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DIRECTED RESPONSE LEARNING BY
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By

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ABSTRACT

DIRECTED RESPONSE LEARNING BY OBSERVATION OF AN APPETITIVE PAVLOVIAN CONTINGENCY

By

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Three experiments explored model-absent observational learning of barpressing in rats. The observation of two mechanically activated bars (S+ and S-) was followed by a transfer of training test. In Experiment 1 the contribution of place learning was assessed by removing position cues. Males tested before reversal of observational learning performed poorly. Males reversed before tested pressed the S+ bar 83% of the time. Habituation of exploratory responses was invoked to account for this difference. Females were run in Experiment 2. Females performed poorly on test, but extended training improved their performance. The poor performance of females compared with males suggested that gonadal steroids play a role. In Experiment 3, amount of magazine training was manipulated. Conditioning to the S+ was retarded with 100 magazine trials, as was directed responding to S+ (context-blocking).

To my mother,
who inspired and rewarded inquisitiveness

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INTRODUCTION

Over the years it has become increasingly clear that the response-reinforcer contingency is not necessary for learning a response (Lajoie & Bindra, 1976). As these investigators point out, "phenomena of response substitution (e.g., Lashley & McCarthy, 1926), observational learning (e.g., Kohn & Dennis, 1972), and learning without responding (e.g., Dodwell & Bessant, 1960; Solomon & Turner, 1962) demonstrate that a new response may be acquired without its occurrence during the training trials."

As Browne (1976) has pointed out,

> The question of whether subjects can learn merely by watching, without acting,is related to a persistent conflict in theories of animal learning, the question of what is learned. According to cognitive theories, learning is mainly a matter of gaining knowledge about relationships between events. On the other hand, according to stimulus-response theories, learning is primarily a matter of forming associations between stimuli and responses. During the 1930's and 1940's, the validity of the two views was debated furiously, but inconclusively. Partially as a reaction against the inconclusive nature of the debates and partially due to the strong anti-theoretical influence of Skinner, issues surrounding the question of what is learned were avoided during the 1960's. (p. 287)

The arguement continues today (Davey, Oakley & Cleland, 1981; Locurto, Duncan, Terrace & Gibbon, 1980; Mellgren & Olson, 1980).

Various theoretical schemes have been proposed to accommodate the facts and investigate the issue of what is learned in a given situation. Estes (1969, 1972) has suggested, essentially, that three types of associative linkages (contingencies) are the basis of learning: stimulus-stimulus (S - S*), stimulus-response (S - R), and response-stimulus (R - S*) contingencies; with each type of contingency being sufficient in itself to support certain behavioral modifications. Going beyond Estes, Walker (1969) accepted the possibility of response-response (R - R) linkages. Bolles (1972) takes the position that behavior modification may arise from either response-stimulus (R - S*), or stimulus-stimulus (S - S*) expectancies. Either type of contingency is sufficient, but neither is necessary. Denny (1967) would argue that the consistent pairing of the stimulus and the response is both necessary and sufficient for learning. In contrast, Bindra (1978) claims that all learned behaviors are explained by S - S* associations, denying any explanatory importance to a response-reinforcer association. Within Bindra's framework, the S - S* contingencies are both necessary and for all instances of instrumental learning.

The observational learning procedure is particularly well suited to assessing the importance of the associations these theoretical schemes stress as it was designed to determine whether learning can occur through mere exposure to a stimulus sequence, that is, in the absence of the performance of the to-be learned response and response contingent reinforcement. In the typical appetitive observational learning situation,

> an experimental subject is allowed to observe the performance of a task by a demonstrator or model of the same species. While the subject is observing, he has no chance to perform the observed behavior and receives no direct

> reinforcement. After observation, the model is removed from the experimental situation, and the observer is tested on the observed task. If the observer learns the task faster than control subjects that have not observed a model, it is assumed that the observer learned something about the task during observation that facilitated subsequent acquisition. (Del Russo,1975, p. 76)

In the first part of the century, studies were conducted to determine if animals could learn by observation (Berry, 1906, 1908; Haggerty, 1909; Thorndike, 1911; Watson, 1908). The issue remained unresolved, as both positive and negative results were reported. It has been suggested that the discrepancy in results characterizing these earlier experiments was due to the poor experimental methods and lack of proper control groups. Warden and Jackson (1935) set up strict criteria for observational learning which eliminated earlier confounds such as the possibility for trial and error learning. Their experiment tested rhesus monkeys on observational learning of four tasks: pulling a chain, manipulating a knob, operating a latch, and operating a double latch. The experimenters found that observers performed significantly better than control subjects and concluded that monkeys can learn by observation and, in fact, exhibit a strong tendency to imitate. Observational learning has been demonstrated in a number of species and in a variety of learning situations since Warden and Jackson's experiment (Corson, 1967; Del Russo, 1971; Dubanoski & Parton, 1971; Hayes & Hayes, 1952; Herbert & Harsh, 1944; Jacoby & Dawson, 1969; Myers, 1970).

While evidence indicates that passive watching facilitates subsequent performance of a task, little is known about the properties of the facilitating effects of the appetitive observational experience. More recently, however, experimenters have turned their attention from mere demonstration to a closer scrutiny of the observational learning processes itself (Del Russo, 1975; Groesbeck & Duerfeldt, 1971; Kohn & Dennis, 1972). Three stimulus cues can be identified in the standard appetitive observational learning procedure: the manipulandum, some movement or change in the manipulandum, and the model. The effect of these variables might be better specified if each stimulus were presented in a manner allowing the separate effects of each cue to be explored. It may be, as we shall argue, that the model is relatively unimportant for facilitating observer performance of the task aside from its role in activating the manipulandum or in maintaining the observer animal's attention on each observational trial. In such a capacity, the model would serve simply as a means to an end in the subject's observation of the consistent pairing of stimulus and reinforcer. In other words, the observer animal gains information about the environmental contingencies (learns S - S relationships) apart from any modeling (imitating) component in the observational situation.

The relative contributions of the informational and the modeling components present in the standard appetitive observational learning situation were examined in a study conducted by Groesbeck and Duerfeldt (1971). Each of six groups of 10 rats received observational learning trials of a visual discriminating task in an elevated Y maze. Subjects were then tested on the task for the number of trials and errors to reach criterion (10 consecutive correct trials). Various combinations of observational learning components (modeling/imitating, informational vicarious reinforcement, following) were available to the six groups. For the information only (model-absent) group, observational learning trials involved the experimenters knocking over the S+ panel to reveal the water bottle at the end of the correct arm of the maze. Model-present groups observed demonstrator rats knock the S+ panel over and proceed down the correct arm of the maze to the water bottle. No differences were found in terms of the number of errors prior to reaching criterion between the group having information only and the group having both modeling and information components. However, the results did indicate that, in terms of the number of trials to reach criterion, the groups with the model present learned significantly faster than did groups without the model. The researchers concluded that modeling of the demonstrator's performance (copying the model's behavior) was the most important variable in the observational learning situation. A closer look at the data, however, indicates this conclusion may have been premature. No differences were found between the model-present and the model-absent groups in the mean number of trials until the first correct discrimination choice was made. Differences between groups only appeared with extended training to reach the criterion of 10 consecutive correct trials. The difference between groups that showed up with extended training could have reflected the observers' paying better attention in the standard condition rather than actually copying what the model did. Attention in early trials, presumably, was mediated by orienting responses to the novel situation and therefore approximately equal across groups. As training proceeded, however, the model could have served to mediate consistent attention to (and thus observation of) the S - S contingencies --the panels paired with water. In contrast, the model-absent groups may have ceased to observe further S - S pairings after the novelty of the situation ceased to sustain attention. Since no mention was made of any method of verifying that subjects in any of the groups actually observed the panel-water pairings, differences in attention remain as a possible confound. So, as yet, the issue of the relative importance of the various components in observational learning is far from conclusive. Indeed, evidence from research with humans seems to support the assertion that the model may be relatively unimportant aside from insuring that the subject observe the consistent pairing of the stimulus and reinforcer. Jacobson and Sisemore (1976) reported that the observation of contingencies (mechanical bar depression paired with reinforcement) was sufficient to elicit a full blown response in subsequent test trials.

If the model is relatively unimportant, then appetitive observational learning could be reanalyzed as an instance of a classically conditioned response system. The facilitation of performance of a task from the observational learning procedure may be derived from the development of behavior directed toward a stimulus that, by virtue of its contingent relation to the reinforcer, serves as a signal of the forthcoming reinforcer. That behavior can be steered toward a stimulus that predicts the imminent arrival of a reinforcer is well documented in the literature as instances of autoshaping or signtracking (see Hearst & Jenkins, 1974, for a review).

Observational learning, from this perspective (model-absent), resembles autoshaping studies where the subject is blocked or restrained from approaching the CS and/or the US during all pairings of the two stimuli (Browne, 1976). Prevention of such directed actions may be accomplished, for example, by inserting a barrier between the subject and the CS or US location, or by harnessing the subject in a place from which CS or US presentations are visible but inaccessible. If actual occurrences of approach and contact are not crucial for the development of tendencies to approach and contact the CS, then prior "observation" of a positive contingency between CS and US should produce immediate or rapid appearance of approach and contact responses when the CS is finally made accessible to the subject (Hearst, 1978).

Kirby, Muir, and Moore (cited in Moore, 1973) exposed pigeons to standard autoshaping procedures, except that a hardware cloth screen prevented the birds from access to the key. The birds were allowed access to grain when the hopper was raised. The birds observed 60 CS+ trials (white keylight followed by grain) and 60 CS- trials (vertical stripes on a key followed by no grain) for 20 daily sessions. The pigeons pecked the CS+ the very first time it appeared during a test with the key available. All 214 pecks that occurred during the test phase went unreinforced. Thus it would appear that learning of the stimulus-reinforcer relation had taken place in the absence of progressively closer approach movements and that autoshaping and related phenomena involving observation of contingencies could not be explained in terms of adventitious reinforcement of keypecking. However, Wessells (1974) pointed out that specific directed movements were clearly conditioned in the observation phase of the experiment. The pigeons repeatedly directed their beaks into the screen and made biting movements. It is important that the directed movements employed as the index of the stimulus-stimulus learning not be conditioned in the observation phase of the experiment, or else there is no clear separation of the associative linkages that led to the behavior modification. Despite such difficulties with these experiments, they have been offered as evidenace of the importance of a stimulus-stimulus contingency as a basis for certain behavior modifications.

Research performed by Denny, Bell, and Clos (Note 1) attempted to address the above issues and control for some of the confounds that led to the difficulty of making clear-cut determinations of the contingencies operating in each phase of a learning situation involving observation of environmental events. First, measures were taken to insure that animals were indeed observing the environmental events. Also, there were no overt directed movements during the observation phase that corresponded to anything like the behavior which served as the measure of stimulus-stimulus learning. Furthermore, the study addressed not only the issue of the initial acquisition of a directed contact response, but also the subsequent persistence and strength of these responses despite changes in the reinforcement context in which the responses occurred (the latter issue is often addressed in studies of the omission effect). The Denny, Bell, and Clos study (Note 1) will be discussed here in some detail as the present series of experiments extended their analysis of the observational learning procedure.

Their experiment could be classified as either a blocked discriminative autoshaping study or a model-absent observational learning study, since both share essentially the same elements--an observation of contingencies phase and a transfer of training testing phase. In the observation phase, the subjects were required to observe the activation of either the right or left bar and its attendant stimuli (light and/or noise), followed by the delivery of an accessible food pellet in the food tray (see Figure 1). The food pellet was not

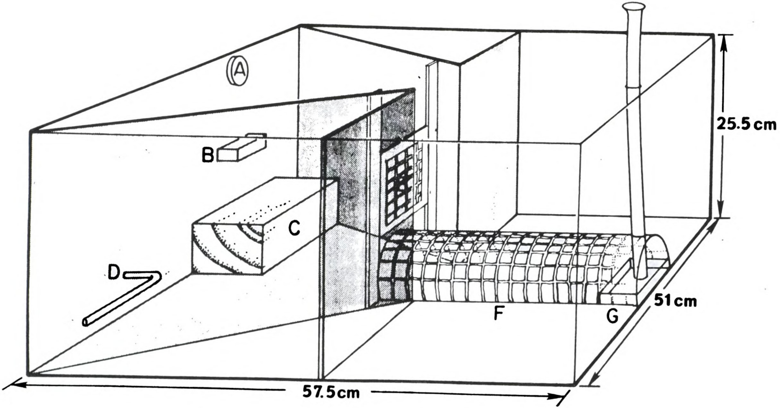

Figure 1. The two-choice observation apparatus (A) The light above right bar. (B) Right bar. (C) Wooden block below right bar (removed for the present series of experiments). (D) Left bar. (E) Hardware cloth tunnel-door in up position, when rat can leave or enter tunnel. Door is down when rat is in tunnel watching bars being activated. (F) Hardware cloth tunnel in which rat observes bars and turns around to obtain food reward. (G) Food tray in which pellet is dropped through tube.

delivered until the rat had jack-knifed around in the tunnel en route to the food tray. This procedure insured that the moving bars and attendant stimuli maintained exclusive stimulus control of the go/no-go behavior. Activation of the other bar (the CS-) was followed by a period of nonreinforcement, and jack-knifing around in the tunnel had no scheduled effects except possibly to increase the intertrial interval (ITI) if the subject failed to return to the tunnel door by the end of the previous ITI. Trials were administered in blocks of 20 with one or two blocks being presented daily until the discrimination criterion was reached. The criterion was (a) inhibiting on 9 out of 10 S- trials in a block by continuing to face the test chamber for at least 10 seconds after the S- bar moved, and (b) leaving the tunnel door for the food tray in less than 10 seconds on 10 out of 10 S+ trials in a block. Accurate performance on this go/no-go discrimination was thus used as an index of the learning of the S - S relationships. The number of trials to criterion included the criterial day.

Once the discrmination criterion was met, the tunnel door was raised and the subject was allowed to enter the test chamber with the tunnel door closed behind it. If the subject pressed a bar it was removed from the chamber and returned to its home cage. Thus, with respect to the food tray the subject was neither reinforced nor nonreinforced for barpressing. If the rat did not press a bar within five minutes it was removed from the test chamber and returned to its home cage. On each of three succeeding days (test days 2, 3, 4) the rat was placed in the tunnel and given one block of 20 booster trials followed immediately by a test as described. On test days 5, 6, and 7 the rat was tested both prior to and following the block of 20 trials.

This gave a total of 10 test trials over a 7 day period. Following the 7 test days these subjects received further observational training with cues reversed. Upon reaching the same criterion as used for the original discrimination the subjects were again given 10 test trials over 7 days.

A second group of subjects received identical treatment as this first group, Group TBR (Tested Before Reversed), until the original discrimination criterion was met. Upon reaching criterion, however, the second group was reversed and given more observational training trials. When the second group, Group RBT (Reversed Before Testing), reached reversal discrimination criterion, it began the testing phase as outlined above. Following the 7 test days, these subjects received further observational training with the cues reversed a second time. A final testing phase ended the experiment for these subjects. Whether the subjects were allowed access to the CS bar in the testing phase prior to or following reversal of the S - S observational learning in the tunnel was the critical difference between the two groups (see Table 1).

All of the subjects in Group TBR after a brief exploration period pressed the CS+ bar on the initial test trial, and continued pressing the CS+ bar on 87% of the 10 test trials. These results, presented in Table 2, are consistent with findings of Browne (1976) and other researchers who conclude that the initial acquisition of directed movements depend mainly on stimulus-reinforcer correlations. When the subjects from this group were tested, Phase 5, after receiving S - S reversal training in the tunnel, not one subject pressed the new S+ bar on the initial test trial. As a group, they selected the original

Table 1

Outline of the Experimental Phases for the Two Groups in Denny, Bell, and Clos Observational Learning Procedure

Group	Phase				
	1	2	3	4	5
TBR	Observation of cues		Test	Observation of reversed cues	Test
RBT	Observation of cues	Observation of reversed cues	Test	Observation of reversed cues	Test

TBR = Tested Before Reversed
RBT = Reversed Before Tested

Table 2

Data from the five phases of the observational learning study in Denny, Bell, and Clos (Note 1), number of trials to observational learning criterion (including criterial day) and percentage barpress responses to stimuli over 10 test trials are listed

Group	Subject	Phase 1	 2	 3	 4	 5
TBR	R 110	(B+) 246	-	(B+) 70% (BL-) 30%	(BL+) 220	(B-) 50% (BL+) 50%
	R 222	(B+) 100	-	(B+) 90% (BL-) 10%	(BL+) 200	(B-) 80% (BL+) 20%
	R 666	(B+) 160	-	(B+) 100% (BL-) 0%	(BL+) 157	(B-) 100% (BL+) 0%
	R 010	(BL+) 308	-	(B-) 0% (BL+) 100%	(B+) 140	(B+) 20% (BL-) 80%
	R 111	(BL+) 190	-	(B-) 30% (BL+) 70%	(B+) 316	(B+) 10% (BL-) 90%
	R 333	(BL-) 180	-	(B-) 10% (BL+) 90%	(B+) 120	(B+) 10% (BL-) 90%
	Mean	197.3	-	(+) 86.7% (-) 13.3%	192.2	(+) 18.3 (-) 81.7
	S.D.	71.9	-		71.2	
RBT	R 003	(BL+) 180	(B+) 172	(B+) 90% (BL-) 10%	(BL+) 237	(B-) 100% (BL+) 0%
	R 001	(BL+) 100	(B+) 160	(B+) 90% (BL-) 10%	(BL+) 140	(B-) 90% (BL+) 10%
	R 005	(BL+) 389	(B+) 310	(B+) 100% (BL-) 0%	(BL+) 340	(B-) 100% (BL+) 0%
	R 100	(B+) 307	(BL+) 288	(B-) 10% (BL+) 90%	(B+) 80	(B+) 0% (BL-) 100%
	R 004	(B+) 230	(BL+) 213	(B-) 10% (BL+) 90%	(B+) 186	(B+) 10% (BL-) 90%
	R 002[a]	(B+) 200	(BL+) 80	(B-) 0% (BL+) 0%	-	-
	Mean	241.2	228.6	(+) 92% (-) 8%	196.6	(+) 4% (-) 96%
	S.D.	111.8	67.7		98.9	

Note. Parentheses indicate training and test stimuli in each phase for that subject. TBR = Tested Before Reversed; RBT = Reversed Before Tested; B = Bar only stimulus (left stimulus); BL = Bar and light stimulus (right stimulus).

[a] Subject was a nonlearner (never performed on test) and was dropped from experiment. Data was not included in mean or S.D. for group.

S+ bar (now the S- bar) on 81.7% of the 10 test trials. Group TBR did not reverse on test. Group RBT showed reversal learning on test (Phase 3) with 5 out of 6 rats in this group reversing and selecting the new S+ bar on 92% of the 10 test trials. With Fisher's Exact Test the difference between the groups was highly significant ($p < 0.001$). However, when Group RBT was given S - S reversal training in the tunnel a second time, the subjects pressed the new S+ bar (in Phase 5) on only 4% of the 10 test trials. Group RBT did not reverse a second time. After both groups had been tested once, by Phase 5, the two groups were showing similar performance on test (i.e., not reversing).

According to elicitation theory, (Denny, 1971), reversal learning is accomplished by the extinction of the original response through the learning of a competing response in the same stimulus situation. The failure to reverse after testing suggested that the original S - R learning (consistent pressing of a particular bar during the first 10 test trials) effectively competed with the directed movements from the interpolated S - S observational learning. Thus, in the stimulus context of the test chamber, Group TBR had a response that directly competed with the directed movements from the new (reversed) stimulus-reinforcer association, so that this group did not reverse on test in Phase 5. However, Group RBT had no response in the context of the test chamber that could compete with the directed movements dependent on the new (reversed) stimulus-reinforcer association, so that this group did reverse on test in Phase 3. After Group RBT had a response established (from Phase 3) in the context of the test chamber that could compete with the directed movements from the new (second reversal) stimulus-reinforcer association, this group also would not reverse when tested in Phase 5. Even though the subjects had learned the S - S reversal, as evidenced by reaching reversal discrimination criterion, subjects failed to reverse on test on the basis of S - S learning. The new S+ bar (after each reversal) which was more predictive of the reinforcer was not the bar which was approached and contacted if the subject had received S - R learning trials previously.

To summarize, subjects can acquire the response demonstrated mechanically in a model-absent situation on the basis of learning S - S relationships (gaining information about environmental contingencies). Furthermore, if prior S - R learning competes with directed movement from new reversed S - S observational learning, the no reversal will occur on test. If there is no prior S - R learning competing with the directed movements from the reversed S - S learning, then reversal will occur on test. Persistence of the S - S directed response was determined by the absence of the occurrence of a competing response in the stimulus context of the observational apparatus (Denny & Adelman, 1955).

The present experiments extended this analysis of the processes which underlie the learning of responses by observation of stimulus sequences using the observational learning procedure. The first of the three experiments was concerned with specifying the locus of control of the directed actions. One of the critical questions raised by the observational learning experiments was how important progressively closer approach movements were for development of the final directed response of barpressing and for the learning of the stimulus-reinforcer relation. As Wessells (1974) pointed out, it was important that the directed movements employed as the index of stimulus-stimulus learning not be conditioned in the observation phase. Any overt response conditioned in the tunnel (such as directionally differentiated orienting) would eliminate the clear-cut separation of the S - S and the S - R learning, and would bring into question which association was directing responding on test trials. The first experiment controlled for certain incipient orienting responses in the tunnel. Experiment 2 assessed the generalizability of this phenomenon by testing for any sexual dimorphism in the learning and retention of an observational discrimination. A number of other nonreproductive behaviors have been identified as being sexually dimorphic in rodents (see Beatty, 1979, for a review). The last of the three experiments assessed the effects of certain pretraining manipulations on the acquisition of directed responses. In the original experiment, each subject typically received five food-only (magazine training) trials, though occasionally a subject would require more trials before it was adequately magazine trained. The contribution of magazine training to autoshaping has been demonstrated to be an important variable in the acquisition of directed responses (Blanchard & Honig, 1976; Downing & Neuringer, 1976; Engberg, Hansen, Welker, & Thomas, 1972). In Experiment 3, the number of US-only trials in pretaining was manipulated to determine whether this variable could be a source of variation among subjects in performance on test trials.

EXPERIMENT 1

In the design of the original set of experiments on model-absent observational learning (Denny, Bell, & Clos, Note 1), subjects could make incipient orienting responses toward a particular location (right or left) during the discrimination learning trials. Incipient orientation toward a bar location, though not regularly observed, could have occurred while the animal was waiting for a trial to begin. Thus, there may have been S - R place learning occurring while the rat was observing from the tunnel. Such learning could have been responsible during the testing phase for directing the animal toward the S+ bar, rather than the correct response during test having been mediated by the S - S observational learning. Indeed, the results would be trivial if all the subjects had learned was to "turn right" or "turn left" during the visual discrimination phase and had not learned anything about moving manipulanda. Experiment 1 was conducted to eliminate this possibility as an explanation for the results from previous experiments.

If rats were using S - R place learning to direct them to an area during test trials we would expect poorer test trial performance when the bars are switched from side to side. On the other hand, making the position cues irrelevant by switching the panels from side to side could have the result of enhancing stimulus control by the moving bars and thereby facilitate S - S learning and performance during test trials. Indeed evidence from Kohn and Dennis (1972) suggests that the attention-getting value of changing cue panels might yield faster learning of an observational discrimination task.

Furthermore, making a salient dimension such as position irrelevant could, as Sutherland and Mackintosh (1971) would predict, produce an overlearning reversal effect - a facilitation of reversal performance when a group is given overtraining trials prior to reversal. In which case, Group TBR that receives 120 overtraining trials during Phase 3 would be expected to show reversal on Phase 5.

Method

Subjects. Twelve naive male albino, Sprague-Dawley, rats approximately 150-200 days old at the start of training were maintained at 90% of ad libitum weight (previous research showed that more highly deprived rats bit the tunnel door and visited the food tray excessively and were thus poor subjects). Subjects were fed supplementary food in their home cages following each experimental session to maintain target weights. The rats were housed individually under conditions of a 12-h light/dark cycle, and all had free access to water in the colony throughout the experiment.

Apparatus. The experimental chamber for this study can be seen in Figure 1. The funnel-shaped compartment containing the bars is the test chamber. The hidden experimenter activated the bars from behind the end panel at all times during training. The tip of the activated bar on the left panel in Figure 1 has a total excursion of 8.5 cm and makes a sharp click when it strikes the chamber floor. The bar on the right panel in Figure 1, when activated, has an excursion of 2.2 cm, turns on a dim light above the bar and produces a faint click from the microswitch. The ceiling over the tunnel is opaque, the one over the bars transparent. The cue panels could be switched from side to side.

Procedure. Half the subjects in each group were trained to the bar and light (right stimulus in Figure 1) as the positive stimulus, and half were trained to the bar only (left stimulus in Figure 1) as the positive stimulus. The first session included the three phases of preliminary training: habituation, magazine training, and shaping of the observing response. Rats were allowed to explore both halves of the observation apparatus with the bars inoperable. At least ten 97 mg Noyes pellets were available in the food tray during exploration. Once the rat ate these pellets, five additional reward pellets were individually delivered after delays of approximately 60 seconds while the rat was confined to the tunnel (magazine training). The observing response was shaped by delivering further pellets only after the rat had left the food tray and faced the closed tunnel door.

Following preliminary training subjects were randomly assigned to the two treatment groups and were shifted to the observation of the contingencies phase. The procedure for this phase differed from previous experiments only in so far as cue panel position was concerned. The panels that the manipulanda were located on were switched from side to side according to a computer generated hypergeometric distribution of switches ($p = .3$). Because there was some attendant noise associated with the changing of panels, phoney switches were scheduled also ($p = .32$). This procedure controlled for response alternation with each switch. During the phoney switch the panels were removed from the back wall of the observation apparatus and then replaced in the original position. An opague panel was placed in front of the tunnel door during all switches. The ITI was a computer generated Poisson distribution of time intervals with a mean of 10 seconds and a range of 1 to 60 seconds. This meant that wait-time could not become a cue for leaving the door and approaching the food tray. The ITI started after the rat returned to the door from the food tray on S+ trials or after the rat had waited 10 sec at the door on S- trials. Extra visits to the food tray during the ITI only increased the ITI if the rat failed to return to the door by the end of the ITI. Seven seconds were added to all ITI values, however, to allow for time to make the panel switches.

Testing began for subjects in Group TBR (Tested Before Reversed) when they reached the discrimination criterion outlined in the introduction. The cue positions were changed following the series used by Fellows (1967). Blocks of trials were chosen on test days so that half the time the tested panel and the last training trial had the S+ on the same side, and half the time they were on opposite sides. The opaque panel was placed in front of the tunnel door prior to all testing, and either a real or a phoney switch occurred. If the rat pressed a bar it was removed from the test chamber and returned to its home cage. Contacts to the left bar (bar only stimulus) were recorded as barpresses if the lever was displaced from the "up" position (.45 rad from horizontal) to at least the horizontal position. Contacts to the right bar (bar and light stimulus) were recorded as barpresses if the microswitch was tripped and the light turned on. If the rat did not press a bar within 5 minutes, it was returned to its home cage. During testing, both the latency to barpress and the particular bar pressed were recorded.

On each of three succeeding days (test days 2, 3, 4) the rat was placed in the tunnel and given 20 booster trials followed immediately by a test as outlined above. On test days 5, 6, 7, the rat was tested both prior to and following the block of 20 trials. This gave a total of 10 tests over a 7 day period. Following the 7 test days these subjects received further observational training with the cues reversed. Upon reaching the same criterion as used for the original discrimination the subjects in Group TBR were again given 10 test trials over 7 days.

The other treatment group, Group RBT, received identical treatment as the first group until the original discrimination criterion was met. Upon reaching criterion, Group RBT was immediately reversed and given more observational training trials. When Group RBT reached reversal discrimination criterion, the testing phase began as outlined above. Following the 7 test days, these subjects received further observational training with the cues reversed a second time. These subjects completed the experiment with a final testing phase.

Results and Discussion

Table 3 summarizes the performance of subjects on discrimination trials and test trials for the five experimental phases in Experiment 1. Subjects were able to learn the go/no-go discrimination with switching cue panels in a mean of 240.8 trials (N = 12). This mean was somewhat greater than the mean number of trials to initial discrimination criterion as found by Denny, Bell, and Clos (Note 1) using stationary panels. Thus, S - S learning was not facilitated (stimulus control by the moving bars was not enhanced) by switching cue panels, at least with respect to number of trials to reach discrimination criterion. This finding is inconsistent with Kohn and Dennis (1972) who found that simply changing cue panel location resulted in a facilitation of the observational learning task. Their findings, though, were probably a result of the changing stimulation maintaining the subject's attention, and in this manner providing for an enhanced distinctiveness of cues. Whereas in the present experiment, presumably attention was sufficiently maintained by the presence of reinforcement in the situation.

The switching of panels from side to side did, however, have a significant effect on test trial performance. As a group, TBR subjects contacted the S+ bar on only 36.7% of the 10 test trials. Half of the subjects did not contact either bar within 5 minutes after test entry on 2 to 7 of the test trials during the first testing phase (Phase 3). This can be compared to the TBR group without switching cue panels in the Denny, Bell, and Clos study (Note 1) in which all subjects contacted one or the other bar on all 10 test trials, and as a group contacted the S+ bar on 86.7% of test trials (see Table 2). Consistent with the overall poor performance of Group TBR on test was the poor performance on the initial test trial. The initial test trial was critical for assessing the S - S learning. Contact to the bar on the initial test would presumably be directed by the S - S observational learning. On subsequent test trials, however, conditioned reinforcement (light, or click of bars) or some other response maintaining mechanism such as "marking" (Lieberman, McIntosh, Thomas, 1979) could have been directing responding along with the S - S learning. Only 3 out of 6 animals in the TBR group contacted the S+ bar on initial test (compared to 6 out of 6 subjects without cue

Table 3

Data from the five phases of Experiment 1. Number of trials to observational learning criterion (including criterial day) and percentage barpress response to stimuli over 10 test trials are listed

Group	Subject	Phase				
		1	2	3	4	5
TBR	R 105	(B+) 232	-	(B+) 0% (BL-) 30%	(BL+) 200	(B-) 70% (BL+) 30%
	R 201	(B+) 201	-	(B+) 60% (BL-) 40%	(BL+) 198	(B-) 30% (BL+) 70%
	R 401	(B+) 288	-	(B+) 10% (BL-) 90%	(BL+) 317	(B-) 10% (BL+) 90%
	R 601	(BL+) 308	-	(B-) 10% (BL+) 70%	(B+) 280	(B+) 0% (BL-) 100%
	R 504	(BL+) 295	-	(B-) 20% (BL+) 50%	(B+) 228	(B+) 30% (BL-) 70%
	R 101	(BL+) 188	-	(B-) 70% (BL+) 30%	(B+) 200	(B+) 50% (BL-) 50%
	Mean	252.0	-	(+) 36.7% (-) 43.4%	237.2	(+) 45% (-) 55%
	S.D.	51.7	-	-	50.2	-
RBT	R 109	(BL+) 252	(B+) 360	(B+) 70% (BL-) 30%	(BL+) 227	(B-) 80% (BL+) 20%
	R 160	(BL+) 188	(B+) 307	(B+) 80% (BL-) 20%	(BL+) 440	(B-) 100% (BL+) 0%
	R 130	(BL+) 243	(B+) 348	(B+) 90% (BL-) 10%	(BL+) 320	(B-) 100% (BL+) 0%
	R 150	(B+) 268	(BL+) 442	(B-) 20% (BL+) 80%	(B+) 360	(B+) 10% (BL-) 90%
	R 106	(B+) 232	(BL+) 320	(B-) 0% (BL+) 100%	(B+) 240	(B+) 0% (BL-) 100%
	R 500	(B+) 194	(BL+) 380	(B-) 20% (BL+) 80%	(B+) 312	(B+) 30% (BL-) 70%
	Mean	229.5	359.5	(+) 83.3% (-) 16.6%	316.5	(+) 10% (-) 90%
	S.D.	32.1	48.3	-	78.8	-

Note. The absence of a response on a test is indicated by a less than 100% when the percentage response to the two stimuli in that phase are summated. Parentheses indicate training and test stimuli in each phase for that subject. TBR = Tested Before Reversed; RBT = Reversed Before Tested; B = Bar only stimulus; BL = Bar and Light stimulus.

panels changing). Thus, TBR subjects showed little evidence of a directed response from the S - S learning. As an additional measure, latency can be used to determine the directedness of the responses that did occur. The median latency to contact was 125 sec as compared with a median latency of 49 sec for groups showing S - S directed responding in earlier experiments with cue panels stationary. Informal observation of TBR animals on test showed that prior to contacting a bar, time was spent exploring the chamber, rearing, or crouching in front of the tunnel door. With only the moving bars and attendant stimuli for cues (without position as a cue), TBR subjects performed poorly on test on a variety of measures. Thus, it would appear that switching cue panels adversely affected test performance. This finding lends support to the notion that S - R place learning may have been directing subjects in previous experiments toward an area where the S+ bar was located.

However, in contrast to Group TBR, subjects reversed before testing (RBT) performed on test much like RBT subjects whose cue panels were not switched. That is, subjects did reverse on test as a result of S - S learning in Phase 2. RBT subjects in Phase 3 pressed the reversed (new S+) bar 83.3% of the time. However, these same subjects which reversed once on the basis of S - S learning failed to reverse on test a second time on the basis of S - S after the intervening S - R learning (Phase 3). As can be seen in Table 3, Group RBT in Phase 5 pressed the new S+ bar only 10% of the time. In other words, the group continued to press the old S+ (new S-) 90% of the time. Five out of six of these RBT animals on the initial test trial in Phase 3 pressed the bar most recently associated with the reinforcer, with all subjects pressing one or the other bar on all subsequent test trials. The median latency to barpress was 31.8 sec. Overall, then, RBT subjects were more directed than Group TBR in their responding. Furthermore, this group showed directed responding without having S - R place learning to guide responding. So subjects can learn and perform on test without position as a cue.

The greatest effect of switching the panels was on reversal performance. Group TBR received 120 additional (overtraining) trials across 6 test days (the booster trials) prior to reversal training. Group TBR learned the go/no-go reversal in a mean of 237.2 trials as compared with Group RBT that required a mean of 359.5 trials. Group RBT was reversed without these extra trials, or overtraining. This difference on trials to reversal criterion was significant (Mann-Whitney Two-Sample Test, $\underline{p} < 0.025$). In other words, there was a significant positive overlearning reversal effect (ORE) when cue panels were switched. In earlier studies without switched cue panels, no significant ORE was found (Mann-Whitney Two-Sample Test, $\underline{p} > 0.1$).

The ORE observed in Group TBR, however, did not extend to barpressing (test phase). After reversal training, TBR subjects on test (Phase 5) contacted the new S+ bar on only 45% of the test trials. As in Phase 3 there was no consistent responding as a group to one bar or the other.

The question remains why Group TBR in contrast to Group RBT failed to show consistent barpressing in either of the two test phases. One tenable explanation follows from an S - R interpretation of the data. Within this framework, learning depends upon consistently eliciting the to-be-learned response in close temporal contiguity with a particular stimulus situation along with the minimization of the elicitation of alternative responses to the same or similar stimulus situations (Denny & Adelman, 1955). In this way, the response that is being learned wins out over other possible responses. However, if alternative responses are allowed to occur in a given situation then those responses are the ones that are learned. Many variables which help mediate learning are those that commonly minimize or eliminate competing responses. Habituation to the experimental chamber with repeated exposure to the stimulus situation, reduces the novelty of the situation minimizing exploratory responses. It is possible that habituation of exploration from repeated exposure to the stimulus situation accounts for the more consistent test trial performance of Group RBT as compared with Group TBR.

Group RBT with the changing cue panels took more trials to reach the reversal criterion and, therefore, was exposed to the experimental situation for a long time prior to ever being allowed into the test chamber for testing. Such exposure could have habituated any exploratory responses that might compete with S - S directed responding in the stimulus situation of the test chamber. However, exploratory responses may not have habituated by the time TBR reached discrimination criterion (less exposure to stimulus situation). Thus, when TBR subjects were tested, these alternative responses were in direct competition with the S - S directed barpress responses, resulting in inconsistent performance. For some of the subjects, the alternative responses (which included rearing, nosing about, and crouching) won out, and no barpress occurred on from 2 to 7 of the test trials. For other subjects, this response competition was indicated by long latencies when the responses did occur.

Group TBR continued to perform inconsistently on retest even though by Phase 5 it had approximately as much exposure to the stimulus situation as Group RBT had had when it was first tested. In other words, Group TBR in the second test phase should have had as much habituation of exploration as RBT had in the first test phase and might be expected to barpress consistently. However, according to our S - R position, since these alternative responses in Group TBR occurred in the test chamber in the first test phase, these were the responses that were learned. These alternative responses learned in the first test phase were still in direct competition with the new S - S directed responding and therefore prevented consistent barpressing in Phase 5.

EXPERIMENT 2

There has been a longstanding tradition in animal psychology (especially rodent research) to conduct experiments on male subjects, perhaps because of the early discovery of estrus linked changes in activity (Slonaker, 1925). Females rats are on a four-day rhythm in gross bodily activity associated with the period of oestrum. Therefore, to avoid introducing unwanted and extraneous variability that might obscure the phenomena of interest, the widely practiced research strategy of excluding females has been adopted.

Despite this long tradition of designing experiments in a manner that precludes discovery of sex differences in behavior, many behaviors have been described as being sexually dimorphic in rodents. Differences between male and female rats have been found to be the rule rather than the exception in aversively motivated learning (Van Oyen, Van de Poll, & de Bruin, 1979). For example, superior performance by females has been found in aversive control procedures in which the presentation of an aversion stimulus is avoided or terminated by a response. While females are superior to males in active avoidance, they exhibit inferior performance on passive avoidance tasks (Beatty, Gregoire, & Parmiter, 1973). The learning and retention of certain kinds of mazes have also been shown to be sexually dimorphic in rats. In general, males are superior (Barrett & Ray, 1970), with complex mazes being most sensitive to sex differences.

General sex differences in emotionality (Gray, 1979) and the activational and organizational effects of gonadal hormones have been offered as being responsible for the manifestation of sex differences in learning tasks (see Beatty, 1979, for a review). Specifically, testosterone proprionate has been implicated in inducing three general classes of change: (a) an increase in persistence of response to a particular type of stimulus, (b) an increase in persistence of response to stimuli in a particular place, and (c) an increase in resistance to distraction (especially with respect to irrelevant stimuli) coupled with an increased ability to sustain attention on a particular localized stimulus (see Andrew, 1976, for a review, though he only discusses chicks and mice). Sexual dimorphism on task would be expected, according to Andrew, to the extent that persistence and attentional processes affect the success or failure on a task. As both processes are critical to success in the observational learning situation, sex differences would be expected.

Method

Subjects. Eighteen naive female hooded and albino rats approximately 150-200 days old at the start of training served as subjects. Rats were housed under the same conditions as subjects in Experiment 1. Deprivation levels were also the same as for subjects in Experiment 1.

Apparatus. The experimental chamber used in Experiment 1 was used in this experiment, with one modification - cue panels were stationary. The bar and light cue panel remained on the right side of the front wall, while the bar only panel remained on the left side (see Figure 1).

Procedure. The eighteen subjects were randomly assigned to three treatment groups. Two of the groups received the same treatment as males received in Group TBR and Group RBT in the original design of the experiment as outlined in Table 1. Performance during observational training trials (trials to discrimination criterion), latency to barpress on test, and the particular bar pressed were recorded. The third group, Group C-TBR, received the same treatment as Group TBR except that this group did not receive the block of 20 (booster) trials on each of the test days. This group was added to control for the possibility that the 120 overtraining trials (over the course of the 7-day test period) affected the course of discrimination reversal training or performance on test trials following reversal training. Eliminating the extra 120 trials in Group C-TBR better equated the treatment received by the two groups (RBT and C-TBR) prior to reversal. The one critical difference that remained was testing prior to or following reversal of S - S learning.

Results and Discussion

Table 4 summarizes the performance of subjects on discrimination trials and test trials for the five experimental phases in Experiment 2. Females learned the go/no-go discrimination in a mean of 227.6 trials (N = 18). Males from Denny, Bell, and Clos (Note 1) learned the same discrimination mean of 192.2 trials. Although compared across experiments, the number of trials to first discrimination criterion was not significantly different for females and males (Mann-Whitney Two-Sample Test, $p > 0.1$). Even so, female performance on early trials differed markedly from that of males. Although not systematically recorded, informal observation indicated

Table 4

Data from five phases of Experiment 2. Number of trials to discrimination criterion (including criterial day) and percentage barpress response to stimuli over 10 test trials are listed

Group	Subject	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
TBR	R 702	(B+) 274	-	(B+) 30% (BL-) 70%	(BL+) 610	(B-) 30% (BL+) 70%
	R 706	(B+) 180	-	(B+) 0% (BL-) 100%	(BL+) 320	(B-) 20% (BL+) 80%
	R 803	(BL+) 184	-	(B-) 30% (BL+) 60%	(B+) 314	(B+) 0% (BL-) 100%
	R 705	(BL+) 391	-	(B-) 20% (BL+) 80%	(B+) 430	(B+) 30% (BL-) 70%
	R 704	(BL+) 220	-	(B-) 60% (BL+) 40%	(B+) 380	(B+) 60% (BL-) 40%
	Mean	249.8	-	(+) 42% (-) 56%	410.8	(+) 52% (-) 48%
	S.D.	87.5	-	-	121.1	-
RBT	R 707	(BL+) 180	(B+) 272	(B+) 70% (BL-) 30%	(BL+) 280	(B-) 60% (BL+) 40%
	R 701	(BL+) 180	(B+) 477	(B+) 90% (BL-) 10%	(BL+) 520	(B-) 100% (BL+) 0%
	R 703	(B+) 296	(BL+) 660	(B-) 40% (BL+) 60%	(BL+) 365	(B+) 50% (BL-) 50%
	R 708	(B+) 268	(BL+) 267	(B-) 0% (BL+) 100%	(B+) 300	(B+) 0% (BL-) 100%
	R 709	(B+) 183	(BL+) 300	(B-) 10% (BL+) 90%	(B+) 347	(B+) 0% (BL-) 100%
	Mean	221.4	395.2	(+) 82% (-) 18%	362.4	(+) 18% (-) 82%
	S.D.	56.2	171.4	-	94.6	-
C-TBR	R 804	(B+) 264	-	(B+) 20% (BL-) 80%	(BL+) 579	(B-) 10% (BL+) 90%
	R 806	(B+) 390	-	(B+) 50% (BL-) 50%	(BL+) 584	(B-) 50% (BL+) 50%
	R 212	(B+) 320	-	(B+) 50% (BL-) 50%	(BL+) 560	(B-) 0% (BL+) 100%
	R 017	(B+) 220	-	(B+) 60% (BL-) 40%	(BL+) 560	(B-) 70% (BL+) 30%
	R 801	(BL+) 260	-	(B-) 0% (BL+) 100%	(B+) 520	(B+) 0% (BL-) 100%
	R 805	(BL+) 306	-	(B-) 30% (BL+) 70%	(B+) 470	(B+) 80% (BL-) 20%
	R 211	(BL+) 200	-	(B-) 10% (BL+) 90%	(B+) 480	(B+) 10% (BL-) 90%
	R 018	(BL+) 200	-	(B-) 40% (BL+) 10%	(B+) 400	(B+) 100% (BL-) 0%
	Mean	270	-	(+) 56.3% (-) 37.5	519.1	(+) 63.7% (-) 36.3%
	S.D.	66.2	-	-	64.7	-

Note. The absence of response on a test trial is indicated by a less than 100% when the percentage response to the two stimuli in that phase are summated. Parentheses indicate training and test stimuli in each phase for that subject. TBR = Tested Before Reversed; RBT = Reversed Before Tested; C-TBR = Control-Tested Before Reversed; B = Bar only stimulus; BL = Bar and Light stimulus that the females' performance on early trials was characterized by long periods of crouching at the back of the tunnel, much defecation and urination, and a reluctance to approach and eat from the food tray or to approach the front of the tunnel. Some females would take an hour of habituation before they would eat from the food tray. When food pellets were dropped through the tube into the tray the attendant noise would often elicit freezing. Long pretraining periods were necessitated by the subjects' behavior, including more magazine training trials and extended training to shape the observing response. The pretraining phase took on the order of several days, although the number of pellets delivered during this extended pretraining phase was not recorded. Males, on the other hand, typically learned the observing response (learned to shuttle back to the tunnel door in 5 trials) and readily ate from the food tray.

Group and sex differences were found on test. As a group, TBR females contacted the S+ bar on only 42% of the first 10 test trials. Performance within the female TBR group was marked by variability, with subjects pressing the S+ bar on from 0 to 8 of the 10 test trials. TBR males contacted the S+ bar on 86.7% of the test trials, with a range from 7 to 10 of the 10 test trials. Consistent with the TBR females' overall poor performance on test, was the poor performance on the initial test trial. Only 2 out of 5 females in the group pressed the S+ bar on the initial test (all TBR males from Denny, Bell, and Clos, Note 1, pressed the S+ bar on initial test). Thus, the TBR females on test showed little evidence of an S+ directed response on the basis of S - S learning.

While TBR females did not as a group press the S+ bar, they did, however, press one bar or the other fairly consistently, with only one female not pressing a bar within 5 minutes of test entry. Indeed, although responses were as often directed at S- as at S+, females responded quickly upon test entry, with a median latency of 33 sec (the median latency for TBR males was 49 sec).

TBR females reached reversal criterion in a mean of 410.8 trials (TBR males reached criterion in 192.2 trials, Table 2). Although it took females many more trials to learn the go/no-go reversal, the females on test performed like the males in that they did not reverse. As a group, TBR females pressed the S+ bar only 52% of the time, however, those females that consistently pressed a bar on the first set of test trials, continued to do so on reversal whether that stimulus was the S+ or the S-. Thus, again, S - R learning (consistent responding to a particular bar) directed responding on test. TBR females, like males, failed to reverse on test on the basis of S - S learning. Unlike males, though, TBR females as a group consistently failed to approach the S+ bar in Phase 3 and 5.

In contrast to the performance of TBR females, which was markedly discrepant from male TBR performance on most measures (trials to reversal criterion, initial test trial performance, and mean test performance), Group RBT females responded simiarly to males on at least some measures. RBT females' mean percent response to the new S+ (old S-) in Phase 3 was 82% (range from 60 to 100 percent), as compared with a mean of 92% for RBT males (range from 90 to 100 percent). Males were somewhat superior to females on test performance. Clearly, though both RBT males and females reversed on the basis of S - S learning.

Moreover, RBT females, like RBT males that reached reversal criterion on the go/no-go discrimination a second time (Phase 4), failed to reverse on test, responding instead to the old S+ on 82% of the test trials. After intervening S - R trials both sexes failed to reverse on the basis of S - S learning in the tunnel.

Thus, an S - R interpretation of the reversal data from the model-absent observational learning situation fits for both sexes. As described earlier, the persistence of a directed response after repeated testing is presumably due to the absence of a competing response in the stimulus context of the test chamber. There remains, however, another plausible explanation for the difference between groups RBT and TBR on reversal performance. Only group TBR received 120 overtraining (booster) trials prior to reversal. It is possible that the overtraining affected reversal performance both in terms of trials to reversal criterion and test trial performance. Group TBR learned the go/no-go reversal in a mean of 410.8 trials, and Group RBT learned the reversal in a mean of 395.2 trials. This small difference was not significant (Mann-Whitney Two-Sample Test, $\underline{p} > 0.1$). The overtrained group (TBR) did not reverse on test, whereas Group RBT did reverse on initial test. A more direct test of the effect of 120 overtraining trials came from comparing results of Group C-TBR (without 120 booster trials) with TBR. Like the TBR group, females in C-TBR failed to show consistent S+ directed responding on test trials (mean of 56.3% correct in Phase 3 and 63.7% in Phase 5). No significant differences were found between C-TBR and TBR in either the number of trials to reversal criterion on the go/no-go discrimination or in the test trial performance following reversal (Mann-Whitney

Two-Sample Test, $p > 0.1$). Nothing significant about reversal performance is accounted for by the 120 overtraining trials.

Although extended training (via the go/no-go reversal) improved RBT female performance on test, the fact remains that sex differences in S+ directed performance were clearly found across groups. Males show a more persistent response attachment to a particular stimulus in a particular place on the basis of S - S observational (cognitive) learning. This finding is consistent with work on search strategy with chicks and mice (Andrew, 1972, 1975; Andrew & Rogers, 1972). In these studies testosterone has been shown to increase persistence in search for both a particular type of food and in a particular place. Such persistence includes decreased distractibility coupled with an increased ability to sustain attention on a particular localized stimulus. A wide variety of different experiments lead to the conclusion that with the manipulation of testosterone, the central specifications used in recognition of a particular stimulus are likely to remain more persistently in use once activated. Comparable effects of androgens on cognitive abilities have been reported in humans, so that mechanisms of widespread importance in higher vertebrates may be involved. For instance, there is reason to suspect that gonadal steroids may influence certain cognitive skills - males perform better than females on spatial measures and these sex differences do not generally emerge until after puberty (Harris, L.J., 1978).

The results of Experiment 1 (position cues controlled) and Experiment 2 with females were similar in that Group TBR subjects failed to show S+ directed responding. This finding suggests an alternative explanation. It could be that exploratory responses in the test chamber had not habituated by the time TBR and C-TBR females reached discrimination criterion (less exposure to stimulus situation) so that these alternative responses were in direct competition with the S - S directed barpress response. The inconsistent responding observed on test in Groups TBR and C-TBR is in keeping with this interpretation. In further support of this interpretation, Group RBT females given extended exposure to the situation prior to test responded to the S+ on 82% of the test trials. This extended exposure (from a lengthy reversal) meant that subjects had brief but daily access to the test chamber when placed in and removed from the apparatus. This exposure could have habituated any exploratory responses prior to test. Thus responses in direct competition with barpressing were eliminated.

However, not all the data fit this interpretation. The females did not obviously explore the test chamber prior to barpressing. The short latencies to barpress on test in TBR and C-TBR subjects indicate a "directedness" to their responses and a lack of competition from other responses. Also only 2 females out of 13 tested before reversal (TBR and C-TBR combined) failed to press a bar, as opposed to half the TBR subjects in Experiment 1.

There is yet another possible explanation for the sex difference observed on test. The females required a longer period of pretraining-including more magazine training trials and extended training to shape the observing response. If during this extended pretraining all the stimuli in the chamber were effective or relevant cues (all predictors of reinforcement), then such training could retard subsequent discrimination training where the brunt of stimulus control must be on one element. Blocking by the background cues could occur. Indeed, a number of pretraining manipulations have been shown to interfere with the acquisition of a directed response (Downing & Neuringer, 1976; Engberg, Hansen, Welker, & Thomas, 1972; Tomie, Murphy, Fath, & Jackson, 1980; Wasserman, 1972). As there is no way of testing the tenability of this explanation from the data gathered in Experiment 2, Experiment 3 was designed to systematically manipulate amount of pretraining.

EXPERIMENT 3

The amount of magazine training during pretraining has been demonstrated to be an important variable in the acquisition of a directed response (Downing et al., 1976; Engberg et al., 1972). Magazine training exposes the subject to unpredictable presentations of the US, and an excessive amount of such training interferes with the acquisition of directed responses.

Wasserman (1972), while examining the influence of cue redundancy on autoshaping, ran a no-cue pretraining group that received unsignalled food presentations during the first phase of the experiment (10 days, 400 trials). Then the group received keylight plus clicker trials followed by food. In this test phase, the no-cue pretraining birds pecked infrequently and autoshaping was greatly retarded compared to control groups. The birds typically paced back and forth in front of the response panel. Similar findings were reported by Engberg et al. (1972). They exposed their birds to many more grain presentations than Wasserman (approximately 900 grain presentations, on a procedure like Wasserman's no-cue group). The result of their manipulation was a significant retardation of autoshaping.

Downing et al. (1976) systematically varied the number of food-only presentations instead of employing only one value as was done in the previously cited studies. They were attempting to determine the form of the function relating number of preliminary food-only trials to how rapidly pecking would develop under autoshaping contingencies. Four groups of chickens received either 1, 10, 100, or 1000 presentations of grain in a hopper. The number of keylight-grain pairings before a bird first pecked the lighted key was found to be a U-shaped function of the number of prior food-only presentations, with pecks occurring significantly sooner after 100 food-only values. This result seems to explain why Mackintosh (1973) found no retardation effect of pretraining contrary to Engberg et al. (1972) and Wasserman (1972). Mackintosh (1973) gave approximately 200 magazine presentations to his food-only birds, which, according to the function from Downing et al. (1976) should not have retarded acquisition of autoshaping (although this comparison is across species).

Investigators have most often appealed to cognitive factors such as "learned laziness" (Engberg et al., 1972) in order to account for the deleterious effects of such pretraining on directed responses. Engberg interpreted "learned laziness" as a parallel phenomenon to "learned helplessness" in an appetitive situation. The conception was based on the premise that the retarded acquisition of autoshaping was a general transfer of training effect - a by-product of associative impairment from pretraining. That is, during pretraining the subject learns that the US is unpredictable. This learning transfers to the autoshaping situation, where it proactively interferes with the directed response.

Tomie (1976) has offered an alternative interpretation of these retardation effects based on the "blocking" phenomenon reported by Kamin (1969). Tomie suggests that pretraining with unpredictable US presentations may condition the static contextual stimuli present in the conditioning environment during pretraining. This excitatory context is then compounded with the illuminated key CS during autoshaping, where it exerts a blocking influence that results in the retardation of acquisition. Empirical support for the context-blocking interpretation comes from experiments utilizing context-shift designs. The results of Tomie et al. (1980) casts some doubt on nonspecific transfer interpretations by demonstrating that retardation is context specific; gross changes in background contextual stimuli prior to initiation of acquisition tests completely alleviate deleterious effects of pretraining.

While the retardation of directed responses has been well documented, including the function describing the number of trials necessary to effect a retardation, work has been confined to studies with pigeons and chickens. There is no reason to expect that the function that determines the number of food-only trials needed for retardation of keypecking with pigeons and chickens would hold for barpressing with rats. Additionally, there is no reason to expect that a function derived from standard autoshaping studies would apply to the blocked autoshaping design employed here. Therefore, in order to answer the question of whether the extra pretraining given females in Experiment 2 actually retarded acquisition of the directed response, a new function must be determined for rats in the present observational learning situation.

Method

Subject. Sixteen naive male albino rats approximately 150-200 days old at the start of training served as subjects. Rats were housed under the same conditions as subjects in Experiment 1. Deprivation levels were also the same as for subjects in Experiment 1.

Apparatus. The experimental chamber used in Experiment 2 was used in this experiment.

Procedure. The sixteen subjects were randomly assigned to four treatment groups. Half of the subjects in each group were trained to the right stimulus (bar and light) as the positive stimulus, and half were trained to the left stimulus (bar only) as the positive stimulus. During the first session, rats were allowed to explore both halves of the observation apparatus with the bars inoperable. At least ten 97 mg Noyes pellets were available in the food tray during exploration. Next 1, 5, 35, or 100 food-only trials were scheduled according to a computer generated Poisson distribution of time intervals between trials. The distribution had a mean of 10 seconds and a range of 1 to 60 seconds, i.e., food was presented independently of behavior on the average of six times per minute in the tunnel with the door closed. The number of food-only trials given to the treatment groups was determined from pilot data which indicated that 100 trials did retard the acquisition of the directed response. The first session with the food-only presentations ended after the required number of trials was presented.

The observational phase of training began in the next session and continued as in previous experiments until the discrimination criterion was met. All animals were tested following observational training. No overtraining or booster trials were given on test days - that is, all animals were in Group C-TBR. Subjects were not reversed, however, as the question of interest was the affect of pretraining manipulations on initial acquisition and test. The number of trials to criterion and performance on test trials were the major dependent variables.

Results and Discussion

Table 5 summarizes the performance of subjects on discrimination trials and test trials in Experiment 3. A Kruskal-Wallis one way analysis of variance by ranks was conducted on the dependent measure, trials to criterion, for the four groups (Siegel, 1956). Results confirmed that amount of magazine training (at least within the range of values measured) did not significantly affect the number of trials to criterion in the go/no-go discrimination: $H (3) = 1.93566$, $p > 0.25$. As can be seen in Figure 2, performance on the CS+ and CS- trials differed as a function of the number of pretraining trials. All subjects in Groups 1, 5, and 35 were responding reliably ($\geq$ 70% correct) on CS+ trials within 80 trials, as compared with Group 100 with only one subject responding reliably within 80 trials. Clearly, conditioning to the CS+ is retarded during the observational phase, and the magnitude of this retardation is directly related to the number of US-only trials. Such data are consistent with a blocking interpretation. However, evidence of blocking is camouflaged when the overall discrimination criterion is used for analysis because of the overall lack of responding to either stimulus in Group 100.

Figure 3 shows that the number of pretraining trials was a significant factor in test trial performance. As a result of pretraining trials 1-35, performance increases monotonically, as shown by a significant positive correlation between the logarithm of the number of pretraining trials and the number of correct responses ($r = 0.48$, d.f. = 10, $p = 0.05$, one-sided). One hundred trials produces a

Table 5

Performance of Subjects Grouped by Number of Pretraining Trials

Group	Subject	Trials to Criterion (S+ direction)	Percent Response to S+
1 - US Only	A-108	220 (R)	80%
	A-203	315 (R)	100%
	A-503	380 (L)	90%
	A-305	235 (L)	0%
	Mean	287.5	67.5%
5 - US Only	A-604	268 (R)	100%
	A-306	415 (R)	90%
	A-603	227 (L)	90%
	A-605	255 (L)	70%
	Mean	291.3	87.5%
35 - US Only	A-202	314 (R)	90%
	A-602	325 (R)	80%
	A-601	260 (L)	100%
	A-304	320 (L)	90%
	Mean	304.8	90%
100 - US Only	A-107	180 (R)	60%
	A-101	160 (R)	10%
	A-502	282 (L)	0%
	A-501	320 (L)	10%
	Mean	235.5	20%

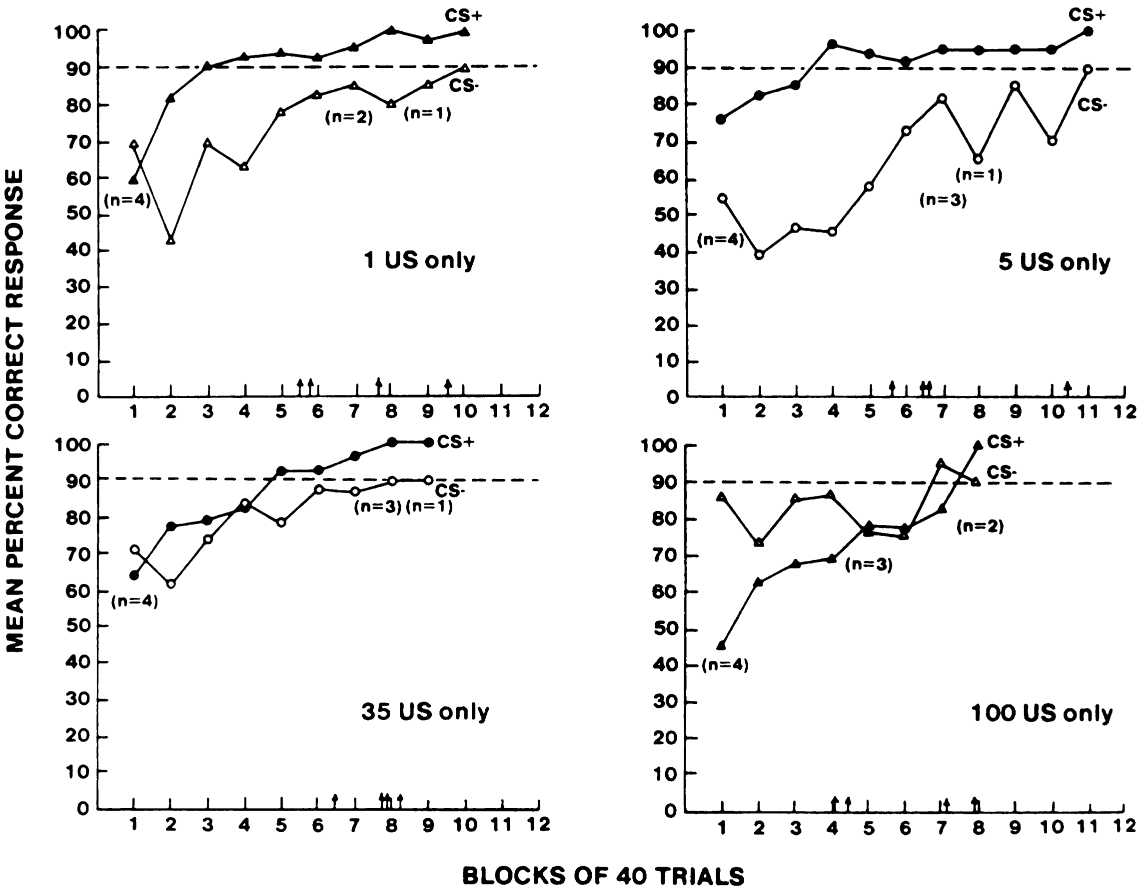

Figure 2. Mean percent responses on CS+ and CS- trials for each of the four groups in Experiment 3. The n represents the number of subjects used in calculating the mean percent correct for that block. The arrows indicate when subjects reached overall criterion. Subjects reaching criterion within a 40 trial block were included in calculating the mean for that block.

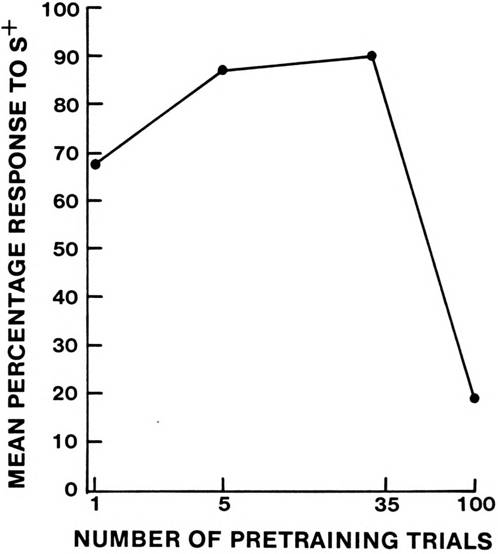

Figure 3. Mean percent correct response on test as a function of the number of pretraining food-only trials. Note abscissa is plotted on a logarithmic scale.

significant retarding effect when compared with 35 pretraining trials (Mann-Whitney Two-Sample Test, $\underline{p} < 0.01$).

From the results of Experiment 3, it seems doubtful that the differences found on test performance in Experiment 2 can be explained by "blocking" from contextual cues since even the most difficult females received fewer than 35 food-only trials. In fact, from the data in Experiment 3, females requiring more than 5 pretraining trials, up to 35 trials, might have actually shown increasingly better performance on test.

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