APPROACH LEARNING AND EXTINCTION AS A FUNCTION OF AVOIDING PREDATORY ATTACKS

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ABSTRACT

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by Joseph Weldon Jennings, Jr.

This thesis presents a model for approach learning and extinction in prey organisms as a function of repeated predatory attacks, a method for testing the model, and data that bear on the model.

The learning model involved the assumption that the basic task confronting the prey organism is to learn to approach a region of the environment to obtain needed reinforcement (water) and then flee this same region to avoid the direct physical attack of an approaching predator. The response of approaching the goal, it was argued, is conditioned to the stimuli accompanying the emotional responses of fear and frustration.

Fear is elicited by the operation of the predator. After a sufficient number of approaches to the goal region, fear-produced stimuli serve as partial discriminative stimuli eliciting the approach response.

Frustration is elicited by the termination of positive reinforcement necessitated by the prey leaving the source of reinforcement in order to avoid the predator's attack. As

with fear, after a sufficient number of approaches to the goal region, frustration-produced stimuli serve as partial discriminative stimuli eliciting the approach response.

Two hypotheses were derived. Both concerned resistance to extinction of the approach response. The first hypothesis predicted that prey without prior experience in approaching the reinforced region under threat of predatory attack would show less resistance to extinction than had they had such prior experience. The second hypothesis predicted that prey allowed less time in the goal region (3 seconds) prior to the onset of predatory attack would show more resistance to extinction of the approach response compared to prey having more time in the goal region (11 seconds) prior to predatory attack. Both hypotheses were supported by the results.

The apparatus used in the three experiments involved a safe box in which the prey (female, hooded rat) was safe from any attack. This safe box was connected with the goal region by a 3 foot enclosed alley. The goal region was actually a three foot continuation of the alley with water available just within the region. At the farthest end of the goal region was the predator. The predator was a 4 inch aluminum disc carrying 11,000 volt, .001 ampere charge on its surface. The electrical charge was produced by an automobile ignition coil. This mechanical predator was

propelled the length of the goal region and alley in pursuit of the prey. If the prey allowed the mechanical predator within 1/8 inch of itself it received a shock. The prey would continue to be shocked until it moved faster than the predator on the way towards the safe box.

Each subject (prey) was run individually once a day for ten minutes. During a session, various measures of the subject's behavior were taken. These measures included: Number of traversals between the safe box and the goal region; the time spent in the safe box, alley and goal region during a session; the number of shocks received; and amount of water consumed.

Suggestions were made for the extension of this work to further laboratory analysis of prey-predator situations and to field work in this area.

Approved M. Ray Denny
Committee Chairman

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By

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In more ways than I can recount, this thesis was made possible by my wife's unstinting love. Carolyn is the author of my happiness and achievements.

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INTRODUCTION

This research deals with possible acquired changes in the behavior of prey organisms under repeated exposure to attack by a predator. A body of literature exists on the subject of prey reactions to predators but it has little relationship to acquired changes, particularly under controlled conditions. There is a lack of data for several reasons. One is that most observations which have any bearing on the topic have been made in the field, that is, under relatively uncontrolled conditions (Seton, 1953; Hediger, 1950; Elton, 1953). Also, these studies have often involved species-specific response patterns (Simmons, 1955; Melzach, 1961; Hinde, 1961; Curti, 1935). Further, in many of these studies the past history of the organism was unknown and could not be controlled (Griffith, 1920; Richardson, 1942; Joslin, 1964), What is wanted is a situation in which 1) the environmental and sequential aspects of the situation are known and controllable; 2) the same animal can be observed repeatedly.

Since the need for control is paramount, an apparatus was developed that was *assumed* to be an anologue of a situation in which a predator could confront a prey. The pilot apparatus as first developed involved, as does the final apparatus, three operationally distinct areas. These

were 1) the "safe box", analogous to the prey's lair, which consisted of a 5" x 12" high box. The prey (hooded rat) had easy exit and entrance to this "safe box" via a 3" hole near the floor. 2) This hole led directly into a 6 foot long alley 4" wide and 12" high (the "unsafe region"). 3) In the middle of the alley (3 ft. from either end) there was a dish containing approximately one ounce of water (the goal region). Thus the rat had to traverse three feet of alley to reach the goal region. At the farthest point from the "safe box", there was a 3½" hollow steel sphere carrying a high tension (10,000 volts), very low amperage charge on its surface. This sphere was suspended by an arm from a movable platform outside the alley which could be propelled the length of the alley up to ¼ inch of the "safe box" door. This sphere, its high tension charge, and its movement were *assumed* to be a mechanical analogue of a predator.

This apparatus defines the task for the water deprived rat, which was to learn to obtain water by moving from the "safe box" to the water dish and at the same time elude the mechanical predator. After a brief delay following *S's* entry into the goal, the mechanical predator begins to move down the alley. If the rat fails to return to the "safe box" in sufficient time and allows the mechanical predator to come 1/8 inch it receives a punishing shock. It then continues to be pursued and possibly shocked until it reenters the

"safe box".

One might justifiably ask why the presentation of apparatus details at this point. It is necessary for the reader to appreciate these details in order to understand the nature of the problem. The pilot work demonstrated that rats learned to cope with the conditions imposed by the apparatus as evidenced by an incremental increase in response rate (traversals between the "safe box" and the goal) while at the same time swiftly achieving an active avoidance of the mechanical predator at a probability in excess of 98%.

After an asymptotic response rate was achieved, the primary reinforcement (water) was removed in order to observe the rate of extinction. This was done for more than curiosity's sake. There was reason to believe that the animal might show greater resistance to extinction than a group of animals which had equal access to the water but had not learned to cope with the predator. Pilot work suggested that this was a valid expectation under the conditions imposed by the apparatus.

Frustration. The role of frustration and frustration produced stimuli in resistance to extinction will be considered first. Under the conditions imposed by the apparatus, frustration is present during both acquisition and extinction.

During the acquisition the rat must leave the goal to escape or avoid the mechanical predator. Leaving the goal region results in the termination or withdrawal of reinforcement. Ferster (1957, 1958) found that stimuli signaling "time out" from positive reinforcement acquire aversive properties. He also showed that the withdrawal of a positive conditioned reinforcer had the functional properties of a negative reinforcer, i.e., suppressing the rate of responding. Therefore, the rat is assumed to be frustrated each time it must leave the goal at the approach of the mechanical predator.

On each trial, then, the rat will respond by being frustrated. We might, therefore, expect that stimuli of the goal region will become cues capable of eliciting frustration response in the rat as it approaches the goal. Thus, after repeated trials, the rat may develop a conditioned anticipatory frustrations responses to the approaching goal cues. But, through repeated approach responding, the stimuli produced by the anticipatory frustration response should become partial discriminative stimuli for the goal approach response. In other words, at least late in acquisition training, the stimuli generated by anticipatory frustration will become cues eliciting continued approach to the goal.

Therefore, when primary reinforcement is discontinued in extinction, rats which have learned to approach the goal in response to frustration produced cues will be more resistant to extinction than to rats which have not been frustrated in their attempts to obtain water.

Another way to say all this is as follows: Nonreinforcement of the approach response during extinction elicits frustration response, but, if frustration-produced stimuli have already become conditioned elicitors of the approach response, then the frustration engendered by nonreinforcement is less effective in eliciting responses incompatible with continued approach. In other words, because frustration produced internal stimuli occur in both acquisition and extinction, the two conditions are less discriminable to the rat than had it not experienced frustration during acquisition.

Such arguments as the preceding have been put forward by Amsel (1958, 1962) and Spence (1960) to explain how partial reinforcement produces result in an increased resistance to extinction in instrumental reward situations. These workers have pointed out that the intensity of frustration elicited by nonreinforcement should increase gradually during acquisition as anticipatory reward increases. Under such conditions, <u>Ss</u> are less likely to show a passive avoidance response to alley and goal cues during extinction compared to <u>Ss</u> which have not had such training. Therefore, the termination of reinforcement which results as the animal avoids

the mechanical predator is viewed as having the same effect as partial reinforcement. That is, the intensity of frustration elicited by withdrawal of reinforcement should increase gradually during acquisition as anticipatory reward increases. Assuming that chaining back also occurs, then Ss will be trained such that anticipatory frustration will elicit responses which are compatible with the instrumental response. Thus, the internal emotional response of frustration elicited during extinction should result in greater resistance to extinction than would be seen in animals not originally trained to approach while at the same time being frustrated.

Fear. The mechanical predator represents a source of punishment if not successfully eluded. Therefore, any persistent responding on the part of the rat during extinction appears to be masochistic, as its behavior would seem to court disaster. Sandler (1964) has reviewed the problem of masochism and notes an unpublished observation by Mowrer (1950). A rat was trained to run an alley to escape an electrified alley; after training, the shock was administered only in a small area just prior to the escape box. The results indicated that keeping this small region electrified resulted in increased resistance to extinction even though the rat could have passively avoided any further shock by not running the alley. Gwinn (1949) found that rats trained like Mowrer's would run the alley faster and display greater

resistance to extinction than control rats that were not shocked during extinction.

Brown, Martin and Morrow (1964) were able to accentuate the effects reported by Mowrer and Gwinn. In two experiments, rats were trained to escape shocks in a starting box and alley by running down the alley into an uncharged goal box. During extinction, shock was no longer administered in the start box, but some groups received shock in part or all of the alley. Control rats were not shocked during extinction. In the first experiment attempted, the control and experimental groups performed alike, that is the experimental animals were not more resistent to extinction for being shocked during extinction. In the second experiment they changed the procedure so that the magnitude of extinction-shock and the number of escape trials were reduced. This was done to make the transition from acquisition to extinction less discriminable. Under these conditions the animals shocked during extinction took longer to extinguish than non-shocked control animals.

Azrin and Holz (Azrin, 1959, 1960; Azrin and Holz, 1961; Holz and Azrin, 1961) did a series of studies which have even greater significance for the present research. Their procedure was such that a positively reinforced response engendered punishment. The method involved the pigeon's pecking response in a key peck Skinner box. After the birds

responding was shaped and food reinforced on various schedules, shock of varying intensities and durations was administered as a second and additional contingency to key pecking. The data from Azrin (1960) indicates that pigeons will deliver shocks to themselves several hundred times to receive intermittent food rewards. Although several variations combine to produce this behavior, the results can be interpreted as indicating that shock under these conditions does little to interfere with typical intermittently reinforced responding.

Holz and Azrin (1961) report stronger evidence that pigeons may increase their response rates as a function of punishment alone. The subjects were run under two daily conditions. In one, the response contingency was a VI food reinforcement and CRF shock. The second involved extinction without the reinforcement-shock contingency.

Assume that punishment or cues associated with punishment elicit an internal response. The label for this internal response will be "fear". The internal response of fear is assumed to be involved in increased resistance to extinction of the approach response by the prey organism for the same reasons as were true for frustration. Namely,

1.) During acquisition, fear produced stimuli become conditioned elicitors for the approach response.

2.) Fear exists in both the acquisition and extinction

conditions, as do its attendent stimuli.

3.) Because of the presence of fear produced stimuli in both acquisition and extinction conditions, the two conditions are less discriminable for the prey animal than for an animal which has not experienced fear during acquisition.

Fear and Frustration Compared. A study by Brown and Wagner (1964) provides support for the functional similarity of "fear" and frustration. Three groups of rats were trained in a simple runway. During acquisition, Group 1 was exposed to nonreinforcement on a 50% reward schedule. Group 2 was exposed to gradually increasing punishment along with consistent food reward. Group 3 was never punished or nonreinforced. Half of each group was then tested for the decremental effects of either consistent nonreinforcement or consistent punishment. Group 1 and 2 Ss were more resistant than Group 3 Ss not only to the decremental variable which they had been trained on, i.e., punishment or nonreinforcement, but also to the alternate test variable. These results were interpreted in support of a commonality between the emotional consequences of punishment and nonreinforcement. The results showed that responding for food and shock was greater than for neither. More importantly, the behavior was maintained even when the food reinforcement was withdrawn from the first condition. In fact, delivering shock alone during the

second or extinction condition resulted in an increased rate of responding.

To quote Holz and Azrin (1961), "These experiments demonstrate that a relatively severe punishment can increase responding...This procedure of selectively pairing a stimulus with a reinforcer is the usual procedure for establishing a discrimination. This discriminative property that the punishment acquired produced the apparent anomaly. Indeed, the discriminative property came to exert an even greater effect on responding than did the aversive property." (p. 231)

A quote from Brown and Wagner (1964) serves to clarify the common effects of "fear" and frustration on resistance to extinction. "If there is more than a conceptual similarity between the emotional responses of fear and anticipatory frustration, it would be reasonable to expect some degree of transfer of behaviors learned in the presence of one to occasions when the other is aroused. Thus it might be expected that <u>Ss</u> which have learned to approach in the presence of anticipatory frustration would also persist in approaching in the presence of fear. Likewise <u>Ss</u> trained to approach in the presence of fear might be expected to continue to approach in the presence of anticipatory frustration. In this context, the present findings of a partial transfer between the learned resistances to punishment and

extinction would argue for a degree of commonality between the two emotional responses." (p. 507)

The reasons for a "partial transfer" rather than a complete transfer observed by Brown and Wagner can be clarified by Carlsmith's (1961, reviewed by Church 1963) study. Carlsmith found that the mean number of trials to a criterion of extinction was uninfluenced by the conditions of punishment (shock or loud sound) but there was a large and significant interaction. If the same aversive stimulus was used as a punishment that was used as a UCS for avoidance training, resistance to extinction was much greater than if the other aversive stimulus was used as punishment. This was interpreted as supporting a discrimination hypothesis. Thus facilitation may occur in cases of punishment of negative instrumental acts because of a reinstatement of specific stimuli present earlier in training.

Therefore, we may view the effects of the type of situation proposed for study as involving the simultaneous conditioning of the internal responses of fear and frustration. Both internal responses appear to work in concert to facilitate resistance to extinction since the animal has been trained such that the anticipatory responses of fear and frustration elicit responses compatable to continued approach to the goal. Also, since the anticipatory responses should be developing a pace under the same external stimulus

conditions, anticipatory responses of fear and frustration should be elicited by the same external stimuli.

Thus the situation confronting the rat or other animal can be viewed as involving fear and frustration as internal responses. After sufficient experience stimuli concomitent with these responses came to elicit responses compatable with approach to the goal region. Therefore, resistance to extinction, should be greater in animals which have had the experience of learning to cope with the repeated attacks of a predator compared to those which have not had to learn to cope with a predator.

Predator. To say that the prey must learn to cope with the predator, is to say that the prey learns to deal effectively with the actions of the predator. The predator's action towards the prey is labelled "threat".

The predator can be conceived of as representing two types of threat to the prey. One is potential, the other actual. That is, the animal can behave differentially depending upon behavior of the predator. The animal must move towards the mechanical predator ot obtain reinforcements. It is therefore exposing itself to potential threat. The potential aspect refers to the fact that the mechanical predator is not waiting beside the water source to spring instantly upon the rat. It is at a distance from the rat and begins to approach the rat only after the rat has arrived

at the water source. Once the mechanical predator is in motion the threat is termed "actual" rather than potential.

The above view of the dual mode of predator action finds support in Keehn's (1959) work. Keehn's study involved an avoidance situation (rats were held in an electrifiable activity wheel) where interval responses served to postpone the onset of the next trial. Animals were trained with and without a warning signal. Those animals which received the warning signal were free to postpone the onset of the signal as well as the shock. What Keehn found was that the animals supplied with a warning signal behaved so as to postpone the shock but not the warning signal. He argued that the signal was not a secondary negative elicitor. Rather, the signal had the properties of a discriminative stimulus because it marked the time in which the appropriate avoidance response would be reinforced.

Keehn's work resembles Sidman and Boren's (1957) although Sidman and Boren's was not as well controlled. They gave their animals considerable avoidance training before the signal was introduced. Sidman and Boren interpreted their results much as Keehn did by suggesting that the discriminated avoidance situation may be considered a multiple schedule in which one avoidance contingency prevails in the presence of the warning stimulus and another in its absence. Thus in the situation where a specific stimulus precedes a noxious event, such as the sights and sounds of the mechanical

predator as it ceases to be a potential threat and becomes an actual threat to the rat, this stimulus comes to distinguish between occasions when avoidance responses will be reinforced and when they will not. For the analogous prey-predator situation, an avoidance response prior to the onset of actual threat should be punished by too early a termination of reinforcement. That is, the animal should learn to stay at the source of primary reinforcement at least until the warning signal of an approaching predator has been perceived.

Additionally, a study by Melvin and Brown (1964) may possibly indicate that even the onset of the predator's approach might not be sufficiently aversive to immediately elicit the avoidance response. In this study a noxious bright light preceded food delivery to rats, for 20, 40, or 80 pairings. After this training, the light was then used alone in an escape learning test. It was found that light-food pairings diminished the light's aversiveness, the effect increasing with frequency of pairings. Loss of aversiveness was attributed to the light's having acquired tendencies to elicit food seeking which competed with escape responses. As an example of a competing response incompatible with escape responses, Melvin and Brown site a locomotor movement toward the former location of the food cup at the back of the apparatus; in other words movement in a direction opposite that necessary to escape.

Resistance to Extinction. By invoking a competing response explanation of resistance to extinction, it is possible to understand why the organism may persist at the source of the primary positive elicitor at least up to and possibly slightly beyond the onset of the actual threat from the approaching predator. Therefore, it seems reasonable to suppose that the effects of frustration and fear compete with the development of a passive avoidance response to the cues of the alley and goal regions.

The terms, "frustration" and "fear" are considered internal responses elicited in the organism by external stimuli that may be labeled negative elicitors, i.e., potential and actual threat and the termination of a primary positive elicitor. The effect of the frustration and fear on overt behavior may be comparable, as Melvin and Brown (1964) have indicated. Therefore, in effect, fear and frustration may be classed together as internal response normally antagonistic to the internal response of relaxation as hypothesised by Denny and associates (Denny and Adelman (1956); Denny and Weisman (1964)). This view of "frustration-fear" is in accord with Amsel's (1962) proposition that extinction is an active not a passive process. It is an active process mediated via discriminable internal stimuli.

Also, it is maintained that the internal response produced stimuli, generated within an animal by external

stimuli which have fearful and frustrating associations can be discriminitive stimuli eliciting continued approach towards the situation associated with potential threat of punishment and withdrawal of reinforcement. Therefore, in the prey-predator analogue, the nonreinforcement of approach responses in the face of threatening cues should result in greater resistance to extinction in animals which have previously learned to approach threatening stimuli than in animals which were previously able to obtain primary reinforcement without fearful or threatening consequences.

Further, an internal response of fear-frustration is viewed as a continuous variable. That is to say, the fear-frustration response may vary in magnitude. While a certain magnitude of fear-frustration may become a conditioned segment of the approach response, an increase in the fear-frustration response over and above the conditioned level should provide responses which compete with continued approach.

Evenso, the increased magnitude of the competing fear-frustration response over-and-above the previously conditioned level should require some time to become contigiously associated with the external stimulus complex, especially the stimuli of the goal region. That is, extinction takes some time to occur as it takes time for the competing responses to build up. Possible support for this latter suggestion is found in a study by Denny (1959). In the first

of two experiments, two groups of rats were trained to press a bar one trial a day for 10 or 50 trials. Both groups were then given 75 extinction trials, one per day. A control group, with no prior training, was given 25 unrewarded trials, also one per day. The bar was always removed from the box as soon as S had depressed it.

During extinction, the latency of the bar-pressing response greatly increased for the control animals, but reached a low, stable, level in the two groups which had previously received either 10 or 50 reinforced trials. There was no evidence of extinction in these two latter groups.

In the second experiment, rats were trained to press a bar five trials a day until each *S's* latency was at least equal to the group in the first experiment which had 10 reinforced trials. They were then given extinction trials until a 3-minute no-response criterion was attained. But, the ITI in this case was 5 minutes not one day. Under these conditions, all *S's* extinguished in less than 60 trials.

Denny interpreted the results from this study as follows: 1.) bar-retraction immediately after discrete bar-pressing does not itself prevent extinction; and 2.) one trial a day, or at least highly spaced trials, is essential to the virtual prevention of extinction. "The importance of bar-restriction was definitely suggested, however, since E observed that approach to the ever present food tray extinguished during the non-rewarded trials even bar responding

did not." "One compelling observation by E in Experiment II was that on the trial or two just before S extinguished, all S's began to make vigorous attempts to escape from the box. An implication here is that frustration effects may accumulate with a 5-minute intertrial interval and become sufficiently strong to instigate competing responses." (p.85)

The implications of Denny's study for the present study lies in the similarity in conditions. Removal of the bar, in the Denny study, is viewed as similar to the animal's withdrawal from the goal region compelled by the "actual threat" of the approaching mechanical predator. During extinction, the conditioning of competing frustration responses to the goal stimuli will be impeded if the animal must quickly avoid the oncoming mechanical predator. On the other hand, if the prey organism is permitted to spend increased time in the goal region the cues of the goal region would become elicitors of the frustration response and thereby hasten extinction.

General Considerations. To summarize the intent of this study is to impose experimental control on an assumed prey-predator situation where the temporal and environmental aspects of the situation are known. Of equal importance is the fact that the behavior of the prey animal can be repeatedly observed and recorded. Through manipulation of factors controlling resistance to extinction, an attempt will be made to understand how the prey organism learns to

to cope with a situation involving potential and actual threat of predation.

The experimental apparatus regardless of claims to an analogy to the naturally occurring situation, could actually be considered a conglomerate of familiar laboratory apparatus. Indeed, the experimental apparatus involves aspects very similar to those found in a shuttle box, a straight alley, and perhaps an obstruction box.

Considered in another light, it should be remembered that many animals have lairs, burrows, or nests. They must forage to stay alive for rarely are the needs of the organism met without leaving the nest. By foraging, the animal exposes itself to predators. Also, in the competition with other members of its own species, they (the prey organism) must take maximal advantage of the limited sources of sustenance available to it (Wynne-Edwards, 1963; Calhoun, 1962). The complexity of the naturally occurring situation dictates the use of a laboratory situation paralleling the natural in its essentials.

Because of the temporal and spatial sequences of events, the prey-predator situation can also be characterised as involving "approach-then-avoid behavior." The study of avoidance behavior, from the outset, has been viewed by some workers as having a direct bearing on the prey-predator situation. As Pavlov (1927) has noted, "The strong carnivorous animal preys on weaker animals, and if they waited to defend themselves until the teeth of the foe were in their flesh, would speedily be exterminated. The case takes on a different aspect when the defense reflex is called into play by the sights and sounds of the enemies approach. Then the prey has a chance to save itself by hiding or by flight" (p.14). Hull (1934) also referred directly to this topic when he wrote, "In the violent struggle for existence pictured by organic evolution.... those animals which responded by flight and other defense reactions in advance of injury would be far more likely to escape and hence would have immensely greater chances of survival and ultimate reproduction than would animals which did not possess such a tendency." (p.434).

HYPOTHESES

From the foregoing considerations, two hypotheses were formulated even though this study is quite explanatory in format.

1. In the prey-predator analogue, the prey which had previously learned to approach threatening stimuli in order to obtain positive reinforcement shows greater resistance to extinction than an animal which had obtained the same positive reinforcement without fearful or threatening consequences and/or without being forced to leave the goal region prematurely (because of threat).

2. In the prey-predator analogue, the prey which had previously learned to approach threatening stimuli in order to obtain positive reinforcement shows greater resistance to extinction if forced to leave the goal region sooner (because of threat) than a prey which is not forced to leave the goal region as soon.

EXPERIMENT I

Method

Subjects. The Ss were 5 naive female hooded rats from the colony maintained by the Department of Psychology of Michigan State University. All Ss were 110 days old at the start of the experiment.

Beginning two weeks prior to the start of the experiment, each S was handled for five minutes a day. Beginning one week prior to the start of the experiment, Ss were placed on a water deprivation schedule of ten minutes of access to water in the individual home cages every 24 hours. Food was constantly available.

Apparatus. An isometric drawing of the apparatus is presented in Figure I, together with labels for the major apparatus components. The major component of the apparatus consisted of a long, rectangular box measuring 8 feet long by 5 inches wide and 2 feet high. This box was closed at both ends; at one end by a fixed end wall, at the other by a hinged door which swung outward and downward from the top. All four sides of this box were constructed of 1/8 inch Masonite with the finished surface facing inward.

This Masonite box was firmly mounted to the top and to one side of a very rigid box platform. This platform measured 8 feet long by 1 foot wide by 5¼ inches high and was constructed by 3/4 inch plywood for the top (which also

served as the bottom of the Masonite box) and 3/4 inch finished pine planking on four sides.

Two rectangular frames were rigidly attached to the platform. One frame was attached to the platform 22-3/4 inches from the end with the hinged door. The frame consisted of two 3/4 inch by 5 3/4 inch pine uprights, one on either side of the platform, rising 29½ inches. The tops of these uprights were connected by a 13 5/8 inch, 3/4 by 5 3/4 inch piece of pine. At the opposite end of the platform was the other and identically constructed frame although it was not inset from its end of the platform. The opening formed by this frame and the end of the platform was covered by a sheet of ½ inch plywood. This made the frame especially rigid and formed a vertical mounting surface for an electric motor. The motor was a 115 volt D.C., .60 ampere, 1725 rpm, 1/20 h.p., NSH-33, reversable Bodine. It was mounted so that its shaft was 20½ inches from the top of its plywood base with its shaft lying horizontally. A 5/8 inch pully was attached to the motor's shaft. The current for the motor was supplied by a variac to control motor speed and a full-wave bridge rectifier.

The various superstructures of the apparatus were attached to the horizontal, overhead members of the two upright frames. This included a pulley and belt system, microswitches, the track for the mechanical predator and

a mirror. The overhead part of the mechanical predator depended from a 6 foot track consisting of a sliding closet door track of extruded aluminum (Sears Catalogue No. 99A60073L).

Under this arrangement, two feet of the Masonite rectangle was not between the two upright frames. This segment of the larger box was the "safe box" and was physically separated from the remainder by a 22 inch high partition with a 2½ inch diameter hole with the bottom edge of the hole 2 inches from the bottom of the partition. This hole communicated to the remaining 6 foot segment of the box. On the other end of the safe box was the previously mentioned hinged door.

The mechanical predator was drawn to and fro along the overhead track via a long loop of high tensile strength cotton string attached by screw eyes to either end of the overhead component of the mechanical predator. This loop of string ran immediately under the track and was guided by pulleys around the ends of the horizontal segments of the uprights and over the top of the track. At the end of the run on which the electric motor was mounted, the string loop was driven by a ½ inch diameter pulley. This pulley was connected by a short shaft to a 1 1/8 inch pulley which was driven through a 21 inch rubber belt from the pulley mounted on the motor shaft.

The movement of the mechanical predator up and down

the 6 feet of the alley was controlled by two microswitches (Micro V4-14). Each switch was suspended over the inner edge of the upright frames by angel brackets. They were actuated by rotational force, so from the shaft of each switch a finger of flexible piano wire hung down into the path of the overhead component of the mechanical predator. The resting position of the mechanical predator was at the end of the alley opposite the safe box. To place it in operation, E momentarily depressed a hand held switch which locked closed a relay supplying current to the electric motor. On reaching the safe box end of the track the mechanical predator deflected the finger actuating the microswitch at that end. This action unlocked the first relay and locked on a second which fed a reversed current to the armature of the electric motor. The mechanical predator, therefore, reversed direction and returned towards its starting position. Just before reaching this end of its track, the mechanical predator deflected the finger from the other microswitch which unlocked the second relay and opened the circuit to the electric motor, thus stopping the mechanical predator until its cycle was begun again by E.

The mechanical predator consisted of two connected components, an overhead apparatus and another at floor level. The latter component was what the Ss had direct

interaction with. A drawing of the complete unit is to be had in Figure II. The overhead component consisted of the four, wheeled track runners supplied with the closet door track. Two runners were hung in the two parallel J-troughs of the track. The two runners in each track were separated on 5 inch centers and ran in opposed pairs front and back. Mounted between the track runners with its bottom surface flush with the bottom edges of the runners was a 7 inch long, 1 7/16 inch wide and 1 5/8 inch high block of pine. Mounted flush to the bottom of the block was a piece of ¼" Masonite measuring 7 inches long by 3 7/8 inches wide in the horizontal plane. Suspended below this horizontal Masonite platform by encircling Masonite mounts was a 6 volt, Allstate ignition coil (Sears catalogue No. 28A8240). The coil was mounted so that its long axis was aprallel to the floor of the alley, its electrical terminals projected towards the safe box end of the alley, and its bottom was flush with the back edge of the Masonite platform from which it hung.

Projecting downward from the horizontal Masonite platform was a 17 inch, 1/8 inch diameter bronze rod. The rod hung from a point 3/4 inch from the front edge of the Masonite platform and 2 3/8 inches from either side wall of the alley. This placed the rod directly in front of the high tension electrode of the ignition coil and was

connected to this electrode by a coil spring assuring good electrical conduction and a fatigue free linkage. This bronze rod thus conducted high voltage current downward to the lower component of the mechanical predator.

The lower component consisted of a 4 inch, 12 gauge aluminum disc lightly sprayed with flat white paint for increased discriminability by S. The disc was bolted to an additional threaded inch of the bronze rod bent at a right angle to the vertical segment and pointing forwards towards the safe box end of the alley. The mounting hole of the disc was in its exact center. Thus the flat surface of the disc was perpendicular to the floor and facing the safe box end of the alley.

The 6 volt current was supplied to the ignition coil from an Allstate battery charger (Model No. 608.N600) first being fed through a Motorola automobile radio vibrator (Type 48B522000). The current was fed to the overhead component of the mechanical predator from a fine gauge, insulated, twin lead hanging from the top of a 2 inch wide, 1 inch thick, 43 inch high post fastened 63 inches to center from the safe box end of the platform. The twin lead wire was 40 inches in length and was connected to the mechanical predator by a vertical stand off with an arm projecting over the side of the alley. This system allowed positive electric supply to the coil without twisting or stretching the wire or allowing it to foul the mechanical operation of the predator.

This system was capable of delivering a 11,600 volt, .001 ampere shock to the *Ss* if they allowed the disc within 1/8 inch of any part of their bodies as voltage at this pressure was quite capable of arcing through the *Ss* hair. This shock punished *S* for failure to avoid in sufficient time. The shock was assumed to be roughly analogous to the effects of the teeth and claws of a predator on the *S's* body without the necessity of actually producing lesions of the skin.

The floor of the apparatus on which *S* actually moved consisted of ¼ inch hardware cloth. In the 6 foot alley this floor was formed by bending down the edges of a 6 foot run of hardware cloth so that the surface was raised 1 1/3 inches above the wooden bottom of the alley. This provided a self-cleaning surface besides being an electrical ground when *S* received a shock.

The floor of the safe box was also formed of ¼ inch hardware cloth with an inch of additional material folded downward and slightly under for additional rigidity. This was done as this floor moved up and down by pivoting on fulcrums immediately outside of and to one side of the safe box.

The lever supporting the floor 2 inches above the wooden subfloor was formed from a 3/16 inch bronze rod. This

rod was bent into a 3 sided rectangle having two 7 inch short sides and a 16½ inch side. Three inches of each of the short sides projected past the fulcrums through the wall of the safe box to be attached to and support the hardware cloth floor. The remaining 4 inches of the short side and the connecting 16½ inches of rod were outside the safe box. With the fulcrums outside the safe box, *S* could not be in any position inside the safe box that would prevent tipping the floor downward. A minimum of 50 grams was necessary to tip the floor. The lever was counter balanced along the 16½ inches arm by a brass weight.

Resting in the middle of the 16½ inch arm was a pivoting mercury switch (an thus silent). The mercury switch was pivoted on a separate 2 inch arm. Thus when *S* was in the safe box the 16½ inch external arm raised and it tilted the mercury switch upwards. When this occured, the mercury switch opened a normally closed circuit to a recording pen on a four pen Gerbrands recorder (Model No. P24). This tilting floor and mercury switch system formed an automatic recording detector for the duration of the *Ss* presence in or absence from the safe box during an experimental session.

Another pen of the recorder automatically recorded the operation of the mechanical predator. A third pen was used to record the time spent in the "goal region". The

goal region was that part of the 6 foot alley beginning 33½ inches from the safe box and extending the remainder of the alley. The beginning of this goal region was marked for E's convenience by the front edge of a square of light orange cardboard lying on the wooden subfloor. This orange had about the same brightness, to E, as the surrounding wooden floor. By means of a hand held switch, E recorded, through the pen recorder, the time S spent in the goal region. E depressed and held the button when ever and as long as any part of S was in the goal region. By means of these recordings, a permanent, accurate record was formed of the number of safe box and goal region entrance and exits and the amount of time spent in each and in the alleyway connecting the two.

A stainless steel drinking tube projected into the goal region 2½ inches from the edge of the goal region or 36 inches from the safe box. The tube projected 1½ inches into the goal with its end 1 inch above the hardware cloth floor. The tube did not project directly through the side wall but through a recessed portal formed of translucent white plastic 2¼ inches in diameter and 7/8 inch deep. The drinking tube was suspended on the outside from a rubber stoppered graduated cylinder. Through this means, E could measure the amount of water an S consumed during a daily session.

In spite of the high walls of the apparatus and overhead superstructures, E could clearly observe Ss behavior in the apparatus through overhead mirrors. One mirror was mounted above the safe box, another over the alley.

The laboratory was well illuminated by diffused fluroescent lamps, but due to the geometry of the apparatus, the illumination inside the apparatus was reduced and further reduced by the low albedo of the interior walls. Table I gives the illumination in foot candles along the floor of the apparatus.

TABLE I

Illumination, in foot candles, of the floor of the apparatus measured at one foot intervals from the safe box end.

distance in	safe box				alley			goal region		
feet	0	1	2*		3	4	5	6	7	8
foot candles	2.0	1.8	1.6	1.8	2.8	3.6	3.4	3.2	2.6	1.2

*readings of 1.6 and 1.8 were made immediately on either side of the safe box wall, which was located at exactly two feet.

The entire apparatus was raised 20½ inches above the laboratory floor for E's convenience in taking Ss in and out of the apparatus and for observing Ss through the mirrors.

The running apparatus was in one room while all control circuitry, power supplies, and the pen recorders were in an adjacent room. The wiring connecting the two was fed

through a hole in the wall. This was done to isolate Ss from as much extraneous noise as possible; especially the circuitry chatter accompanying the recording of Ss various activities. Pilot work demonstrated demonstrated that abrupt noises tended to inhibit the Ss.

The operation of the mechanical predator produced noise. This noise was considered part of the stimulus complex signalling actual threat to the S. Below are two tables listing noise levels within the apparatus during the operation of the mechanical predator.

TABLE II

Noise levels, in decibels, recorded with the Noise Level Meter microphone beside the drinking tube. Readings were taken at one foot intervals as the mechanical predator moved towards the safe box. All readings include an ambient noise level of 72 db.

	goal region				alley		
distance in feet	0	1	2	3	4	5	6
decibels	78.0	79.0	77.0	77.5	78.0	78.0	78.5

TABLE III

Noise levels, in decibels, recorded with the Noise Level Meter microphone in the middle of the safe box. Readings were taken at one foot intervals as the mechanical predator moved towards the safe box. All readings include an ambient noise level of 72 db.

	goal region				alley		
distance in feet	0	1	2	3	4	5	6
decibels	76.0	78.5	76.0	76.0	78.5	77.0	77.0

Figure 1. Isometric drawing of the apparatus. The key to the numbered components is on the following page.

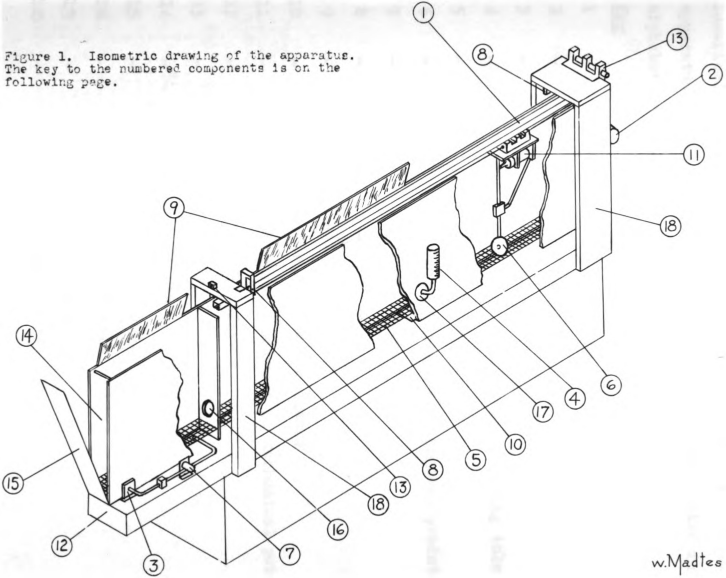


TABLE IV

Numerical key to the various components of the experimental apparatus shown in Figure I. The components are listed in alphabetical order.

Key		Component
1	-	aluminum track
2	-	electric motor
3	-	fulcrum
4	-	graduated cylinder and drinking tube
5	-	hardware cloth
6	-	lower component of mechanical predator
7	-	mercury switch
8	-	microswitch
9	-	mirrors
10	-	orange cardboard square
11	-	overhead component of mechanical predator
12	-	pine platform
13	-	pulleys
14	-	safe box
15	-	safe box door
16	-	safe box hole
17	-	tube portal
18	-	uprights

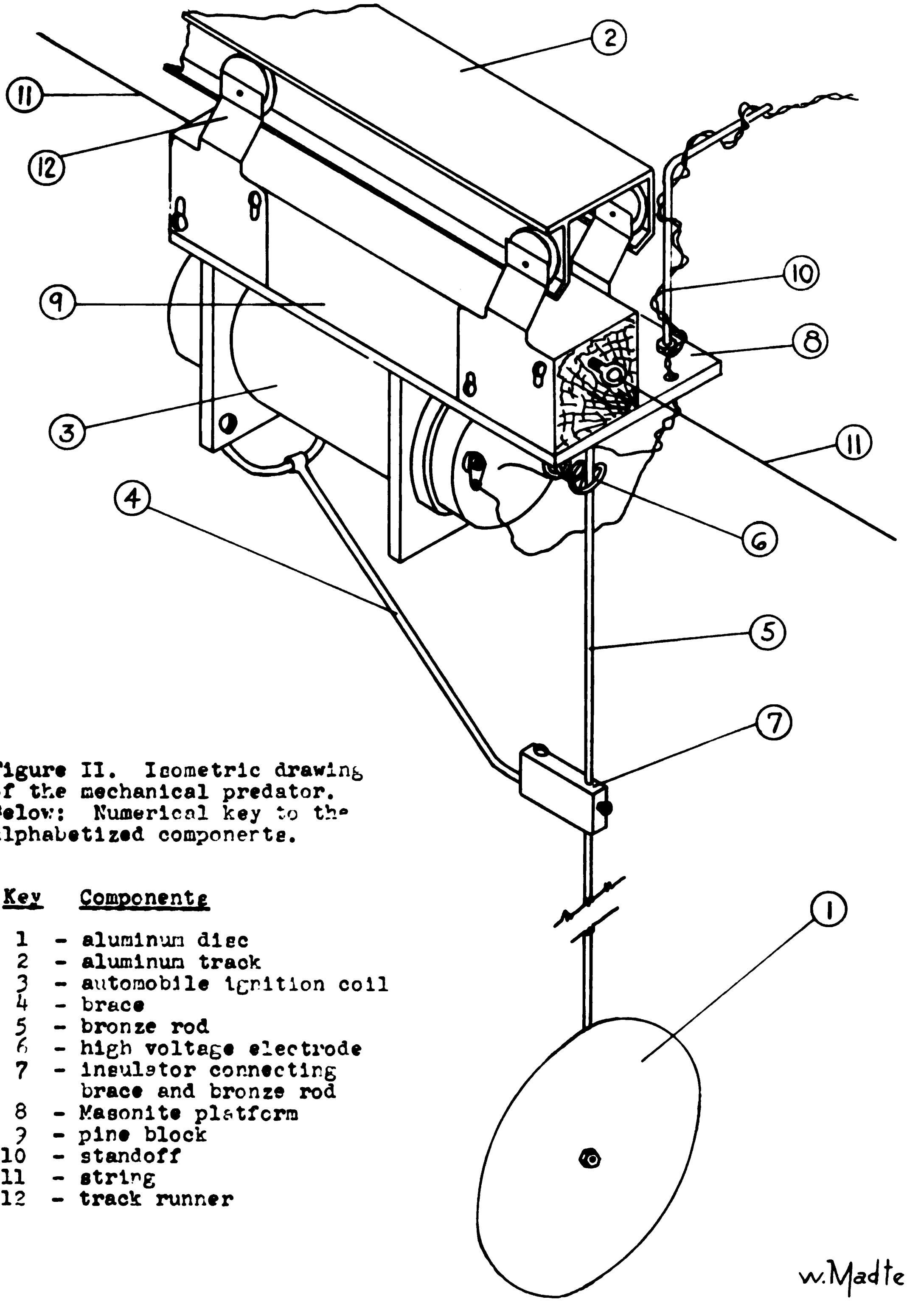


Figure II. Isometric drawing of the mechanical predator. Below: Numerical key to the alphabetized components.

Key	Components
1	- aluminum disc
2	- aluminum track
3	- automobile ignition coil
4	- brace
5	- bronze rod
6	- high voltage electrode
7	- insulator connecting brace and bronze rod
8	- Masonite platform
9	- pine block
10	- standoff
11	- string
12	- track runner

w. Madtes

Design. A within subjects or steady state design was used to provide maximal control of individual differences and unknown variables. The four conditions or phases of the experiment were: 1) Free Access; 2) Extinction; 3) Acquisition; 4) Re-extinction.

Each phase lasted 15 days. The experiment, therefore, required 60 days to complete. Regardless of the phase, each S was run for one, ten minute session per day.

In Phase 1 or Free Access S had unlimited access to the goal region throughout, without fear of pursuit from the predator. In Phase 2, S was exposed for the first time to conditions where goal entries were both nonreinforced and subject to potential and actual threat from the predator. In Phase 3, goal entries were again reinforced as in Phase 1, but such approach was followed by attack from the predator. Thus, S in this phase were subject to both fear and frustration. In Phase 4, S was re-extinguished with the expectation that extinction would take longer than in Phase 2.

Procedure. The four experimental phases are described in detail below. Phase 1 consisted of fifteen days of free access to water in the experimental apparatus. During this phase, entrance into the goal area or region did not result in the approach of the mechanical predator. Throughout this phase, the mechanical predator was present and

electrically charged though always stationary at the end of the alley opposite the safe box. In Phase 2, the water reinforcement was not available although the drinking tube was still in place. Also, any entry by any part of S into the goal region resulted in the approach of the mechanical predator after a fixed delay of 7 seconds. For Phase 3, water reinforcement was reinstated. In all other respects it was identical to Phase 2. During this phase, S learned to approach the goal stimuli when these stimuli were associated with frustration and threat or punishment. The last phase, Phase 4, was procedurally identical to Phase 2. The goal entry response was the major dependent variable. This response was defined as any traversal from the safe box to the entry of any part of S into the goal region.

Except for the differential treatments given during Phase 1 and 3, the remainder of the running procedures were uniform throughout the four phases. All Ss were continuously maintained on the water deprivation schedule to which they were adapted prior to the beginning of the experiment. This schedule was ten minutes of access to water in the individual home cages once a day not sooner than thirty minutes after an S had been run for that day. The running order of the animals, for each day, was systematically varied so that no S was consistently run in the same position within a day as on the preceeding day. Ss

were brought, individually, from the colony room into the testing room, run, and then returned to the colony room. This was done to prevent any Ss exposure to apparatus sounds while not being run.

An equally uniform running procedure was used across all phases. A S was placed in the safe box; E then turned on the switch controlling the paper feed for the remote pen recorder. E then started a stopwatch while at the same time lifting a panel from in front of the safe box hole. The stopwatch was used to take the session length and the 7 second delay between S's entry into the goal region and operation of the mechanical predator. The panel prevented Ss leaving the safe box until the stopwatch was started. E then sat in a position where he could observe S via the overhead mirrors on the apparatus. In this position E also operated the switches which controlled the remote recording of the time spent by S in the goal area on each entry and the switch which turned on the motor driving the mechanical predator. E also kept notes on S's behavior during the session.

Throughout Phases 2, 3, and 4, the mechanical predator was actuated only after a constant delay of 7 seconds after the entrance of S into the goal region. A 7 second delay was chosen on the basis of pilot work. Delays shorter than 7 seconds were found to retard the acquisition of the approach response which would have prolonged Phase 3.

In Phases 2, 3, and 4, the mechanical predator was propelled to and fro at a constant velocity of 1 foot per second. This velocity was chosen so that S had to retreat from the goal and into the safe box at minimally a fast walk or slow run to avoid contact with the advancing disc. This was done to reduce variability in flight from the goal. The advantages or disadvantages of compelling S to run as swiftly as possible were unknown.

The response by S upon which actuation of the mechanical predator was contingent was the same in Phases 2, 3, and 4. S was in no way forced to remain in the goal region after entering.

RESULTS AND DISCUSSION

Statistical Analysis. The data are presented in graphic and tabular form at the end of this section and in Appendix I. Figure III gives the response rate (number of times S enters the goal region in a 10 minute session) across sessions for the four experimental phases. A analysis of variance response rates during the two extinction phases (Phases 2 and 4) showed that there is a significant difference in the absolute magnitudes of response rates. The response rate is significantly higher in Phase 4 than in Phase 2. This is clear evidence that the learning during Phase 3 had the predicted effect of conditioning the approach response to the goal region under threat of attack from the predator.

TABLE V

Analysis of variance (Edwards, 1960) of response rates across sessions of Phase 2 versus Phase 4.

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
Treatment	1267.30	1	1267.30	7.44*
Error	1363.62	8	170.45	
Sessions	169.87	14	12.13	1.72
Treatment X Sessions	140.80	14	10.06	1.43
Error	788.78	112	7.04	
Total	3730.37	149		

* significant at the .05 level

The treatment means and standard deviations for Phase 2 are $\bar{X}$ =1.84, SD = .717. For Phase 4 they are $\bar{X}$ =7.65, SD =1.981.

The nonsignificant Sessions effect indicates that when the treatment effect is averaged across sessions there remains no effect peculiar to sessions alone. The nonsignificant interaction of treatments X sessions indicates that the extinction process was of the same form in Phase 2 and 4, differing only in magnitude.

The low response rate recorded during Phase 1 must be interpreted in terms of Ss' task. During Phase 1, Ss were never forced to leave the goal region. Observations of Ss' behavior during Phase 1 indicated that most of the time accumulated in the goal region was spent drinking (see Table VI for the mean water consumption across sessions of Phases 1 and 3). The remainder of the time during a Phase 1 session was spent exploring the apparatus. This exploratory behavior probably accounts for the fact that there was a response rate greater than 1 response per session. Figures IVa and IVb show the mean total time spent in the safe box, alley and goal across sessions during the four phases. Figures IVa and IVb show that during Phase 1, the Ss spent most of each 600 second or 10 minute session in the goal region. This was not the case during the remaining phases where most of the time was spent in the safe box.

A further means of comparing the resistance to extinction of Ss responding was through the difference between regression coefficients of the curves from Phases 2 and 4. Inspection of the response rates during Phase 2 indicated that the effect

of the extinction sessions was completed by the eighth session. Therefore, the slopes of both curves were derived for the first eight sessions. For Phase 2, the regression coefficient is $b_{xy} = -.285$. For Phase 4, the regression coefficient is $b_{xy} = -.480$. The pooled error term is $S_D = .447$. This yields a t-ratio of .436, d.f. = 12, which is not significant at the .05 level. This test shows that when the differences in absolute magnitude are eliminated, there is no significant difference in the rate of extinction in Phases 2 and 4.

The test of regression coefficients indicates that the tasks prior to extinction is of the utmost importance. *S's* rate of responding will be greater during extinction, in terms of the absolute number of responses, after they have learned to cope with predatory attacks to obtain reinforcement, a was learned in Phase 3, compared to conditions which did not equip the *Ss* to cope with predatory attacks (Phase 1). Once extinction has begun, though, either type of prior experience results in the same *relative* rate of extinction.

Another way to analyze *Ss* behavior is through the mean time spent in the goal per response. This information is available in Figure V. Inspection of Figure V and response rates given in Figure III suggest a relationship between response rate and the time spent in the goal region per response. A Pearson product moment correlation between response rate and mean time in goal per response computed across

sessions in Phase 1 yielded an $r = -.810$ (significant at the .0005 level). For Phase 2, the correlation was $r = +.521$ (significant at the .025 level). For Phase 3, the correlation was + .719 (significant at the .005 level). While for Phase 4, the correlation was $r = +.644$ (significant at the .005 level).

As far as Phase 1 is concerned, there is a strong inverse relationship between response rate and time in goal per response. The fact that this relationship is not ÷ 1.00 can most probably be attributed to exploratory behavior. For the remaining 3 phases the relationship seems to be a direct one. During the last 3 phases, the response rate and time spent in the goal per response can be considered functions of the same factor. This factor appears to be the extent to which fear and frustration produced stimuli are conditioned elicitors of the goal response. This assumes that both response rate and time in goal per response may both be indicative of the degree to which conditioning has taken place. Inspection of Figure V shows that during Phase 2 the mean time spent in the goal per response was always less than the 7 second delay period. This may indicate that staying in the goal region was as noxious as entering the goal region. In Phases 3 and 4, though, time spent in the goal per response equaled or exceeded the 7 second delay period except in Phase 3 and late in Phase 4: Early in Phase 3 little conditioning had taken place, late in Phase 4, extinction was well advanced. The results with respect to time in the goal were not specifically predicted although the possibility was

discussed in the introduction under the section labeled Predator.

Phases 2, 3, and 4 were compared statistically on mean time in goal region per response by means of matched-pairs T-tests. The comparisons were made across the 15 session by pairing sessions in order. The results showed that Ss spent significantly more time in the goal per response during Phase 3 compared with Phase 2 (T_d = 7.12, d.f. = 14, significant at the .001 level). The Ss behavior did not differ significantly between Phase 3 and 4 (T_d = 1.84, d.f. = 14, not significant at the .05 level). It appears that once the conditioning to the posited fear and frustration cues had taken place more time was spent in the goal region than prior to conditioning. Also, once conditioning took place, the behavior producing the increased time was very resistant to extinction.

Observational Data. While Ss were free to explore the apparatus during Phase 1, they soon learned to avoid an area approximately 2 inches in front of the disc. The disc was charged at all times. After Ss had received a shock apiece during the first session (one S took 2 shocks in a row), they continued to show interest in the disc but only from a distance. In the remaining sessions of Phase 1, three different Ss ventured close enough to be shocked more than once (see Table VII for the frequency of shocks across sessions of the four phases).

region. Also, as Phase 2 progressed, the Ss behavior in the safe box changed. During the early sessions, Ss frequently appeared very aggitated. They paced about the safe box and frequently crouched facing the safe box hole. In later sessions, the Ss spent increasing amounts of time sitting quietly in one or another corner of the safe box. Also, by later in Phase 2, most Ss had entirely abandoned any attempts to drink. What time was spent in the goal was used to crouch or nervously scan the surroundings.

Table VII shows that during Phase 3, the Ss received more shocks than during any other phase. Three Ss who received shocks during the first session of this phase because once they had begun drinking, they were very loath to discontinue. Either they did not stop drinking until shocked or moved towards the safe box too slowly and hesitantly as if it were equally noxious to leave the water and to remain and face the approaching predator. This hesitant, conflict like retreat from the goal region was the usual reason for receiving shocks during Phase 3. Quite frequently during the first 3 sessions of Phase 3, the Ss would flee the goal before the 7 second delay had elapsed. This was not the case during the latter sessions of Phase 3 as can be seen in Figure V.

Observations made on the Ss behavior during the latter part of Phase 3 suggested that the frequent hesitant retreats from the goal region were the results of partial extinction

of the avoidance response. Assuming that the arguments put forth in the Introduction are correct, a partial extinction of the avoidance response could take place. This is especially true in the latter sessions of Phase 3 as the stimuli which should elicit avoidance becomes instead conditioned elicitors for approach and entry into the goal region. As was previously mentioned, the hesitant retreat from the goal was the usual reason. Ss were shocked during the latter part of Phase 3. Also, during the latter part of this phase, besides an increasing amount of time spent in the goal region perresponse many Ss would, with increasing frequency, emerge from the safe box and begin approaching the goal reginn soon after the mechanical predator had reached its closest approach to the safe box and was then on its return to the opposite end. Occasionally an S would approach and enter the goal region by following on the very heels of the withdrawing mechanical predator. Also on the increase at the end of this phase were bursts of aggitated appearing behavior in the safe box. The Ss would suddenly begin bounding about the safe box in a very vigorous way. These bursts of behavior were usually accompanied by very swift dashes to the goal region. Finally, in the latter sessions the usual approach to the goal region was a swift run from the safe box door without observable signs of hesitancy or wariness.

Table VII shows that during Phase 4, the Ss received as many shocks as in Phase 2. In Phase 2, though, 8 of the

10 shocks were received during the first sessions while in Phase 4 the 10 shocks were scattered throughout the phase. Observations of the Ss' behavior during Phase 4 suggested that the reasons for receiving a shock were different than during Phase 2. In Phase 4 it appeared that as the strength of the approach decreased so did the avoidance of the mechanical predator. Perhaps as the stimuli eliciting approach lost their power to do so, these stimuli also lost the power to elicit avoidance. This might be a tenable supposition in terms of the hypothesis.

In the early sessions of Phase 4, the Ss on several occasions would, on entering the goal region, completely ignore the drinking tube and continue moving towards the stationary disc. The closer they approached the disc the more wary their behavior appeared to become. No S was ever seen to come closer than 6 inches from the disc. As sessions progressed, the drinking tube was more and more ignored but not in favor of approaching the disc, but in favor of cautiously scanning the surrounds crouching by the drinking tube facing in the direction of the disc.

During the early sessions of Phase 4, on a number of occasions Ss were seen to chew and tug vigorously at the tube. Also during the early sessions, the Ss would on occasion bound and leap about the safe box especially after having attempted to drink. They would sometimes chew the edge of the safe box hole and the hardware cloth floor. The

incidence of standing on the hind legs increased during this phase together with vigorous sniffing. Occasionally an S would attempt to jump straight up the sides of the safe box walls. None succeeded in reaching the top though. Perhaps these behaviors were indicative of an increased magnitude of frustration.

General Considerations:

Because of the exploratory nature of this experiment, the decision was made to use the same Ss in both extinction phases (Phases 2 and 4). The assumption was made that, in rats, re-extinction is not retarded and, in fact, may be fascilitated (North and Morton, 1962). Any fascilitation of re-extinction would work against the hypothesis. In the future, though, it is recommended that independent groups be used so that re-extinction will be unnecessary and thus making assumptions unnecessary.

The model used in this experiment to predict differential resistance to extinction represents a combination of existing theories such as competing response theory, frustration theory, and secondary reinforcement theory. The theory which best fits the general model is Elicitation Theory (Denny and Adelman, 1956).

Theories of the drive reduction, inhibition, and generalization decrement were not viewed as being capable of predicting the present results. It is hard to conceive of any way in which drive reduction or inhibition theories could predict these results. Generalization decrement theories

would stand a better chance by noting that the stimulus conditions between Phases 1 and 2 were change to a much greater extent than between Phases 3 and 4. It is difficult to see how a generalization decrement position would completely account for the results in that all _Ss_ received shock during Phase 1 so that the advent of punishment in Phase 2 was not an entirely novel state of affairs.

In any case, only the present model could account for the results in the following experiments.

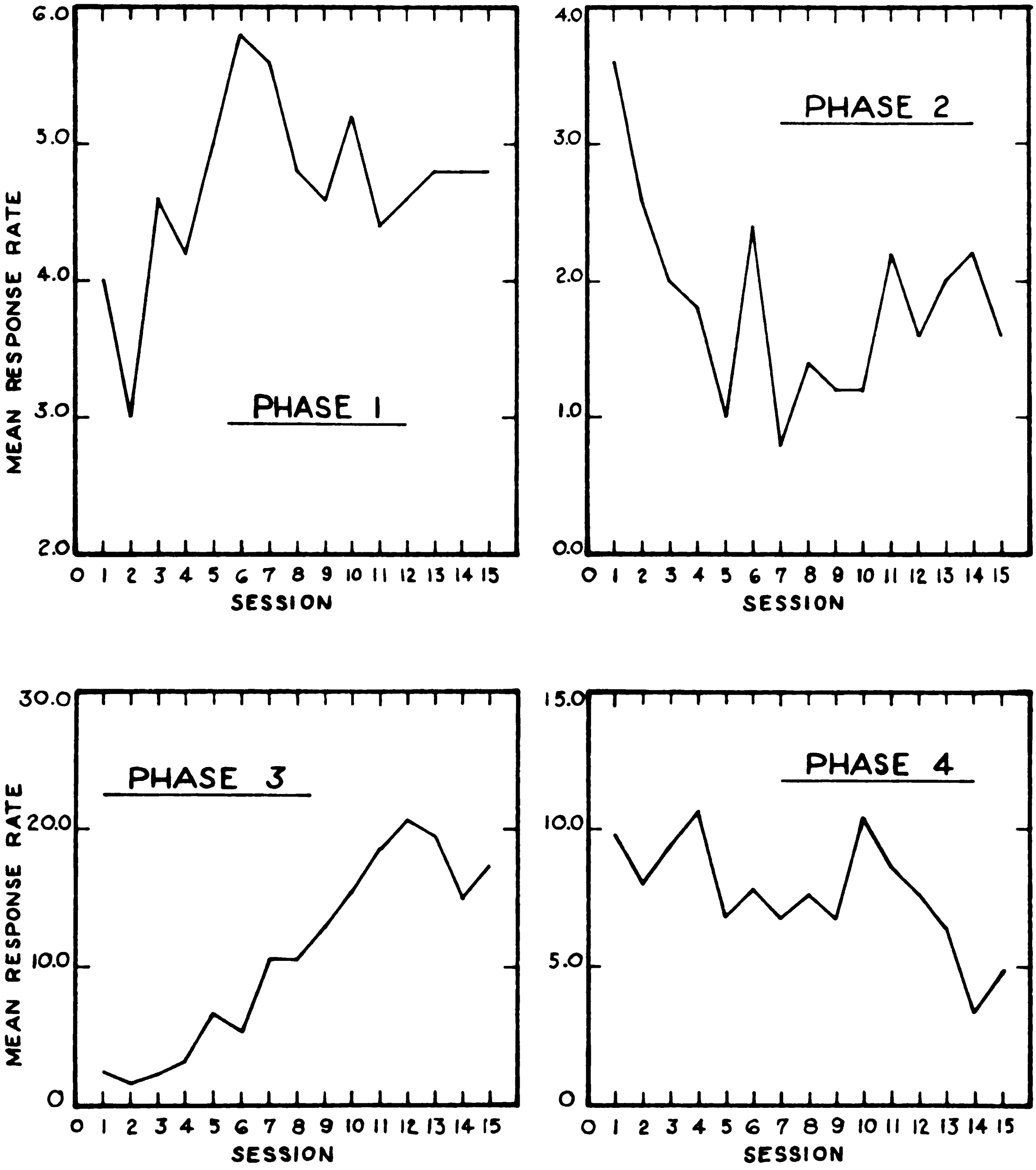


Figure III. Mean response rate per session of the four phases of Experiment I. Take note of the change in ordinate units from graph to graph.

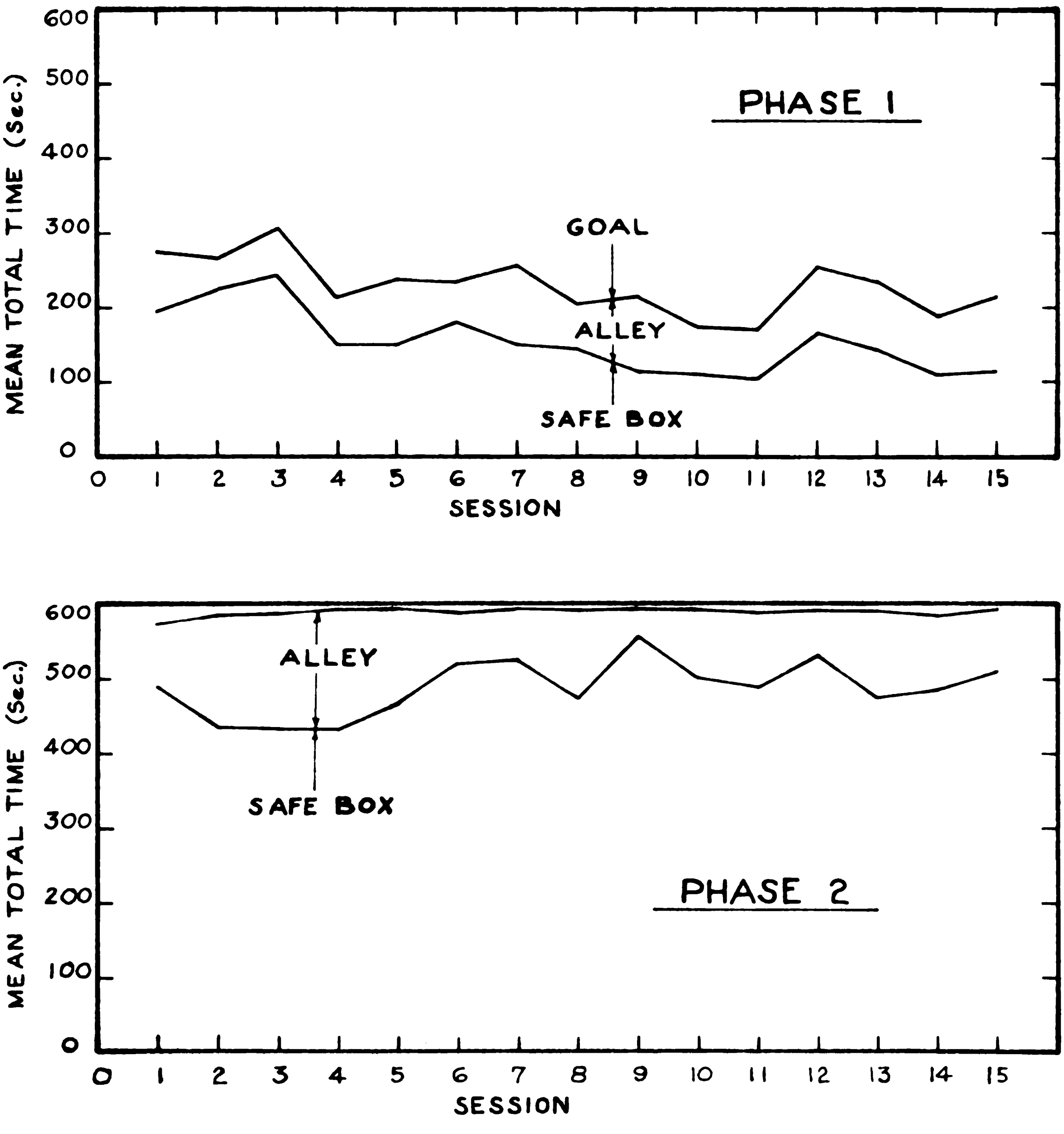
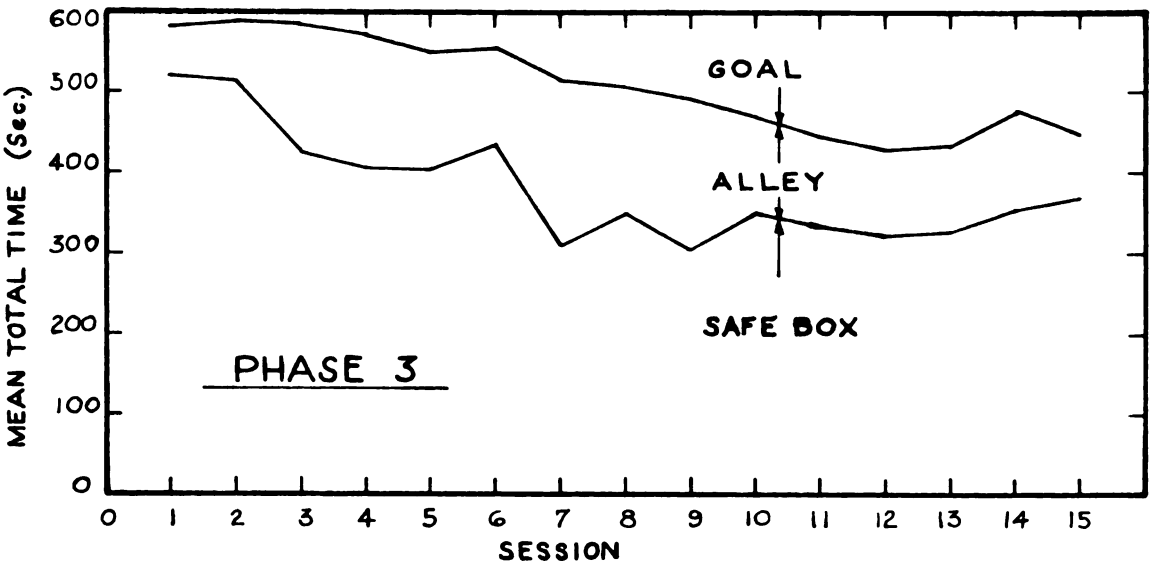


Figure IVa. Mean total time spent in the safe box, alley, and goal region per session of Phases 1 and 2 of Experiment I.



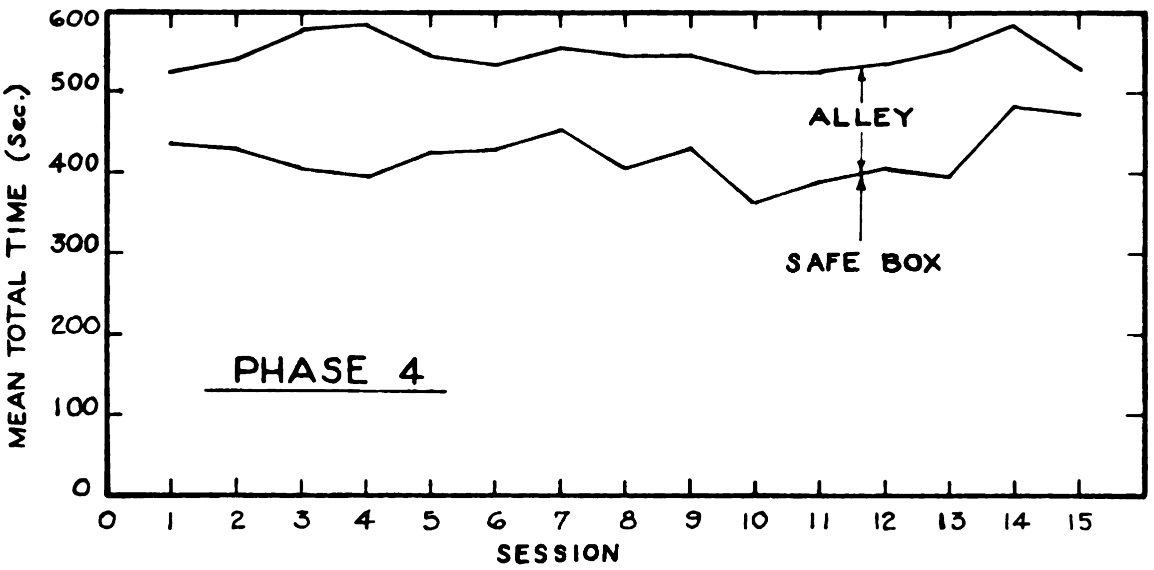


Figure IVb. Mean total time spent in the safe box, alley, and goal region per session of Phases 3 and 4 of Experiment I.

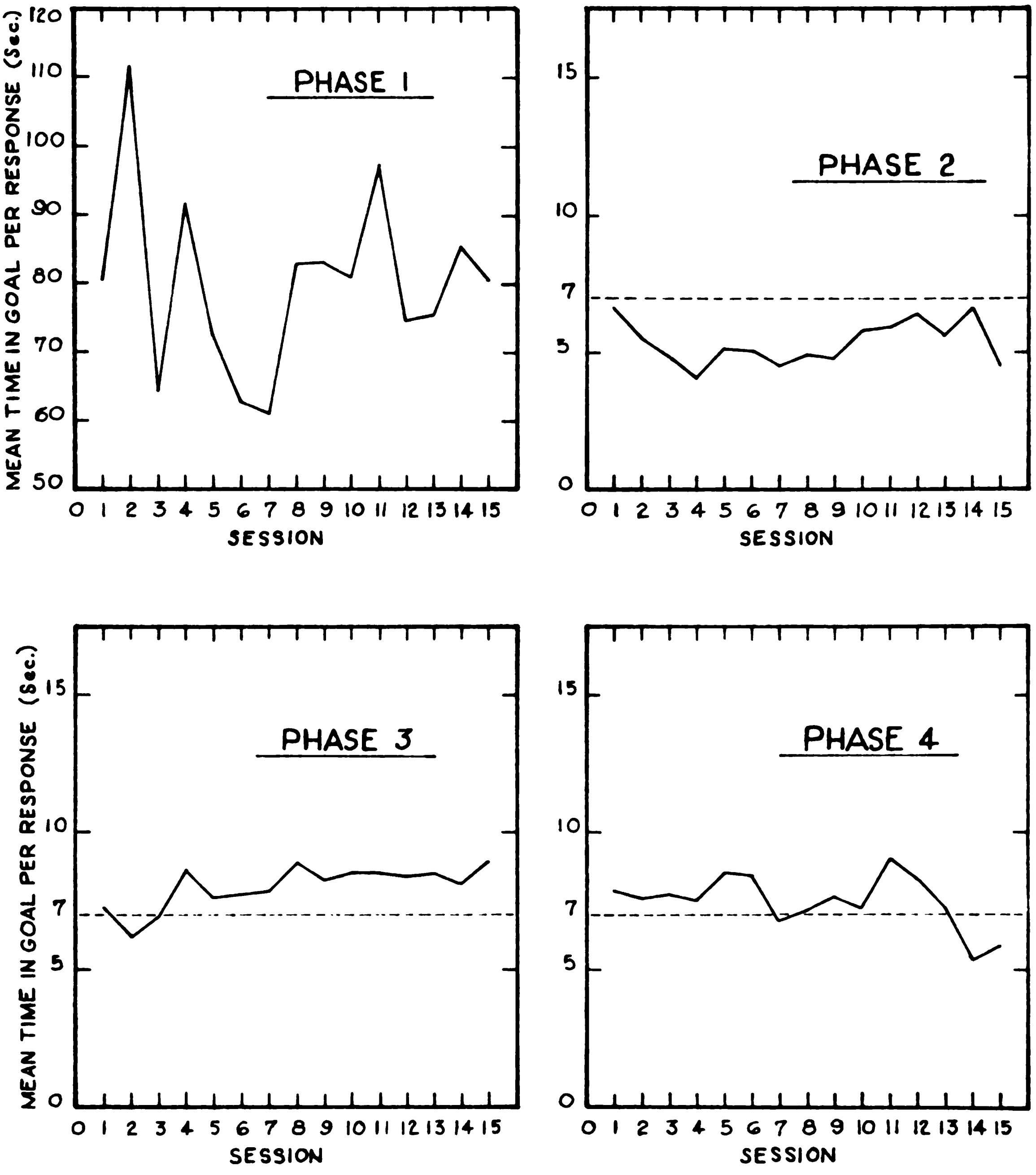


Figure V. Mean time in the goal region per response per session of the four phases of Experiment I. The broken, horizontal line at the 7 second mark indicates the time of onset of the mechanical predator from the time of an *S's* entry into the goal region.

TABLE VI

Mean water consumption (ml.) per session of Phases 1 and 3 of Experiment I.

Phase 1	Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ml.	of water	5.6	7.0	7.0	7.6	7.4	7.6	7.2	8.6	8.0	8.0	7.6	6.4	7.6	8.0	7.8

Phase 3	Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ml.	of water	.1	.1	.1	.5	.6	.6	2.0	1.9	2.1	3.2	3.4	4.4	3.6	2.7	3.4

TABLE VII

Frequency of shocks received per session of the four phases of Experiment I.

Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Shock frequency															
Phase 1	6	1	0	0	0	1	0	0	0	0	0	1	0	0	0
Phase 2	8	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Phase 3	5	0	0	1	2	1	1	3	0	2	2	2	2	2	2
Phase 4	0	1	1	2	0	1	0	0	0	0	1	0	3	1	0

EXPERIMENT II

This experiment constituted the test of the second hypothesis. Given the confirmation of the first hypothesis obtained in Experiment I, it was assumed that the internal stimuli from fear-frustration continued to serve as discriminative stimuli. Additional support for the present analysis through a procedure which allowed for the manipulation of the opportunity to make competing responses in association with the discriminative stimuli.

It was assumed that extinction is an active process involving the conditioning of frustration responses to the goal stimuli so that the goal stimuli elicit responses in competition with continued goal entry. But, since fear-frustration stimuli are assumed to be capable of eliciting goal entry because of the conditioning which took place during acquisition, it would appear that an increased intensity of the internal stimuli would be necessary to elicit the competing responses. Presumably, this should occur when reinforcement is removed.

To demonstrate a predictable differential, it was further assumed that the longer *Ss* were allowed to remain in the immediate vicinity of the goal stimuli during non-reinforcement the greater the likelihood that frustration responses would occur and compete with goal entry. A group allowed to

spend a longer time in the goal region should display less resistance to extinction than a group spending less time in the goal region.

Method

Subjects. The Ss were 10 naive female hooded rats from the colony maintained by the Department of Psychology of Michigan State University. All Ss were from 110 to 120 days old at the start of the experiment.

Beginning two weeks prior to the start of the experiment, each S was handled for five minutes a day. Beginning one week prior to the start of the experiment, Ss were placed on a water deprivation schedule of ten minutes of access to water in the individual home cages every 24-hours. Food was continuously available. Also, during the last week prior to the beginning of this experiment, Ss were, individually, allowed ten minutes per day to explore the experimental apparatus and drink in the apparatus.

Apparatus. The apparatus used in Experiment I was used in this experiment without modification.

Procedure. The procedure used called for a combination within and between subjects design. The four conditions or phases of the experiment were: 1.) Acquisition; 2.) Extinction; 3.) Reacquisition; 4.) Re-extinction.

Phase 1 lasted fifteen days as did Phase 2. Phase 3 lasted ten days. Phase 4 lasted five days. Regardless of

the phase, each S was run for one, ten minute session per day.

During Phase 1 or Acquisition, the Ss learned to approach the goal. They were water reinforced, but, they entered the goal under conditions of threat from the mechanical predator which in turn resulted in termination of reinforcement on each trial. This phase was procedurally identical to Phase 3 of Experiment I. Any entry by any part of an S into the goal resulted in the approach of the mechanical predator after a fixed delay of 7 seconds.

At the end of this phase, the 10 Ss were divided into two groups. Each group had approximately the same mean response rate across the sessions of Phase 1. The groups were assembled from pairs of Ss, more or less matched for mean response rate across sessions (see Table VIII below). The response was defined as a traversal from the safe box into the goal region. All the measures taken in Experiment I were taken in Experiment II.

The groups were randomly assigned to the experimental conditions of Phase 2.

In Phase 2 all Ss, regardless of group, underwent extinction. This is, that the water reinforcement was no longer available upon reaching the goal. The independent variable was the amount of time the Ss were allowed in the goal prior to the approach of the mechanical predator. There was two conditions of the independent variable, 3 seconds

TABLE VIII

Group composition in terms of the mean response rate across Phase 1.

Group A		Group B	
subject	mean response rate	subject	mean response rate
1.	17.5	6.	17.6
2.	16.1	7.	15.9
3.	12.6	8.	12.3
4.	11.9	9.	10.1
5.	5.8	10.	8.1
	63.9		64.0
	$\bar{X}$=12.78		$\bar{X}$=12.80

and 11 seconds. Group A received the 3 second condition; Group B the 11 second condition.

Three seconds and 11 seconds are both 4 seconds away from the 7 second delay used in Phase 1. These values were chosen for two reasons: 1) pilot work indicated that a 3 second delay strongly retarded initial acquisition of the approach response. Because the second hypothesis predicts greater resistance to extinction for Group A (3 seconds) compared to Group B (11 seconds) making the short delay a time known to retard responding during acquisition strengthens the design if differences develop in the predicted direction. 2) Both 3 and 11 seconds represent equal changes in time from 7 seconds and should constitute approximately an equal amount of generalization decrement, if any. Bidirectional

generalization gradients are typically symetrical.

It must be understood that regardless of the time used, either 3 or 11 seconds, the Ss were not forced to remain in the goal for any length of time. They were simply allowed more or less time in which to remain in the presence of the goal cues.

Phase 3 was identical to Phase 1 with the sole exception that Phase 3 was ten days long. That is, each animal was given ten daily sessions, one session per day. Phase 3 with its return to a 7 second predator delay was used to allow the groups to return to their response rates achieved towards the end of Phase 1. This was necessary too, as Phase 4 or Reextinction constituted a test of the reliability of the results obtained in Phase 2.

In Phase 4, reinforcement was not available. Group A which had received a 3 second delay during Phase 2 now received an 11 second delay. Group B which had received an 11 second delay in Phase 2, now received a 3 second delay.

By reversing the conditions for the two experimental groups from those imposed during Phase 2, two things were accomplished. First, this procedure was a stringent test of the hypothesis. If the results were again in the predicted direction, this would be interpreted as strong support for the hypothesis and eliminate the possibility that differences found in Phase 2 were due to some uncontrolled differences between the groups. Secondly, the reversal of

conditions made possible a within-subjects analysis.

Except for the differences in procedure discussed above, all other procedures used in this experiment were identical to those used in Experiment I.

RESULTS AND DISCUSSION

The data are presented in graphic and tabular form at the end of this section and in Appendix II. Figure VI gives the response rate for Groups A and B across sessions of the four experimental phases. Analysis of variance of the response rates of Group A versus Group B during Phase 2 shows that the two groups did not differ significantly in resistance to extinction (see the analysis of variance Table IX). By this test, the second hypothesis was not supported.

TABLE IX

Analysis of variance (Edwards, 1960) of Group A versus Group B response rate across Phase 2.

Source of Variation	Sum of Squares	d.f.	Mean Squares	F
Treatment	128.80	1	128.80	.40
Error	2559.22	8	319.93	
Sessions	1096.97	14	78.36	7.08*
Treatment X Sessions	223.70	14	15.98	1.44
Error	1240.38	112	11.07	
Total	5249.07	149		

*significant at the .01 level

The treatment mean and standard deviation for Group A are $\bar{X} = 8.04$, SD = 3.447. For Group B they are $\bar{X} = 6.19$, SD = 2.643.

The significant sessions effect indicates that when the treatment effect is averaged across sessions there is an effect peculiar to sessions alone. Inspection of the Phase 2 graph in Figure VI suggested a negatively accelerated function usually associated with extinction.

Regardless of the fact that for 11 of the 15 sessions Group A means were higher than Group B means, the treatment effects were insufficient to produce a significant difference. Inspection of the graph of Phase 2 in Figure VI shows that the greatest absolute difference between group means occured during the first session. A T-test of these two means gave a value of T=1.405 with 8 d.f. which is not significant at the .05 level. Thus, for the first session of Phase 2, the results were in the predicted direction but not to a significant extent.

Turning to Phase 4, Figure VI shows that for at least the first session, the results are again in the predicted direction. The data, also, took a form very much like the first five sessions of Phase 2. Inspection of the data indicated once more that if there was any significant difference between the group means it would be in the first session. A T-test of these two means gave a value of T=.846 with 8 d.f. which was not even significant at the .20 level. Thus, for the first session of Phase 4, the results were in the predicted but to no significant extent.

A further analysis of the response rate data was made by using each *S* as its own control. That is, each *Ss*' response rate under the 3 second delay condition was matched against its response rate for the 11 second condition. A matched-pairs T-test was used to analyze. This gave a T_d = 2.04 with 9 d.f. which is significant at the .10 level but

not at the .05 level. With individual differences controlled, the expected trend is more apparent.

The lack of clearly significant results not withstanding, the response rate data suggest that predicted effects are real. The effect may be only of short duration. The effect is replicable if Phase 4 is considered a replication of Phase 2. The difficulty appears to lie in an insufficient number of subjects, as the main effects are obscured by a high degree of variability.

Inspection of the response rate data from Phase 1 indicates a great similarity to the results obtained in Phase 3 of Experiment I. This suggests that there was no savings for the Ss in Experiment I at the beginning of Phase 3. This was not the case for Ss in Phase 3 of Experiment II. The combined mean response rate of Groups A and B for the first session of Phase 1 of Experiment II is $\bar{X} = 3.9$. The combined mean response rate of Groups A and B for the first session of Phase 3 of Experiment II is $\bar{X} = 16.7$. This gave a savings score of 303% in terms of response rate. A matched-pairs T-test of the mean response rates of the first sessions of Phases 1 and 3 gave a $T_d = 4.870$ with 9 d.f. A T-ratio of this size is significant at the .001 level. Inspection of the response rates for the first sessions of Phases 2 and 4 also suggested a savings. The mean combined response rate for Groups A and B for session 1 of Phase 2 is $\bar{X} = 15.9$. For

the first session of Phase 4, the mean is $\bar{X} = 8.9$. This represents a 44% savings for the first session. A matched-pairs T-test of the mean response rates gave a $T_d = 2.609$. With a 9 d.f. the T-value is significant at the .05 level. These savings represent a significant amount of positive transfer.

The following analysis is of particular importance for the major hypothesis. In Figures VIIa and VIIb, the graphs for Phase 2 and 4 show a difference in the mean total time spent in the goal region between the group receiving the 3 second and the group receiving the 11 second delay condition. This difference is seen more clearly in Figure VIII. The graphs of the mean time in the goal per response for Phases 2 and 4 show that when a group is allowed more time in the goal region, more time is spent there. Also, the graphs for Phases 2 and 4 of Figure VIII show that the two curves, session for session, are about equally displaced from the 7 second point. On the average, a group under the 11 second condition spent less than the full delay interval in the goal region per response, while a group under the 3 second condition spent more than the delay interval. In line with the argument put forward in the discussion, it is suggested that something less than 11 seconds was sufficient for the magnitude of the frustration response to increase enough beyond previously conditioned levels so that the <u>Ss</u> spontaneously fled the

goal region. Under the 3 second delay condition, on any one trial, the magnitude of the frustration response did not increase sufficiently to result in the Ss spontaneously fleeing the goal region.

This brings up the question of why there was no decline of time in the goal region per response in Phase 2 (Group A), $b_{xy} = + .270$; (Group B), $b_{xy} = +.230$. In Phase 2, the response of remaining in the goal upon entering may be more resistant to extinction than the entry response. This would seem reasonable assuming that the alley cues decline in approach eliciting power in relation to their distance from the goal. Therefore, as extinction progressed, the approach gradient would collapse towards the goal. The negative slopes seen in the Phase 4 graph of Figure VIII (Group A, $b_{xy} = -.290$; Group B, $b_{xy} = -.280$) may be the result of repeated extinction making the functional reinforcing properties of the conditioned elicitors generally more vunerable to the extinction process. This is all very hypothetical, but worth considering for future research.

In the later sessions of Phase 1 and throughout Phase 3 there was a decided increase in the mean time in the goal region per response beyond the 7 second delay period. This is the same effect as seen in Phase 3 of Experiment I and probably occurs for the same reasons previously proposed.

Table X gives the frequency of shocks by session for Groups A and B. Inspection of the shock frequencies for

Phases 2 and 4 show that any decreased resistance to extinction shown by the *Ss* under the 11 second delay condition cannot be attributed to a higher shock frequency. The *Ss* under the 3 second delay condition always received the greatest amount of shocks. Observations of the *Ss* behavior indicates that a hesitancy to retreat from the goal region or hesitancy to enter the safe box was the usual reason an *S* received a shock. This behavior was manifested more frequently in the group under the 3 second condition compared to the group under the 11 second condition. This differential amount of hesitancy may have a common cause with the response of remaining in the goal region upon entry. The reasons for this were previously discussed.

Beyond the differentials in observed behavior patterns reported above, the behavior of both groups during Phases 1 and 3 closely resembled the behavior observed for the *Ss* in Phase 3 of Experiment I. There was an equal similarity between observed behavior of the *Ss* during Phase 4 of Experiment I and the behavior of the *Ss* in Experiment II during Phase 2 and 4. With the exception of the differential tendency to hesitant retreats and tendency to stay in the goal region, *E* was not able to discern any reliable difference in the manifestation of fear or frustration between Groups A and B.

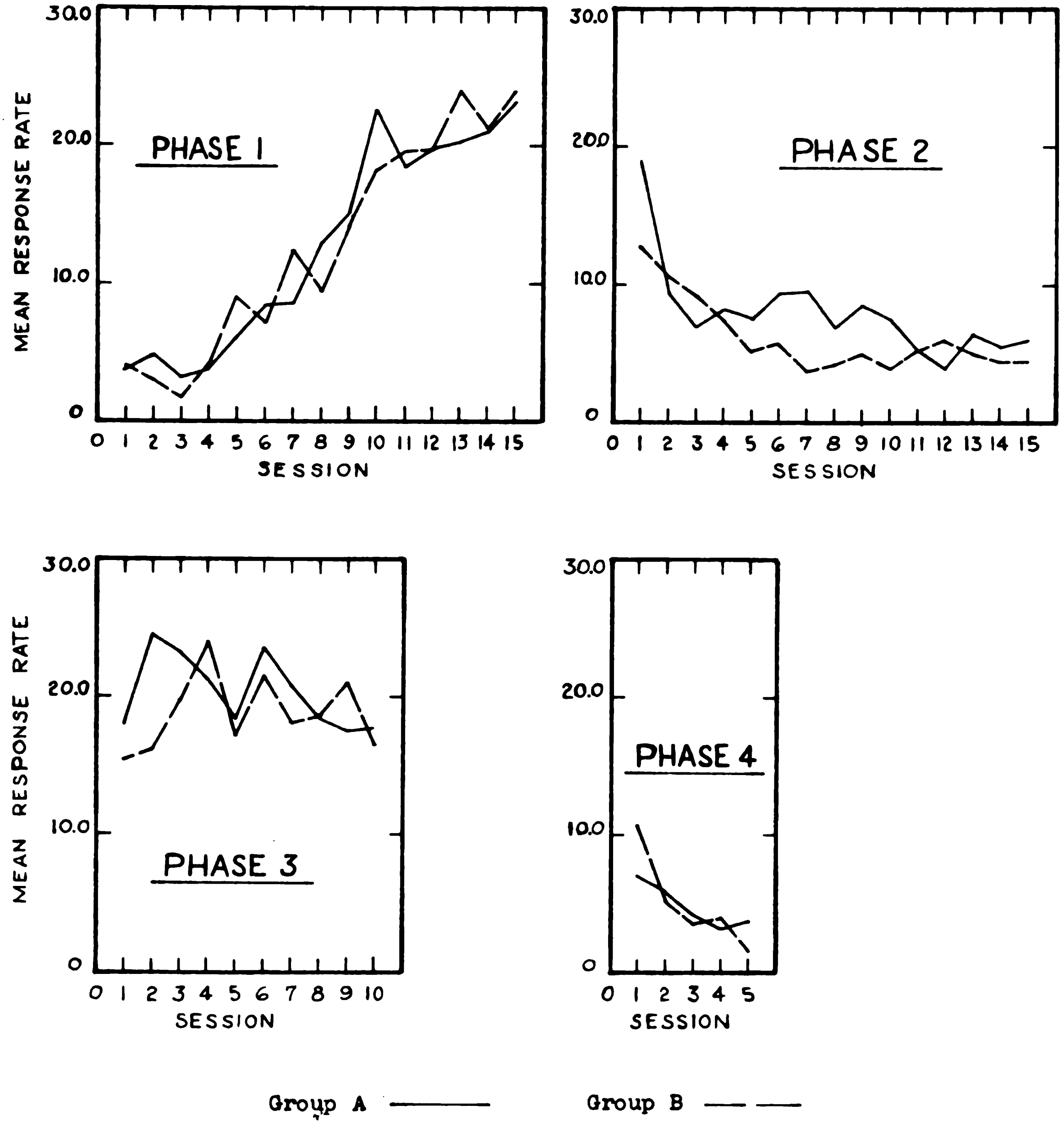


Figure VI. Mean response rate per session of the four phases of Experiment II.

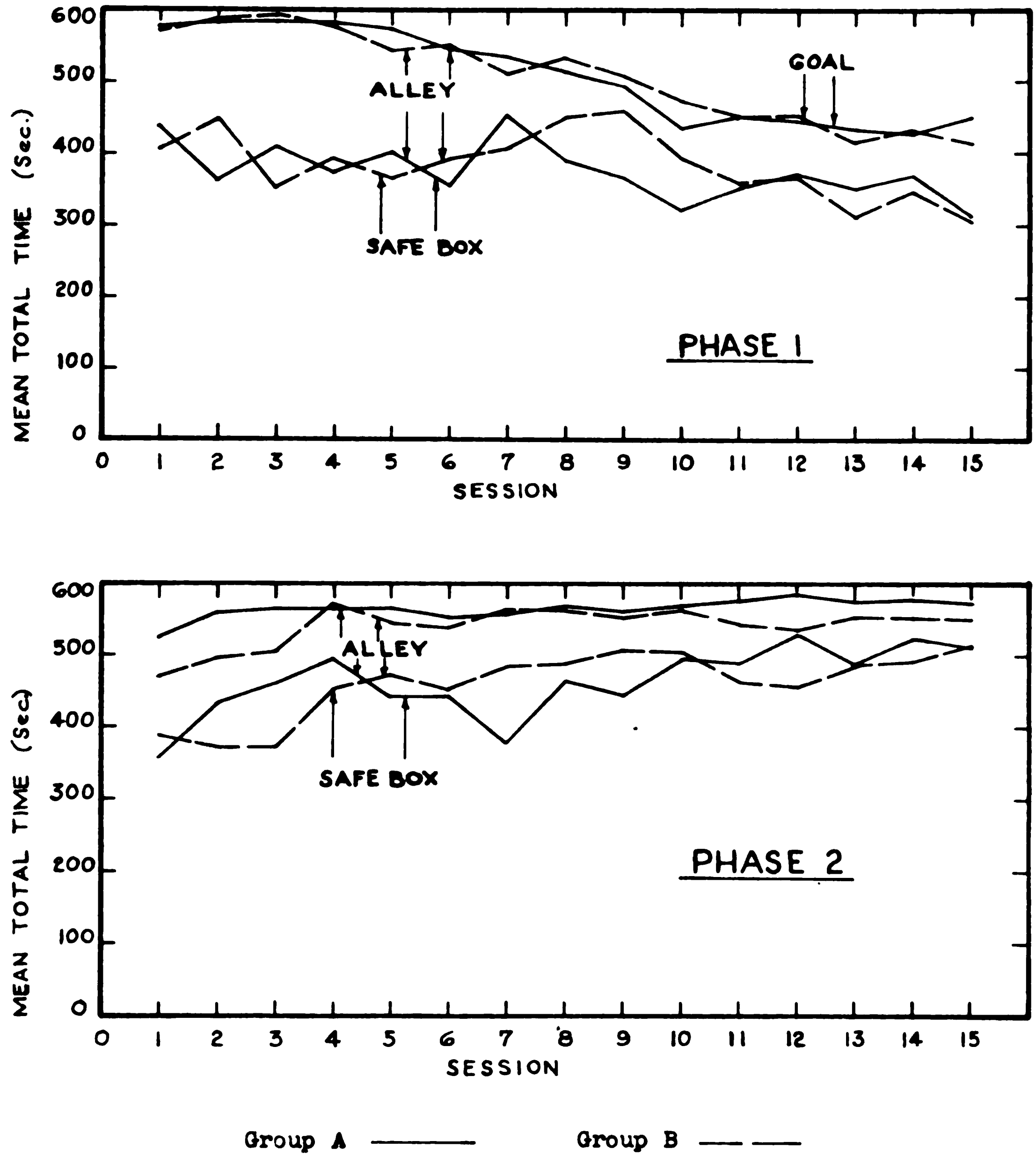


Figure VIIa. Mean total time spent in the safe box, alley, and goal region per session of Phases 1 and 2 of Experiment II.

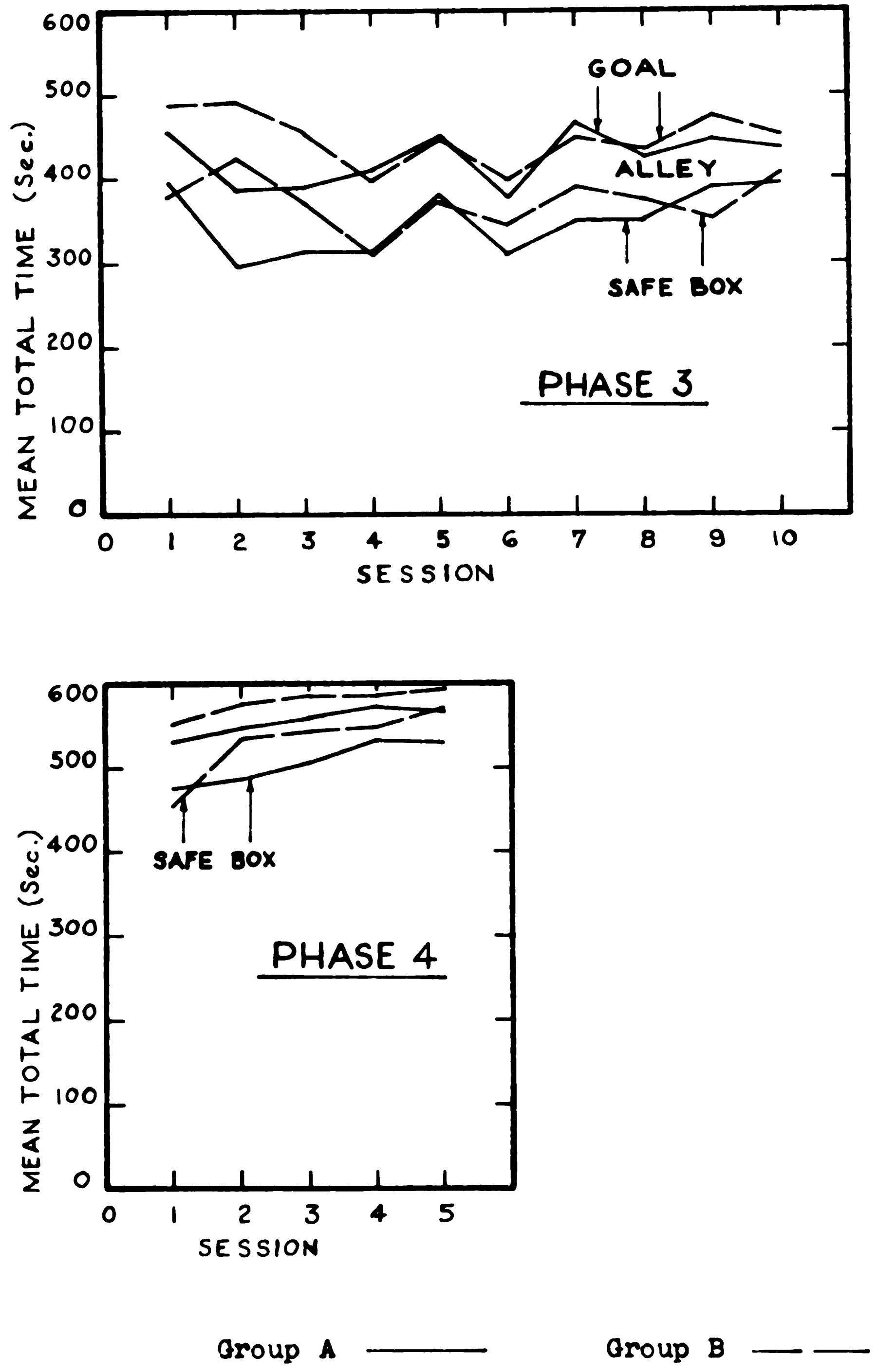


Figure VIIb. Mean total time spent in the safe box, alley, and goal region per session of Phases 3 and 4 of Experiment II.

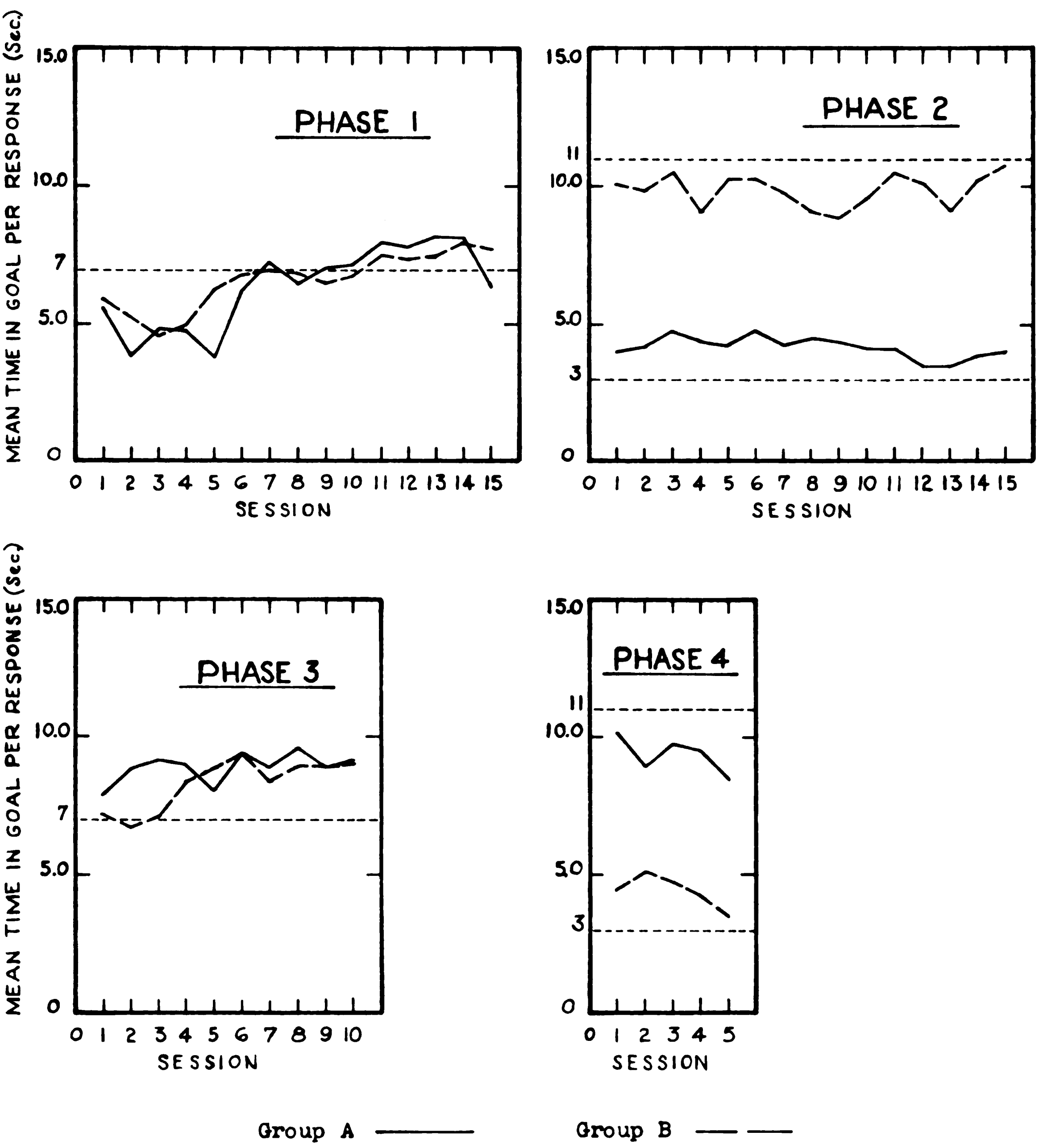


Figure VIII. Mean time in the goal region per response per session of the four phases of Experiment II. The broken, horizontal lines at the 3, 7, and 11 second marks indicate the time of onset of the mechanical predator from the time of an S's entry into the goal region, depending on the group and the phase(see the text).

TABLE X

Mean water consumption (in ml.) by Ss of Groups A and B during Phases 1 and 3 of Experiment II.

Phase 1

Sessions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group A, $\bar{X}$ ml. consumed	.6	.7	.7	1.4	1.0	2.3	2.1	2.8	3.6	6.0	4.6	5.4	5.4	6.0	6.4
Group B, $\bar{X}$ ml. consumed	.8	.6	.4	1.4	2.0	1.5	2.5	2.2	3.6	4.3	5.0	4.8	6.6	5.8	5.4

Phase 3

Sessions	1	2	3	4	5	6	7	8	9	10
Group A, $\bar{X}$ ml. consumed	4.5	7.6	7.0	6.6	5.4	8.4	6.6	6.6	5.2	5.7
Group B, $\bar{X}$ ml. consumed	3.6	4.3	5.2	7.0	4.8	6.8	5.4	5.8	6.6	5.0

TABLE XI

Frequency of shocks received by Ss of Groups A and B during the four Phases of Experiment II.

Phase 1

	Sessions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group A,	Shock frequency	13	1	1	3	1	0	2	0	2	1	1	2	0	2	1
Group B,	Shock frequency	12	3	1	1	5	1	1	2	1	0	1	0	0	2	1

Phase 2

	Sessions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group A,	Shock frequency	1	2	0	0	0	1	0	0	0	1	1	0	0	0	0
Group B,	Shock Frequency	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0

Phase 3

	Sessions	1	2	3	4	5	6	7	8	9	10
Group A,	Shock frequency	1	0	1	2	2	3	1	2	5	4
Group B,	Shock frequency	2	4	1	2	2	4	1	0	1	2

Phase 4

	Sessions	1	2	3	4	5
Group A,	Shock frequency	0	0	1	0	0
Group B,	Shock frequency	1	1	1	0	1

EXPERIMENT III

Due to the failure to obtain statistically significant results in Experiment II, Experiment II was replicated in this experiment. The number of subjects was increased.

METHOD

Subjects. The Ss were 14 naive female hooded rats from the colony maintained by the Department of Psychology of Michigan State University. All Ss were from 110 to 120 days old at the start of the experiment.

Beginning two weeks prior to the start of the experiment, each S was handled for five minutes a day. Beginning one week prior to the start of the experiment, Ss were placed on a water deprivation schedule of ten minutes of access to water in the individual home cages every 24-hours. Food was continuously available. Also, during the last week prior to the beginning of the experiment, Ss were, individually allowed ten minutes per day to explore the experimental apparatus and drink in the apparatus.

Apparatus. The apparatus used in Experiments I and II was used in this experiment without modification.

Procedure. The procedure for this experiment was identical to that used in Experiment II with but one exception. In the present experiment, Phases 2, 3 and 4 (Extinction, Re-acquisition, and Re-extinction respectively) were all reduced

in length to five days each. That is, five daily sessions per each S, one session per day. This reduction in phase length was justified by the results from Experiment II. Experiment II results showed that if significant differences were to occur in Phases 2 and 4, they would occur during the first few days. Experiment II also showed that no more than five days were needed for Phase 3 to return Ss to their steady response rates obtained at the end of Phase 1. It was apparent from Experiment II that Phase 1 or Acquisition had to remain fifteen days long.

As in Experiment II, at the end of Phase 1, the 14 Ss were divided into two groups. Each group had approximately the same mean response rate across sessions. Again, the groups were assembled from pairs of Ss more or less matched for mean response rate across sessions (see Table XII below and Figure in the results section). A response was defined as a traverse from the safe box into the goal region.

TABLE XII

Group composition in terms of the mean response rate across Phase 1.

Group C			Group D		
Subject		Mean response rate	Subject		Mean response rate
1	-	17.80	8	-	21.47
2	-	14.47	9	-	14.40
3	-	12.73	10	-	13.20
4	-	11.93	11	-	9.53
5	-	9.00	12	-	9.53
6	-	8.80	13	-	6.00
7	-	3.20	14	-	5.60
		= 77.93			= 79.73
	$\bar{X}$ =	11.13		$\bar{X}$ =	11.39

Each group was then randomly assigned to the experimental conditions in Phase 2.

RESULTS AND DISCUSSION

The data are presented in graphic and tabular form at the end of this session and in Appendix III. Figure IX gives the response rate for Groups C and D across sessions of the four experimental phases. As in Experiment II, inspection of the graph of Phase 2 in Figure IX shows that the greatest difference between group means occured, as might be expected during the first session. A T-test of these two means gave a value T=1.70; with 12 d.f., this difference is not significant at the .05 level. A likely reason for this nonsignificant result lies in the response rate of one *S* of Group C. This *S* made only 1 response during the first session. The response rates for the remaining *Ss* of Group C in the first session ranged from 13 to 24. The response rate of the one *S* badly skewed the data. When the data from *S* with the lowest response rate was discarded from *both* Groups C and D, a T-test of the resulting two means (Group C, $\bar{X} = 17.83$; Group D $\bar{X} = 10.83$) gave a T=2.79 which with 10 d.f. is significant at the .02 level. Thus, for the first session of Phase 2, the results were in the predicted direction and were significant when the data of a highly deviant *S* were excluded.

Turning to Phase 4, Figure IX shows that the results are again in the predicted direction. Once again, the greatest difference between group means occured during the first session. A T-test of these two means gave a value of T= 3.20 which with 12 d.f. is significant at the .ol level. To be consistent with the analysis in Experiment II, the data from the S with the lowest response rate for this session was discarded from both Groups C and D. The two lowest performing Ss in Phase 4 were not the same two lowest performing Ss in Phase 2. After the removal of the data for the two poorest performing Ss in session 1 of Phase 4, the mean for Group C became 7.33 versus the previous mean of 6.71. For Group D, the mean became 15.67 versus the previous mean of 14.71. A T-test of these resulting two means gave a T= 3.10 with 10 d.f. which is significant at the .02 level. Thus, for the first session of Phase 4, the results were clearly in the predicted direction. The second hypothesis was supported.

A further analysis of the response rate data was made by using each S as its own control (No data were excluded). That is, each S's response rate under the 3 second delay condition was matched against its response rate for the 11 second condition. A matched-pairs T-test was used to analyze the results. This gave a T_d= 3.64 with 13 d.f. which is significant at the .01 level. This matched-pairs analysis clearly supports the predicted effect.

Inspection of the response rate data from Phase 1 indicates a great similarity to the results obtained in Phase 3 of Experiment I and Phase 1 of Experiment II. In this experiment as in Experiment II, there is some savings

in reacquisition. The combined mean response rate of Groups C and D for the first session of Phase 1 of Experiment III is $\bar{X} = 3.93$. The combined mean response rate of Groups C and D for the first session of Phase 3 of Experiment III is $\bar{X} = 10.76$. This represents a savings of 288% in terms of response rate. A matched-pairs T-test of the mean response rates of the first sessions of Phases 1 and 3 (using each S as its own control) gave a $T_d = 3.205$ with 13 d.f. which is significant at the .01 level. Inspection of the response rates for the first sessions of Phases 2 and 4 revealed only a 14% savings. Compare this savings with the 44% savings found in Experiment II. A matched-pairs T-test between Phases 2 and 4 of Experiment III gave a $T_d = .675$, d.f. = 13. The 14% savings represents a nonsignificant savings in responding. Probably the shortening of Phase 2 (or extinction) from Experiment II to Experiment III accounts for the appreciable loss in savings. The five sessions of Phase 2 in Experiment III may have been an insufficient number of sessions to allow the development of an appreciable amount of positive transfer.

As in Experiment II, the analysis of time measures is of particular importance for the major hypothesis. Figure X presents the mean total time spent in the goal region for the group receiving the 3 second delay condition and the group receiving the 11 second delay. The difference noted here was also seen in Experiment II. This difference can be

better appreciated in Figure XI. The graphs of the mean time in the goal per response for Phases 2 and 4 show, as they did in Experiment II, that when a group is allowed more time in the goal region, more time is spent there. In Figure XI, the two curves are not quite so equally displaced from the 7 second point as was the case in Experiment II. However, the effects were very similar. The 11 second group again spent less than the full delay interval in the goal region per response while the group under the 3 second condition spent more than the delay interval. As in Experiment II, the same explanation could apply; Namely, that an 11 second delay is sufficient time for the frustration response to increase beyond the previously conditioned levels, while a 3 second delay is not.

One of the most interesting aspects of the extinction phases for these data is that the time in goal per response tends to increase rather than decrease. This is especially true in Phase 4 for the 11 second delay group (Group C). The increase in goal time in Group C in Phase 4 is possible because the predator does not start moving until after an 11 second delay. Why goal time per response increases when there is no water available can only be explained, in part at least, by the assumption that staying in the goal is still the strongest or prepotent response in this stimulus situation.

The slope constants for the curves seen in the graph of Phase 2 in Figure XI are $b_{xy} = + .110$ for Group C and

b_{xy} = + .080 for Group D. These slight positive slopes might suggest that there was little if any margin for further conditioning at the outset of Phase 2. The slight negative slope computed for the Group D curve of time in the goal region per response in Phase 4 suggests that since this group started out spending a deal of time in the goal per response compared to Group C in Phase 2, Group D's performance may have been near maximal in the first session and thus had no place to go but down.

As in Experiment II, in the final four sessions of Phase 1 and throughout Phase 3, their is a reliable increase in the mean time spent in the goal region per response beyond the 7 second delay period. Once again, this is the same effect as seen in Phase 3 of Experiment I. Reasons for this were proposed in Experiment I.

Table XII gives the frequency of shocks for each session and each phase for Groups C and D. As in Experiment II, inspection of the shock frequencies for Phases 2 and 4 again shows that decreased resistance to extinction shown by the *Ss* under the 11 second delay condition cannot be attributed to a higher shock frequency. The *Ss* under the 3 second delay condition always received the greatest number of shocks during the first session and the entire phase. As in Experiment II, the observations of Ss behavior again indicated that hesitancy in retreating from the goal region and entering the safe box

were major reasons for an *Ss* receiving a shock. Again, the observed differential in amount of hesitancy was seen. Finally, *E* was not able to discern any reliable difference in the manifestation of fear or frustration between Groups C and D.

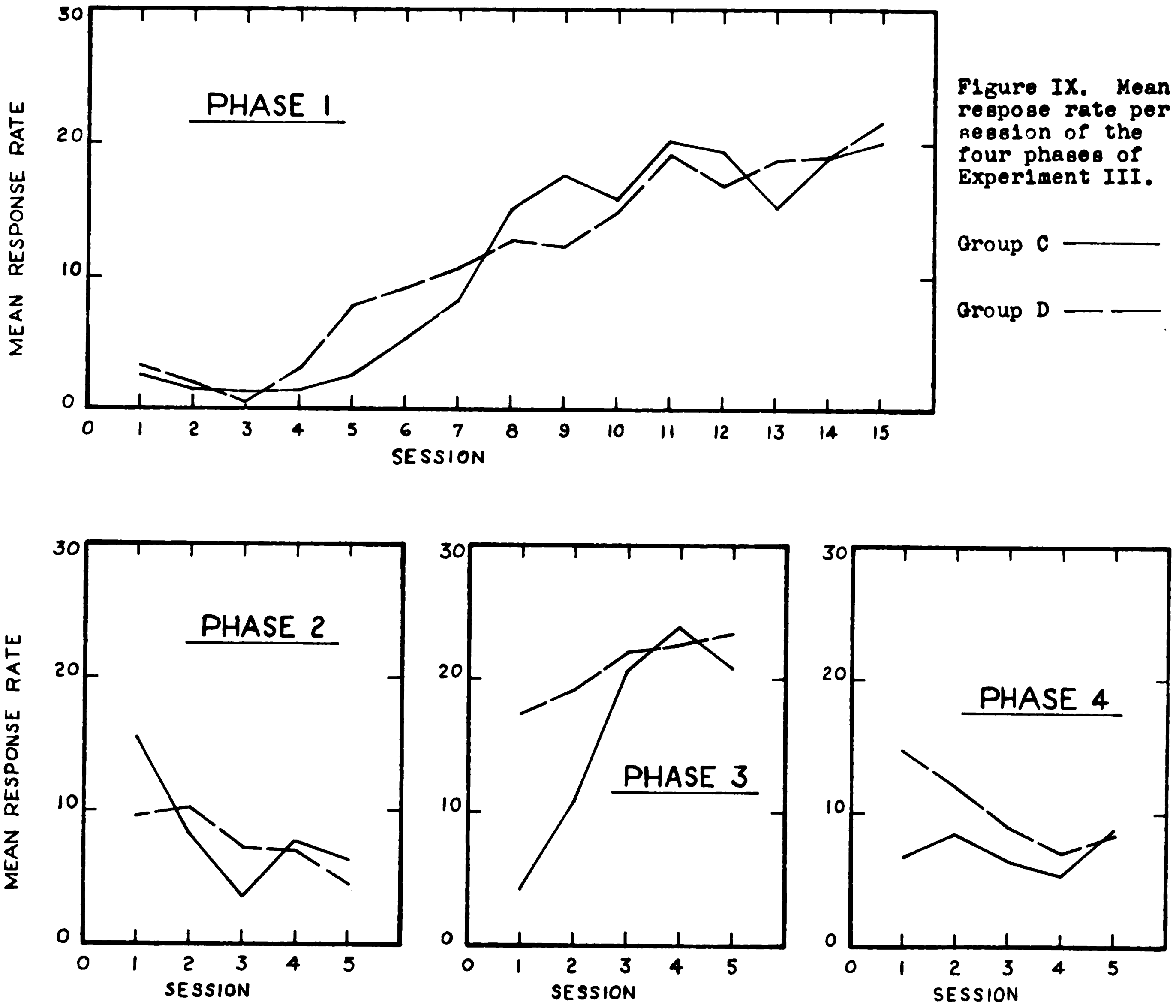


Figure IX. Mean respose rate per session of the four phases of Experiment III.

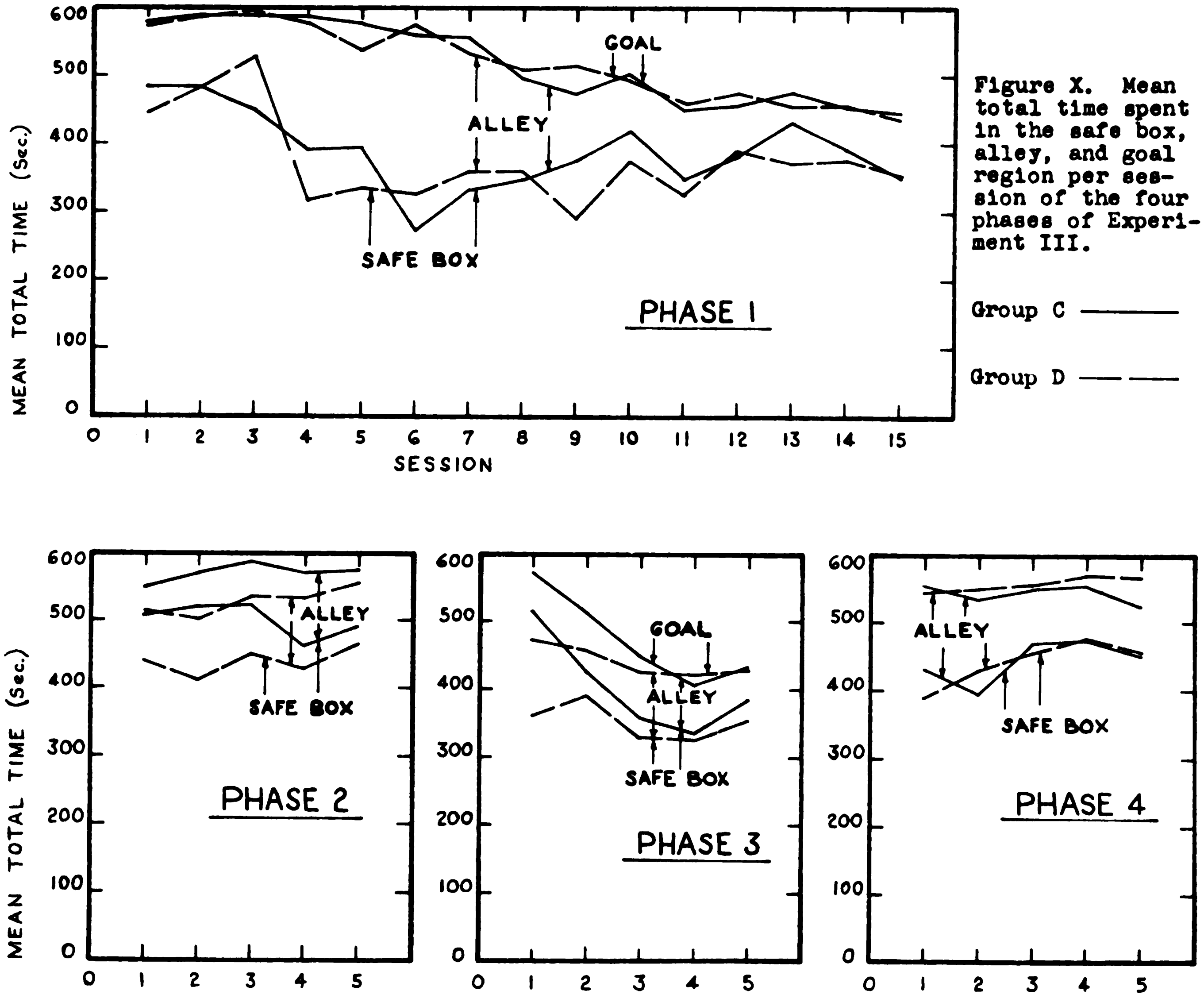


Figure X. Mean total time spent in the safe box, alley, and goal region per session of the four phases of Experiment III.

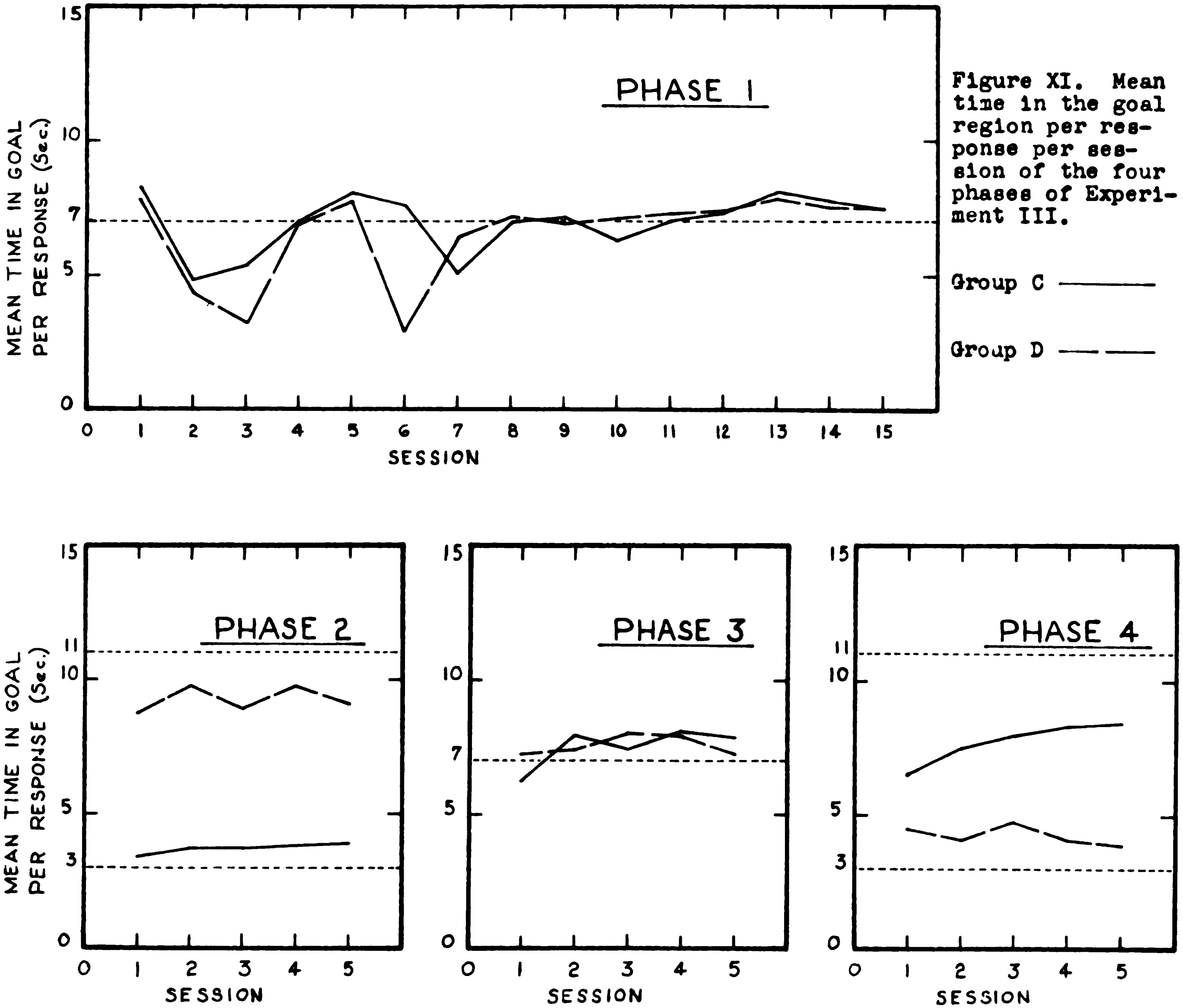


Figure XI. Mean time in the goal region per response per session of the four phases of Experiment III.

TABLE XIII

Mean water consumption (in ml.) by Ss of Group C and D during Phase 1 and 3 of Experiment III.

Phase 1

Sessions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group C, $\bar{X}$ ml. consumed	1.1	0.0	.3	1.0	.8	2.2	2.7	4.9	5.7	5.5	7.0	6.0	5.2	6.8	8.0
Group D, $\bar{X}$ ml. consumed	1.0	.6	.1	1.6	2.9	3.4	3.6	3.3	3.8	3.9	5.6	4.9	5.6	5.8	6.8

Phase 3

Sessions	1	2	3	4	5
Group C, $\bar{X}$ ml. consumed	1.2	4.7	8.4	9.0	7.8
Group D, $\bar{X}$ ml. consumed	5.0	5.2	6.3	6.8	7.3

TABLE XIV

Frequency of shocks received by <u>Ss</u> of Groups C and D during the four Phases of Experiment III.

Phase 1

	Sessions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Group C,	Shock frequency	18	2	2	4	1	1	3	0	2	2	0	4	3	1	2
Group D,	Shock frequency	16	2	0	0	1	4	0	6	0	1	1	2	0	0	2

Phase 2

	Sessions	1	2	3	4	5
Group C,	Shock frequency	1	2	0	1	4
Group D,	Shock frequency	0	1	0	1	0

Phase 3

	Sessions	1	2	3	4	5
Group C,	Shock frequency	0	1	2	0	1
Group D,	Shock frequency	0	2	1	1	2

Phase 4

	Sessions	1	2	3	4	5
Group C,	Shock frequency	0	1	1	0	0
Group D,	Shock frequency	2	0	2	2	0

CONCLUSIONS AND SUMMARY

In the introduction to this study, a model was presented for approach learning and extinction in prey organisms as a function of repeated predatory attacks. The learning model involved the assumption that the basic task confronting the prey organism is to learn to approach a region of the environment to obtain needed reinforcement and then flee this same region to avoid the direct physical attack of an approaching predator. The response of approaching the goal, it was argued, is conditioned to the stimuli accompanying the emotional responses of fear and frustration.

Fear is elicited by the operation of the predator. After a sufficient number of approaches to the goal region, fear-produced stimuli serve as partial discriminative stimuli eliciting the approach response.

Frustration is elicited by the termination of positive reinforcement necessitated by the prey leaving the source of reinforcement in order to avoid the predator's attack. As with fear, after a sufficient number of approaches to the goal, frustration-produced stimuli serve as partial discriminative stimuli eliciting the approach stimuli response.

Two predictions were made concerning resistance to extinction. The prediction was made that prey without prior experience in approaching the reinforced region under threat of predatory attack would show less resistance to extinction

than had they have such prior experience. Also, it was predicted, from the model, that prey allowed less time in the goal region prior to the onset of predatory attack would show more resistance to extinction of the approach response compared to prey having more time in the goal region prior to predatory attack. These predictions were supported by the results.

The model makes use of apparently justified assumption that under appropriate learning conditions, normally noxious and aversive stimuli can come to serve as stimuli helping to increase resistance to extinction. Convincing evidence for this assertion is to be had by noting that in Experiments II and III the groups which show the greatest resistance to extinction are also the groups which receive the greatest number of shocks.

The results supporting the two hypotheses and the other results which came to light during this study must be generalized with great caution. Direct application of the present findings to the field must be quite tenative. However, two conclusions seem fully warranted. First, this study has set forth a means of systematically studying a complex problem. The problem is to find a way to evaluate the type and form of learning which a prey organism displays as it learns to cope with its predators. It is felt that this study represents a step in the right direction. The basic task confronting the subjects in the present study

may be limited in scope in terms of all possible confrontations of prey and predator, but the situation is readily modifiable along several dimensions. These dimensions are, for instance: The special relationship of safe region, goal, and intervening space; the initial locus of the predator; the detectability of the predator before and after the beginning of its approach towards the prey organism; the stimuli characterizing the predator such as size, speed of approach, type of stimuli signaling approach of the predator; the possibility of varying the type of and number of alternative paths leading to and from the goal region; variation in the type of reinforcement and deprivation conditions of the prey; and of course, the type of prey organism used.

The second point is that an attempt has been made to formulate the problem. This formulation or theorizing gives a structured framework for future research in the field. The present study could serve to focus field efforts towards the gathering of detailed information on the continuing behavior of individual prey organisms. This study could serve to equip the observer with a set of expectations on the learning of prey organisms. These expectations could then be supported, modified, or disconfirmed by careful observations in the field. By this means a reciprocal relationship between laboratory and field work might be developed.

Sheer common sense would dictate that the conditions confronting the prey organism in the field are much less

stable than in the laboratory. Evenso, some tentative suggestions can be put forth from the results of the present "hyperstable" study. It is suggested that increased resistance to extinction of approach to a region previously associated with reinforcement might prove to be adaptive for the prey organism. This might be so in that the conditions which make reinforcement available in the first place may repeat themselves. This would make it unnecessary for the organism to search new and wider areas for other sources of reinforcement. This effect might help explain territoriality in organisms which have fairly demarcated foraging ranges.

Also, increased resistance to extinction under conditions of short delay in predatory attack compared to long delays might prove adaptive. More returns to a previously reinforced region could disclose other sources of reinforcement close to the original region.

Also, through the conditioning of approach response to fear-frustration stimuli it is possible that a prey organism may be more resistant to abandoning new, potential sources of food or water (reinforcement) if it is attacked in this region while being reinforced.

These suggestions are put forth to show further avenues of study in the area of modification of prey behavior through the medium of predator encounters.

Finally, it is hoped that the present study will alert

other workers to the need to view behavior modification in light of its adaptive significance for the organism displaying the behavior change. In the last analysis, learning should be viewed as one way an organism deals with a hostile environment.

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APPENDIX I

Means and standard deviations of the response rates per session of the four phases of Experiment I

Phase 1

Sessions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\bar{X}$	4.00	3.00	4.60	4.20	5.00	5.80	5.60	4.80	4.60	5.20	4.40	4.60	4.80	4.80	4.80
SD	1.58	1.87	1.34	1.09	2.23	1.30	1.14	1.79	1.34	2.17	1.67	1.51	1.30	1.64	1.30

Phase 2

Sessions															
$\bar{X}$	3.60	2.60	2.00	1.80	1.00	2.40	.80	1.40	1.20	1.20	2.20	1.60	2.00	2.20	1.60
SD	3.03	1.34	.71	1.48	.71	3.21	.83	.55	.83	.83	1.92	.89	1.23	2.17	1.34

Phase 3

Sessions															
$\bar{X}$	2.40	1.80	2.20	3.20	6.80	5.40	10.60	10.60	13.00	15.60	18.6	20.80	19.60	15.00	17.20
SD	4.60	2.68	2.68	4.09	6.30	6.19	10.26	7.89	8.97	7.64	4.83	7.39	9.69	9.95	9.45

Phase 4

Sessions															
$\bar{X}$	9.8	8.00	9.40	10.60	6.80	7.80	6.80	7.60	6.80	10.40	8.60	7.60	6.40	3.40	4.80
SD	7.87	6.78	7.60	7.83	6.53	6.83	4.21	4.33	5.35	5.85	6.65	4.21	3.85	2.07	2.95

APPENDIX II

Means and standard deviations of the response rates of Groups A and B per session of the four phases of Experiment II

Phase 1

essions		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
up A	$\bar{X}$	3.80	4.40	3.20	3.80	6.20	8.40	8.60	13.00	15.20	22.60	18.40	19.80	20.20	21.00	23.20
up	SD	4.98	2.51	3.42	1.30	5.89	7.47	5.55	9.14	9.65	4.21	5.77	7.91	7.73	5.00	3.11
	X	4.00	3.00	1.80	4.20	9.00	7.20	12.40	9.60	14.20	18.20	19.60	19.80	24.00	21.20	24.00
	SD	3.16	1.58	1.48	2.68	6.75	7.91	8.62	8.82	5.76	6.30	5.81	6.05	5.05	10.52	6.33

Phase 2

essions		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
roup A	$\bar{X}$	19.00	9.40	7.00	8.20	7.60	9.40	9.60	7.00	8.60	7.60	5.20	4.00	6.40	5.60	6.00
roup	SD	8.75	7.97	6.33	6.38	4.93	5.55	7.77	4.89	5.81	5.98	3.34	2.65	4.28	4.33	5.87
	X	12.80	10.40	9.20	7.40	5.20	5.80	3.60	4.20	5.00	4.00	5.20	6.00	5.00	4.40	4.40
	SD	6.73	7.19	6.18	6.54	5.40	4.15	3.27	3.56	3.81	4.47	5.71	7.55	4.47	4.21	4.83

Phase 3

essions		1	2	3	4	5	6	7	8	9	10
roup A	$\bar{X}$	18.00	24.40	23.20	21.20	18.40	23.60	20.80	18.40	17.00	17.80
roup	SD	10.07	2.70	4.03	7.09	8.17	3.43	5.31	3.43	8.01	9.28
	X	15.40	16.20	19.80	24.00	17.20	21.40	18.20	18.60	21.00	16.40
	SD	10.07	7.69	8.53	6.78	4.81	6.43	5.49	2.70	4.69	7.53

Phase 4

essions		1	2	3	4	5
roup A	$\bar{X}$	7.00	6.00	4.20	3.20	3.80
roup	SD	6.04	3.16	3.03	2.17	2.28
	X	10.8	5.20	3.60	4.00	1.60
	SD	8.13	5.54	4.51	4.79	1.34

APPENDIX III

Means and standard deviations of the response rates of Groups C and D per session of the four phases of Experiment III

Phase 1

essions		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
roup C	$\bar{X}$	2.57	1.57	1.29	1.43	2.57	5.29	8.14	15.00	17.57	15.85	21.43	19.43	15.14	19.00	20.71
	SD	2.77	1.51	1.60	2.07	6.50	7.29	9.72	7.70	8.02	7.86	7.65	10.02	9.27	6.63	7.03
roup D	$\bar{X}$	3.29	2.00	.43	3.14	7.85	9.14	10.71	12.71	12.29	14.85	12.14	16.65	18.71	19.00	21.57
	SD	2.13	2.65	.53	4.91	10.82	9.85	12.33	8.15	9.21	6.33	7.38	6.93	5.99	6.37	6.77

Phase 2

ssions		1	2	3	4	5
oup C	$\bar{X}$	15.43	8.29	3.57	7.71	6.29
	SD	7.53	6.45	4.23	6.65	6.87
oup D	$\bar{X}$	9.57	10.14	7.14	7.00	4.57
	SD	2.12	4.32	5.17	4.83	2.32

Phase 3

essions		1	2	3	4	5
Group C	$\bar{X}$	4.14	10.85	20.57	23.85	20.85
	SD	7.51	11.02	11.15	8.41	7.85
oup C	$\bar{X}$	17.43	[illegible]	[illegible]	27.57	23.29
	SD	6.45	[illegible]	[illegible]	7.41	9.02

Phase 4

ssions		1	2	3	4	5
oup C	$\bar{X}$	6.71	8.43	6.43	5.29	8.85
	SD	2.98	[illegible]	4.10	4.71	7.05
oup D	$\bar{X}$	14.71	[illegible]	2.00	7.05	8.42
	SD	5.93	9.18	5.35	5.21	6.32