 and L-D 100 were indistinguishable group D-D-D was ranked below them. Similarly, group D-L-D was given the lowest rank although it performed equal to L-D 900 but below L-D 20.

Table 20

Between-Group Comparisons Based on Mean TWP for the D-L-D Group Relative to All Dark Autoshaped Groups

Block 1	Block 2	Block 3
D-L-D<D-D (900) [1]	D-L-D<D-D (900) [1]	D-L-D<D-D (900) [1]
D-L-D=D-D (100)	D-L-D>D-D (100) [4]	D-L-D>D-D (100) [1]
D-L-D>D-D (20) [3]	D-L-D>D-D (20) [4]	D-L-D>D-D (20) [1]
D-L-D=D-D (1)	D-L-D<D-D (1) [1]	D-L-D<D-D (1) [1]
D-L-D<L-D (900) [1]	D-L-D<L-D (900) [1]	D-L-D=L-D (900)
D-L-D<L-D (100) [1]	D-L-D<L-D (100) [1]	D-L-D<L-D (100) [1]
D-L-D=L-D (20)	D-L-D=L-D (20)	D-L-D<L-D (20) [2]
D-L-D=L-D (1)	D-L-D<L-D (1) [1]	D-L-D<L-D (1) [1]

[1] $U=0$, $p=.004$, [2] $U=1$, $p=.008$, [3] $U=2$, $p=.016$ and [4] $U=4$, $p=.048$.

The group experiencing light on conditions (L-L-L) emitted the first CS peck, second peck, and reached acquistion criterion respectively on mean trials 39.2, 41.7, and 47.7. The group extinguished to the novel context (L-D-L) required 46.8, 67.0, and 72.0 mean trials, in that order, to emit the first peck, second peck, and achieve criterion. These initial performance measures did not differ statistically between groups. Figure 8 plots the mean TWP (top) and mean TCSP (bottom) for both groups as a function of successive autoshaping sessions. Groups do not appear to differ with respect to the former measure with both groups achieving high levels of responding. Comparisons of five session blocks failed to reveal any significant group differences in Blocks 1, 2, or 3 as indexed by mean TWP (see Table 22). The TCSP metric, however, indicates higher rates of keypecking for the L-D-L group. Between block comparisons revealed

Table 21

Between-Group Comparisons Based on Mean TCSP for the D-L-D Group Relative to All Dark Autoshaped Groups

Block 1	Block 2	Block 3
D-L-D<D-D (900) [1]	D-L-D<D-D (900) [1]	D-L-D<D-D (900) [1]
D-L-D>D-D (100) [2]	D-L-D>D-D (100) [1]	D-L-D>D-D (100) [1]
D-L-D>D-D (20) [3]	D-L-D=D-D (20)	D-L-D=D-D (20)
D-L-D=D-D (1)	D-L-D<D-D (1) [1]	D-L-D=D-D (1)
D-L-D<L-D (900) [3]	D-L-D<L-D (900) [1]	D-L-D<L-D (900) [1]
D-L-D<L-D (100) [2]	D-L-D<L-D (100) [1]	D-L-D<L-D (100) [1]
D-L-D>L-D (20) [1]	D-L-D=L-D (20)	D-L-D<L-D (20) [1]
D-L-D=L-D (1)	D-L-D<L-D (1) [1]	D-L-D<L-D (1) [1]

[1] *U*=0, *p*=.004, [2] *U*=2, *p*=.016, and [3] *U*=3, *p*=.028.

Table 22

Between-Group Comparisons Based on Mean TWP for the L-L-L Group Relative to All Light Autoshaped Groups

Block 1	Block 2	Block 3
L-L-L=L-D-L	L-L-L=L-D-L	L-L-L=L-D-L
L-L-L>L-L (900) [3]	L-L-L>L-L (900) [1]	L-L-L>L-L (900) [1]
L-L-L=L-L (100)	L-L-L=L-L (100)	L-L-L=L-L (100)
L-L-L>L-L (20) [3]	L-L-L>L-L (20) [1]	L-L-L>L-L (20) [1]
L-L-L=L-L (1)	L-L-L=L-L (1)	L-L-L>L-L (1) [1]
L-L-L=D-L (900)	L-L-L>D-L (900) [1]	L-L-L>D-L (900) [1]
L-L-L=D-L (100)	L-L-L>D-L (100) [2]	L-L-L>D-L (100) [1]
L-L-L=D-L (20)	L-L-L=D-L (20)	L-L-L=D-L (20)
L-L-L=D-L (1)	L-L-L=D-L (1)	L-L-L=D-L (1)

[1] *U*=0, *p*=.004, [2] *U*=1, *p*=.008, and [3] *U*=4, *p*=.048.

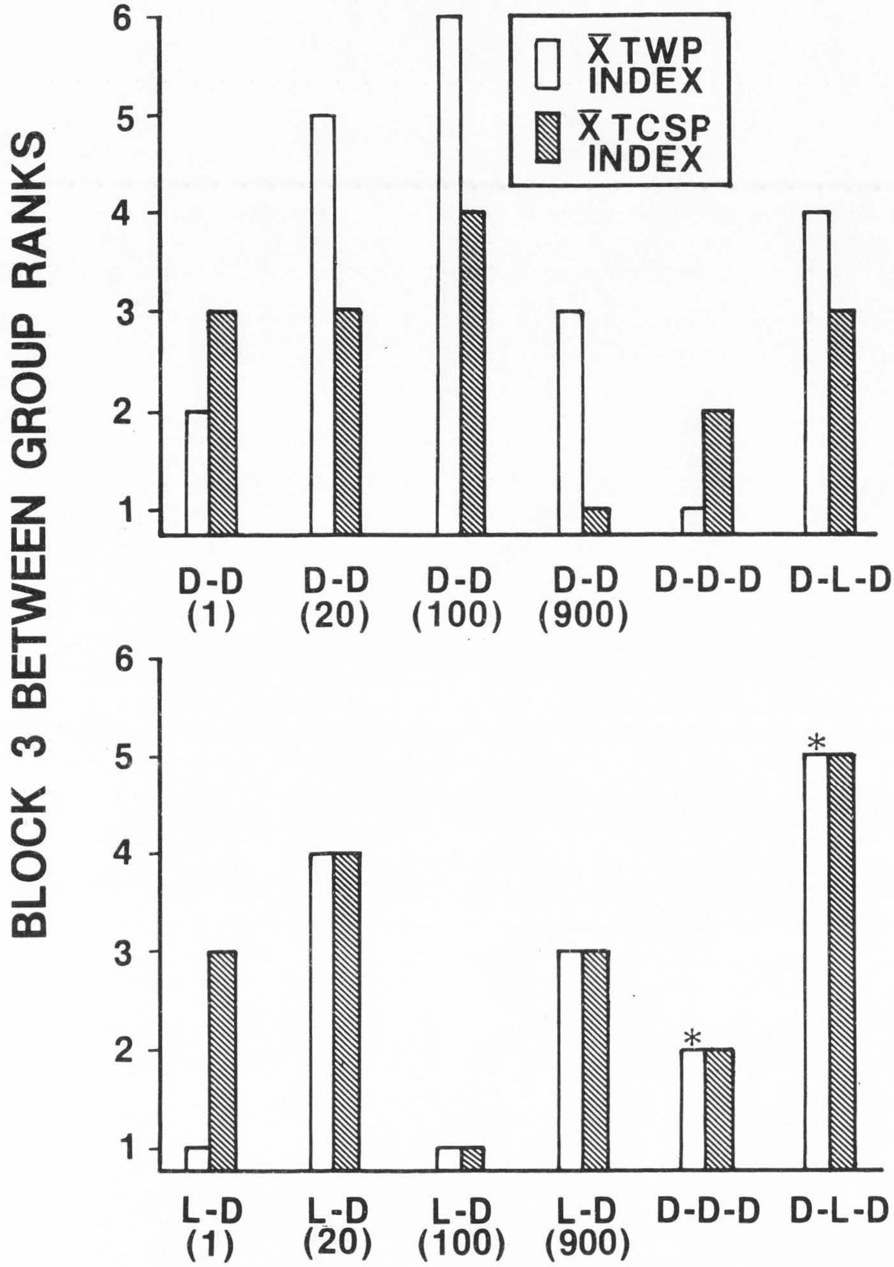


Figure 9. Block 3 between group ranks based on mean trials with a peck and mean total CS pecks for the D-D-D and D-L-D groups relative to the D-D groups (top) and L-D groups (bottom) of Experiment 1. Numbers in parentheses indicate the number of magazine training trials received. A rank of 1 signifies best relative performance and all ranks are significantly different ($Us \leq 4$, $ps \leq .048$) from all other ranks. An asterisk indicates a conservative, or lower, rank for groups that could have been assigned one of two ranks according to the $\bar{X}$ TWP metric. See text for additional information.

indifference in Block 1 and higher response levels for the L-D-L group in Blocks 2 and 3 (Us$\leq$4, ps=.048; see Table 23).

To assess the general effects of extinction to the magazine training context or a novel context on subsequent autoshaping with the houselight on the L-L-L and L-D-L groups were compared to the L-L and D-L groups of Experiment 1.

Initial peck measures revealed no significant differences between the L-L-L group and L-L or D-L groups exposed to 1, 20, 100, or 900 US-only trials. In Block 3, as indexed by mean TWP, the L-L-L group was equivalent to the L-L 100 group but superior to the L-L 900, 20,

Table 23

Between-Group Comparisons Based on Mean TCSP for the L-L-L Group Relative to All Light Autoshaped Groups

Block 1		Block 2		Block 3	
L-L-L=L-D-L		L-L-L<L-D-L	[2]	L-L-L<L-D-L	[1]
L-L-L>L-L (900)	[2]	L-L-L>L-L (900)	[1]	L-L-L>L-L (900)	[1]
L-L-L=L-L (100)		L-L-L<L-L (100)	[1]	L-L-L<L-L (100)	[1]
L-L-L>L-L (20)	[2]	L-L-L>L-L (20)	[1]	L-L-L>L-L (20)	[1]
L-L-L=L-L (1)		L-L-L>L-L (1)	[1]	L-L-L>L-L (1)	[1]
L-L-L=D-L (900)		L-L-L>D-L (900)	[1]	L-L-L>D-L (900)	[1]
L-L-L=D-L (100)		L-L-L>D-L (100)	[1]	L-L-L>D-L (100)	[1]
L-L-L=D-L (20)		L-L-L>D-L (20)	[1]	L-L-L>D-L (20)	[2]
L-L-L=D-L (1)		L-L-L<D-L (1)	[1]	L-L-L<D-L (1)	[1]

[1] U=0, p=.004, and [2] U=4, p=.048.

and 1 groups (Us$\leq$4, ps$\leq$.048 for all significant differences, see Table 22). The mean TCSP measure showed group L-L-L responding significantly less than the L-L 100 group but more than all other L-L groups (see

Table 23). Relative to D-L groups, group L-L-L, as measured by mean TWP, was indifferent from the D-L 20 and 1 groups but superior to the D-L 900 and 100 groups (see Table 22). The mean TCSP metric, showed that the L-L-L group responded significantly less than the D-L 1 group but significantly more than the D-L 900, 100, and 20 groups (see Table 23).

On the basis of initial peck data the L-D-L group could not be distinguished from the L-L or D-L groups exposed to 1, 20, 100, or 900 US-only trials. However, Block 3 performance was significantly different in many instances ($\underline{U}s \leq 4$, $\underline{p}s \leq .048$ for differences noted). As indexed by mean TWP, group L-D-L was not different from the L-L 100 group but was superior to the L-L 900, 20 and 1 groups (see Table 24). The mean TCSP measure showed the L-D-L group to be inferior to the L-L 100 group but superior to the L-L 900, 20, and 1 groups (see Table

Table 24

Between-Group Comparisons Based on Mean TWP for the L-D-L Group Relative to All Light Autoshaped Groups

Block 1	Block 2	Block 3
L-D-L=L-L (900)	L-D-L>L-L (900) [1]	L-D-L>L-L (900) [1]
L-D-L=L-L (100)	L-D-L=L-L (100)	L-D-L=L-L (100)
L-D-L=L-L (20)	L-D-L>L-L (20) [1]	L-D-L>L-L (20) [1]
L-D-L=L-L (1)	L-D-L>L-L (1) [2]	L-D-L>L-L (1) [1]
L-D-L=D-L (900)	L-D-L>D-L (900) [1]	L-D-L>D-L (900) [1]
L-D-L=D-L (100)	L-D-L>D-L (100) [1]	L-D-L>D-L (100) [1]
L-D-L=D-L (20)	L-D-L=D-L (20)	L-D-L=D-L (20)
L-D-L=D-L (1)	L-D-L=D-L (1)	L-D-L=D-L (1)

[1] $\underline{U}=0$, $\underline{p}=.004$, and [2] $\underline{U}=3$, $\underline{p}=.028$.

25). Relative to D-L Groups, the L-D-L group responded on more trials than the D-L 900 and 100 groups but was similar to the D-L 1 and 20 groups (see Table 24). As measured by mean TCSP the L-D-L group was similar to the D-L 1 group but outperformed the D-L 900, 100, and 20 groups (see Table 25).

Table 25

Between-Group Comparisons Based on Mean TCSP for the L-D-L Group Relative to All Light Autoshaped Groups

Block 1	Block 2	Block 3
L-D-L>L-L (900) [3]	L-D-L>L-L (900) [1]	L-D-L>L-L (900) [1]
L-D-L=L-L (100)	L-D-L=L-L (100)	L-D-L<L-L (100) [2]
L-D-L>L-L (20) [3]	L-D-L>L-L (20) [1]	L-D-L>L-L (20) [1]
L-D-L=L-L (1)	L-D-L>L-L (1) [1]	L-D-L>L-L (1) [1]
L-D-L=D-L (900)	L-D-L>D-L (900) [1]	L-D-L>D-L (900) [1]
L-D-L=D-L (100)	L-D-L>D-L (100) [1]	L-D-L>D-L (100) [1]
L-D-L=D-L (20)	L-D-L>D-L (20) [1]	L-D-L>D-L (20) [1]
L-D-L=D-L (1)	L-D-L=D-L (1)	L-D-L=D-L (1)

[1] U=0, p=.004, [2] U=1, p=.008, and [3] U=4, p=.048.

Figure 10 summarizes the L-L-L and L-D-L groups ranking relative to all L-L groups (top) and D-L groups (bottom) based on Block 3 performance.

Initial peck data failed to differentiate the L-L-L group from either the D-D-D or D-L-D groups. However, the L-L-L group did respond on significantly more trials than the D-D-D group in Blocks 2 and 3 and emitted significantly more responses in Blocks 1, 2, and 3 (see Tables

26, 27). Group L-L-L also outperformed group D-L-D, with respect to both the TWP and TCSP metrics, in Blocks 1, 2, and 3 (see Tables 26, 27). There were no statistically significant differences in the initial peck data between the L-D-L group and either the D-D-D or D-L-D groups. The L-D-L group did, however, respond on more trials than the D-D-D group in Blocks 2 and 3 and emitted more keypecks in Blocks 1, 2,

Table 26

Between-Group Comparisons Based on Mean TWP

for All Experiment II Groups

Block 1	Block 2	Block 3
L-L-L=D-D-D	L-L-L>D-D-D [1]	L-L-L>D-D-D [1]
L-L-L>D-L-D [1]	L-L-L>D-L-D [1]	L-L-L>D-L-D [1]
L-D-L=D-D-D	L-D-L>D-D-D [1]	L-D-L>D-D-D [1]
L-D-L>D-L-D [1]	L-D-L>D-L-D [1]	L-D-L>D-L-D [1]

[1] _U_=o, _p_=.004.

Table 27

Between-Group Comparisons Based on Mean TCSP

for All Experiment II Groups

Block 1	Block 2	Block 3
L-L-L>D-D-D [3]	L-L-L>D-D-D [1]	L-L-L>D-D-D [1]
L-L-L>D-L-D [1]	L-L-L>D-L-D [1]	L-L-L>D-L-D [1]
L-D-L>D-D-D [2]	L-D-L>D-D-D [1]	L-D-L>D-D-D [1]
L-D-L>D-L-D [1]	L-D-L>D-L-D [1]	L-D-L>D-L-D [1]

[1] _U_=o, _p_=.004, [2] _U_=1, _p_=.008, and [3] _U_=2, _p_=.016.

and 3 (see Tables 26, 27). Relative to the D-L-D group, group L-D-L responded on significantly more trials in Blocks 1, 2, and 3 and emitted more keypecks in Blocks 1, 2, and 3 (see Tables 26, 27). In short, autoshaping with the houselight on following novel (L-D-L) or familiar (L-L-L) context extinction is superior, in terms of overall performance levels, to autoshaping in the dark following novel (D-L-D) or familiar (D-D-D) context extinction.

Discussion

As in Experiment I, initial peck data failed to differentiate between groups and autoshaping with the houselight on was superior to autoshaping in the dark. Overall performance measures, however, revealed an unexpected pattern of significant differences in Block 3.

When magazine training and autoshaping occurred in the dark, extinction of the dark magazine training context (group D-D-D) resulted in higher performance levels, as indexed by mean TWP and TCSP, than a group extinguished to a novel context (D-L-D). In general, group D-D-D also performed better than most other D-D and L-D groups which experienced fewer magazine training trials. However, the D-L-D group performed at an intermediate level relative to the D-D groups of Experiment I and was outperformed by nearly all L-D groups. More specifically, the D-D-D group outperformed the D-D 900 group with respect to mean TWP. However, the latter group ranked higher with regard to mean TCSP. On the other hand, the D-L-D group ranked below the D-D 900 group with respect to both measures. In short, extinction of the dark magazine training context has a facilitating effect on autoshaping in the dark; but extinction of a novel context (houselight on) has a highly disruptive effect on autoshaping in the dark.

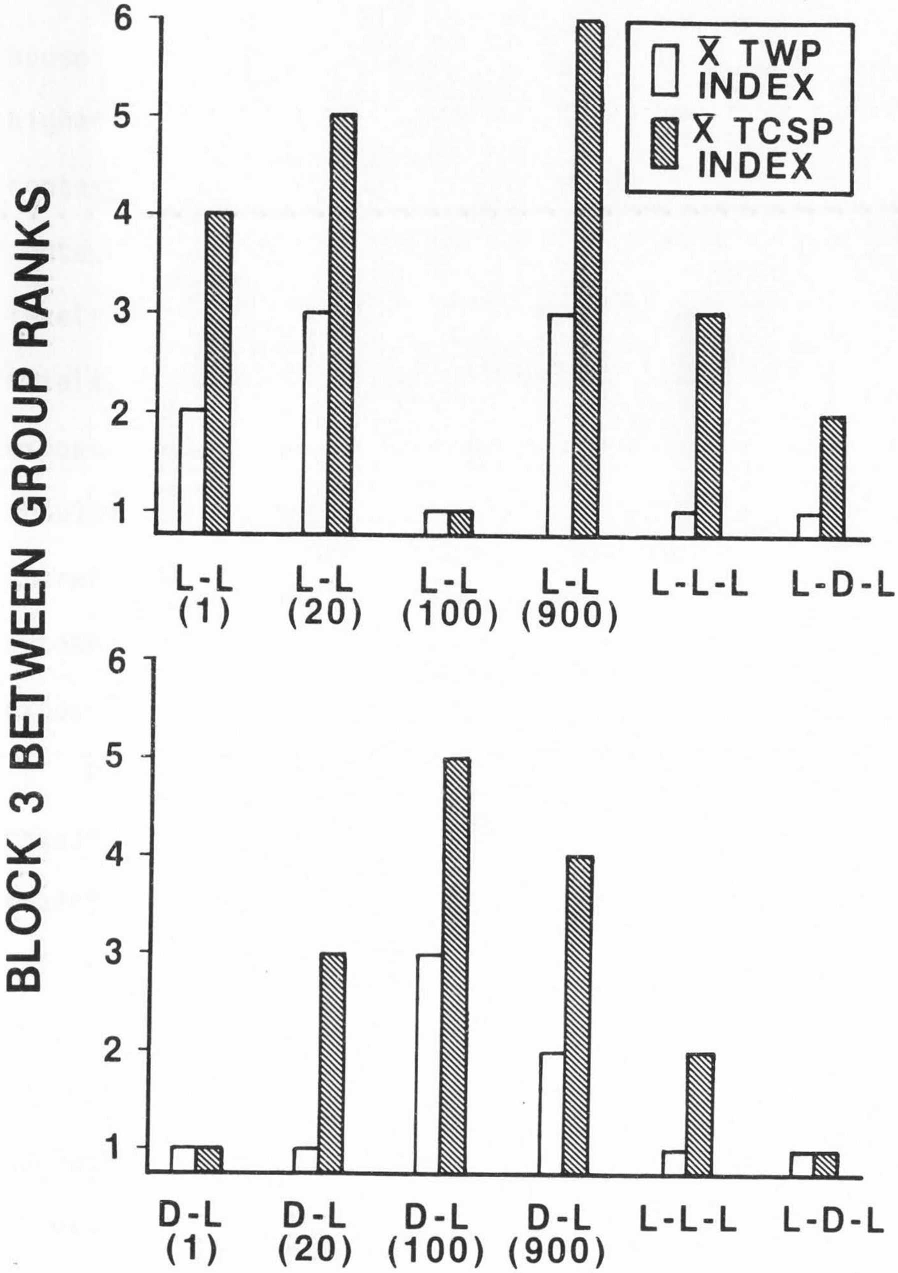


Figure 10. Block 3 between group rank based on mean trials with a peck and mean total CS pecks for the L-L-L and L-D-L groups relative to the L-L groups (top) and D-L groups (bottom) of Experiment 1. Numbers in parentheses indicate the number of magazine training trials received. A rank of 1 signifies best relative performance and all ranks are significantly different ($\underline{U}s \leq 4$, $\underline{p}s \leq .048$) from all other ranks. An asterisk indicates a conservative, or lower, rank for groups that could have been assigned one of two ranks.

When both magazine training and autoshaping occur with the houselight on exposure to a novel context (group L-D-L) results in a higher rate of pecking than extinction to the light on magazine trainng context (group L-L-L). Generally, extinction of the magazine training context (L-L-L) or novel context (L-D-L) results in higher performance levels than L-L or D-L groups which received fewer magazine training trials. Relative to the L-L and D-L 900 groups of Experiment I simple exposure to either the magazine training context or a novel context resulted in better performance, as indexed by mean TWP and TCSP. Therefore, following magazine training with the houselight on autoshaping with the houselight on may be facilitated by nonreinforced exposure to either the magazine training context or a novel context.

Recall that Kamin's (1969) blocking hypothesis, as applied to the magazine training context, predicted that extinction of the magazine training context would reduce or eliminate the proactively interfering effect of this context on autoshaping. The fact that the D-D-D group outperformed the D-D 900 group, as indexed by mean TWP, and the L-L-L group performed significantly better than the L-L 900 group, as indexed by both mean TWP and TCSP, supports the blocking hypothesis. Although no explicit predictions were made regarding the control groups simply exposed to a novel context, it was presumed that this treatment would have little if any effect on subsequent autoshaping. The finding that novel context exposure had detrimental effects on dark magazine training and autoshaping but a facilitating effect on magazine training and autoshaping with the houselight on is problematic for the context-blocking hypothesis. However, the magazine training and autoshaping contexts are clearly critical in the emergence of autoshaped keypecking. Moreover, it supports the proposition advanced in Experiment I (Discussion) that light and dark magazine training contexts are not similarly influenced by all variables (e.g., number of US-only trials, novel context exposure).

CHAPTER VII

GENERAL DISCUSSION

Four major findings emerged from the present studies. First, autoshaped keypecking will emerge in a dark context although overall performance as indexed by mean TWP and mean TCSP is typically better with the houselight on. Second, irrespective of whether autoshaping takes place with the houselight on, or off, performance was generally better, as measured by overall performance, if magazine training occurred in a different context. Third, the function relating overall performance to the prior number of US-only trials is determined by both the magazine training and autoshaping contexts. Fourth, extinction of the magazine training context, via simple nonreinforced exposure, enhances subsequent autoshaping, indicating that the proactive interfering effect of the magazine training context is reversible. However, novel context exposure disrupts autoshaping in the dark while facilitating autoshaping with the houselight on.

That autoshaped keypecking emerges with the houselight off under a variety of magazine training contexts and US-only trials supports and extends the generality of the findings by Oberdieck et al. (1977, 1978). In view of this data a modified cue localization hypothesis is proposed which states that autoshaped performance is superior with the houselight on because fewer redundant contextual cues accompany CS onset. This supposition is distinct from Wasserman's (1973) radical cue localization hypothesis which precludes the emergence of autoshaped keypecking in the dark. Note that both hypotheses can account for Zentall and Hogan's (1975) finding that with the houselight on autoshaping with a bright keylight is suppressed relative to autoshaping with a dimmer keylight.

The other findings are more problematic. The impetus for the present studies was the application of Kamin's (1969) blocking hypothesis to the magazine training context, a speculation supported by Tomie's (1976a, b) finding that autoshaping is influenced by contextual stimuli. Although some of the present data is amenable to a magazine training context blocking interpretation, several factors argue against this as a complete, or even best account. First, initial peck data and initial block performance levels often failed to differentiate between groups. Although this may be due to the insensitivity of the measures employed or variability in the data, a distinctive pattern of initial differences was (perhaps unrealistically) expected. Second, a blocking interpretation would predict that if magazine training and autoshaping occur in a similar context more blocking is expected with increased US-only trials. If the magazine training context can only support a limited amount of conditioning the blocking effect is expected to reach asymptote after a given number of US-only trials and then level off. Neither prediction was supported by the data. Third, if magazine training and autoshaping occur in different contexts increasing the number of US-only trials should not have a systematic effect on subsequent autoshaping. This implication was not borne out. Fourth, a blocking account cannot explain the differential effects of novel context exposure when magazine training and autoshaping occur in the dark relative to the light.

Other accounts of magazine training and its role in subsequent autoshaping would also be hard pressed to accommodate the present data. For example, Logan's (1971) view that autoshaped keypecking is the result of generalized pecking from the grain hopper implies that increasing the number of US-only trials should strengthen generalized pecking and thus facilitate subsequent autoshaping. The data indicate that this may occur but only under certain magazine training and autoshaping context combinations.

Downing et al. (1976) proposed an underlying motivational process to account for the U-shaped function relating the number of US-only trials to trials to first peck. The motivational process is purported to facilitate new learning but is only activated when an optimal number of prior reinforcements are delivered. Unfortunately, it is impossible to define optimal number of prior reinforcements except in a post hoc manner. More detrimental, however, is the fact that a U-shaped function relating US-only trials to subsequent autoshaping was found only under certain context conditions.

The "learned laziness" analysis of Engberg et al. (1972) and the "competing reponse" view of Wasserman (1972) and Schwartz et al. (1974) also fail to account for the present data. Both of these schemas were postulated to account for the detrimental effects of massive US-only trials on subsequent autoshaping. However, the present studies revealed that many US-only trials were not necessarily deleterious and in some context combinations actually facilitated subsequent autoshaping. It would seem difficult for either the "learned laziness" or "response competition" hypotheses to explain the differential effects of numerous US-only trials on subsequent autoshaping.

Thomas' (1970) concept of "general attentiveness" is also inapplicable because this view implies that increased US-only training would hinder subsequent autoshaping. The detrimental effect of massive US-only trials would result from the reduced attentiveness caused by the lack of correlation between stimuli and US delivery in the magazine training phase. As already noted, however, this debilitating effect only emerges under some context conditions.

In summary, all the hypotheses formulated which attempt to relate the number of US-only trials to subsequent autoshaping are inadequate because they fail to take into account the magazine training and autoshaping contexts. The present studies clearly implicate the importance of these contexts and reveal that not all context combinations are functionally equivalent. On the basis of the present data it becomes apparent that the role of US-only trials on subsequent autoshaping is highly dependent on the contexts employed in both magazine training and autoshaping. Although at present no adequante explanation of the data can be proposed, several hypotheses may be conjoined to form a loose explanatory matrix.

First, the modified cue localization hypothesis mentioned may be invoked to account for the superior performance of autoshaping with the houselight on relative to the houselight off condition. Second, Kamin's (1969) view that only "surprising" reinforcers are effective in conditioning may accommodate the finding that autoshaping in a light or dark context is superior if magazine training occurred under a different context. Intuitively, it may be presumed that a US delivered in a novel context is presumably more surprising, and therefore results in more rapid conditioning, than a US delivered in a familiar context in which US's have previously been presented. In the present instance delivery of the reinforcer in the novel autoshaping context would be expected to result in faster, or more, conditioning to the CS (or keylight). Of course, conditioning to the CS also occurs if the autoshaping context is familiar because the CS predicts US delivery and even in a familiar context US presentations have some "surprise" value. Moreover, during magazine training, when no stimulus reliably predicts US occurrence some conditioning is expected to accrue to the contextual stimuli present (Odling-Smee, 1975; Rescorla & Wagner, 1972). Consequently, if these same contextual stimuli are present in the autoshaping phase, they are expected to interfere with conditioning to the CS. The data, in fact, reveal this interfering effect to be long lasting and never, within the somewhat limited number of sessions administered, being overcome. Recall that even in Block 3 performance was best if the autoshaping context was different from the magazine training context. This implies that if the autoshaping and magazine training contexts are similar the ITI periods in autoshaping do not completely extinguish conditioning to the contextual cues present. If conditioning to the context were extinguished during the ITI's, when US's are not delivered, autoshaping in the light (or dark) would eventually be expected to reach similar performance levels irrespective of the magazine training context. Simply, the interfering effect of the magazine training context would be expected to dissipate.

Third, it must be accepted that the houselight on and houselight off contexts are not functionally equivalent. It was presumed that the two contexts were equivalent and interchangeable. Consequently, it was assumed that the only critical variable was whether the magazine training and autoshaping contexts were similar or not. The data reveal this view to be too simplistic; magazine training in the light and in the dark are not equivalent and therefore interact differentially with subsequent autoshaping in the light or dark. The difference may be due to the fact that the stimuli that may be attended to and the behaviors that may be engaged in between US-deliveries are different in the houselight on and off conditions. These differences consequently effect subsequent autoshaping in distinct ways. The finding that novel context exposure has distinct effects, depending on the magazine training and autoshaping contexts (Experiment II) underscores the view that light and dark contexts are functionally different.

The explanatory matrix presented cannot account for the various functions relating overall performance to number of US-only trials. At best, and post hoc, it may only be said that this function may be an inverted U, or biphasic, depending on the magazine training and autoshaping contexts. Although the studies reported here have left many questions unanswered, they have emphasized the importance of the contexts involved in magazine training and subsequent autoshaping. In so doing the constraints and inadequacies of explanations which sought to account for the effect of many US-only trials on autoshaping have been revealed. Finally, these studies disclose the incompleteness of any account of autoshaping that simply emphasizes the predictiveness of the CS (e.g., Hearst & Jenkins, 1974; Schwartz & Gamzu, 1976).

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