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THE ROLE OF DISCRIMINATION IN THE PASSIVE AVOIDANCE BEHAVIOR OF RATS

A DISSERTATION

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THE ROLE OF DISCRIMINATION IN THE PASSIVE

AVOIDANCE BEHAVIOR OF RATS

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APPROVED FOR THE DEPARTMENT OF PSYCHOLOGY

By

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Abstract

In the first experiment, the contributions of response contingent vs. noncontingent shock, strain of rat, and 3 levels of shock location discriminability to passive avoidance performance were investigated. Both response contingency and increasing discriminability increased performance. Experiment two found that response contingency, increased discriminability, and strain of rat effected performance. The results showed that the relative amounts of time of the CER (freezing) and instrumental avoidance were determined by the discriminability of the shock location. Implications for Bolles' SSDR's are discussed.

The Role of Discrimination in the Passive

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Robert L. Fulwiler

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The most apparent difference between active and passive avoidance is that active avoidance involves the occurrence of a particular response and passive avoidance involves the absence of a particular response. There is a rich history of theoretical development concerning active avoidance but comparatively less development for the passive avoidance situation. Of course, it is possible that the same processes which control active avoidance also control passive avoidance, although this possibility is not settled.

There have been a number of recent attempts to theoretically account for passive avoidance behavior. Randall and Riccio (1969) hypothesize that there are two factors involved with passive avoidance: (a) a classically conditioned fear response to environmental stimuli, and (b) instrumental behaviors to avoid the stimuli associated with shock. This hypothesis is in accord with the "two factor" theory of Mowrer (1960) to account for active avoidance. In a slightly different account, Blanchard and Blanchard (1970) hypothesized that passive avoidance involves (a) fear which is conditioned to specific stimuli and (b) a generalized fear reaction to the entire situation which might result in immobility.

Several studies (Calhoun and Murphy, 1969; Mellgren, Willison, and Dickson, 1973; Mellgren and Fulwiler, 1974) have shown that acquisition of passive avoidance of one compartment of a two compartment apparatus was improved when shock was delivered contingent upon the occurrence of a response (entering the shock compartment) relative to subjects which were directly placed in the shock compartment. Considering the previous theoretical speculations these hypotheses and these results, it may be hypothesized that passive avoidance behavior is governed by as many as three components: (1) an instrumental avoidance of the stimuli associated with shock, (2) immobility due to fear being classically conditioned to the experimental situation, and (3) a specific weakening of the movement response which resulted in the occurrence of the aversive stimulus.

In their experiment, Mellgren et al (1973) postulated that the superiority of the response contingent procedure might be a function of the subjects in this condition being able to discriminate between the safe and shock locations because of their experience of encountering no shock in the shock compartment (the placed shock subjects never experienced the safe compartment and were simply placed directly into the shock compartment). While there was an escape contingency in the Mellgren et al study, it had no effect. There is no escape contingency in the present study.

The present experiment was designed to investigate the extent to which each of the above hypothesized mechanisms are involved in passive avoidance behavior. To do this, more behaviors than just the usual measure of time taken to exit the safe compartment and enter the shock compartment were recorded. In particular, the second hypothesized factor (fear-related immobility) was operationalized as the amount of time the subject spent "freezing" (immobile) on the test trials. The instrumental avoidance component (factor 1) was operationalized as the amount of time between the termination of freezing and the initial exit latency into the shock compartment. The logic of this operationalism is consistent with Bolles' (1970) species specific defense reactions (SSDR's). Bolles hypothesizes that an avoidance response (R_a) "can only be rapidly acquired if it is an SSDR, and only at the expense of other SSDR's." If one hypothesizes along with Bolles that a rat's SSDR repetoire consists of freezing, fleeing, or fighting, only one of the responses may be learned rapidly since it must be learned at the expense of the other two. In passive avoidance, fleeing, or any behavior resulting in the subject moving from one side of the apparatus to the other, is incompatible with R_a (in fact, fleeing was punished in the response contingent condition) and there is nothing to fight; hence, freezing is the only SSDR which is compatible with R_a. Bolles also states that with the minimization of shock (or presumably other aversive stimuli) one may expect a gradual return of the subjects normal behavioral repetoire such that the current behavior is no longer restricted to the SSDR's. Following this logic, it is reasonable to hypothesize that the more discriminable the shock source, the more R_a is stimulus specific, i.e. the shock source may be avoided while the subject engages in other behaviors such as exploration, grooming, etc. Therefore, it is predicted that subjects with a highly discriminable shock source can successfully avoid the shock source while engaging in other behaviors, but subjects with low shock object discriminability cannot, i.e. the low discriminability subjects will spend more time freezing than the high discriminability subjects but would also show less total or instrumental avoidance as measured by the time to leave the safe compartment.

The first experiment was designed to test these hypotheses by varying the level of discriminability of the place where shock was presented. One dimension of discriminability was the relative brightness of the safe and shock compartments, the second was the comparison of response contingent vs. placed shock delivery, and the third was the use of albino vs. hooded rats because hooded rats, having greater visual capabilities, should be more able to employ differential visual cues.

Method

Subjects.--The subjects were 36 male albino rats of the Sprague-Dawley strain and 36 male hooded rats of the Long-Evans strain approximately 120 days old from the University of Oklahoma colony, maintained *ad lib* for food and water.

Apparatus.--The apparatus was a wooden box which had a hardware cloth top and a grid floor. The sides were lined with cardboard inserts which were black, white, or grey. The inside dimensions of the box were 90 cm long, 14 cm wide and 30 cm deep. The grid floor consisted of aluminum tubes, 13 mm in diameter, spaced 4 cm center-to-center. The box was divided into two compartments by a tan engraving stock guillotine door. A Grason-Stadler shocker (Model 700) was used to deliver a scrambled shock. A stopwatch which read to the nearest 0.1 sec was used.

Procedure.--Training. The design of the experiment was a 2 X 2 X 3 factorial. Acquisition of passive avoidance was tested following either a response contingent or placed shock, by either a hooded or albino rat, in a differential brightness (black white), slight different brightness (black or white grey), or nondifferential brightness (grey grey) condition. In the response contingent condition, the subject was placed in the safe compartment with the guillotine door closed and 5 sec later the door was raised. When the subject had crossed to the shock side, the door was lowered and 5 sec later the shock was delivered. The shock was 1.0 mA in intensity (nominal setting) and 5.0 sec in duration. Upon shock termination, all subjects were removed to the home cage. In the placed condition, the subject was placed directly in the shock compartment and 5 sec later the shock was delivered. In the differential brightness condition, one compartment was white and the other black; in the slightly different condition, one compartment was either black or white and the other grey; in the nondifferential condition, both compartments were grey. The order of brightness and side of apparatus serving as the safe compartment were counterbalanced. Combining these variables gives twelve groups of subjects. The group abbreviations are constructed such that the strain of rat is represented by either H (hooded) or A (albino); the method of shock delivery by RC (response contingent) or P (placed); and the levels of discriminability by D (differential), SD (slightly different), or ND (nondifferential brightness). These may be combined such that group

HRCD was hooded rats receiving response contingent shock in the differential brightness condition; group APND was albino rats receiving placed shock in the nondifferential brightness condition; and group HPSD was hooded rats receiving placed shock in the slightly different brightness condition, and so on. All subjects received one acquisition trial and two 15 min test trials at 24 and 48 hrs post shock,

Testing. On the test trials, the subject was placed in the safe compartment and 5 sec later the door was raised. The six measures of passive avoidance were: (1) initial exit latency (IEL), (2) freezing (F) (the freezing measure was begun 10 sec after the door was raised until the animal had moved both front paws one bar), (3) initial exit latency minus freezing (IEL-F), (4) total time spent in the shock compartment (TOB), (5) the number of crossings between the safe and shock compartments (Exits), and (6) entries into the shock compartment which did not reach exit criterion. The criterion of exiting was both hind paws on the third bar past the door.

Results

Unless otherwise noted, all statistical differences to be discussed are $p < .05$ or better using the analysis of variance and Tukey's procedure for comparing individual groups. As can be seen from Fig. 1, on the first test trial, response contingent subjects had longer exit latencies than placed subjects, hooded rats had longer exit latencies than albino rats ($F = 2.99$, $df = 1/60$, $p < .10$), and exit latencies increased with increasing discriminability. Response contingent rats froze less than placed rats and increasing discriminability led to decreasing amounts of time spent freezing. In regard to the measure of instrumental avoidance (IEL-F), hooded rats avoided more than albino rats, response contingent rats avoided more than placed rats, increasing discriminability led to increased avoidance, and the method of shock X level of discriminability interaction was significant. Post hoc analysis of the cell means indicated that within the placed condition D = SD, SD = ND, but D > ND and within the response contingent condition D > SD > ND (all comparisons reported for the present experiments utilized the Tukey HSD procedure for post hoc comparisons at the .05 level of significance). Response contingent rats made fewer crosses into the shock compartment than did placed rats and increasing discriminability led to decreased number of exits. Response contingent rats made more entries than placed rats, increasing discriminability led to more entries, and the method of shock X level of discriminability interaction attained significance. Post hoc analysis indicated that within the placed condition D = SD = ND, but within the response contingent condition, D = SD, SD = ND, but D > ND. Response contingent rats spent less time in the shock compartment than did placed rats, increasing discriminability led to decreased time spent in the shock compartment, and the method of shock X level of discriminability interaction was significant. Post hod analysis revealed that within the placed condition D = SD = ND, but within the response contingent condition D = SD > ND.

Insert Figs. 1 and 2 about here

On the second test trial (Fig. 2), response contingent rats still had longer exit latencies than placed rats, increasing discriminability still led to increased latencies, and the strain of rat X level of discriminability interaction was significant. Post hoc analysis indicated that for hooded rats D = SD = ND and for albino rats D = SD, SD = ND, but D > ND. Fig. 3 shows that on the freezing measure, the strain of rat X method of shock X level of discriminability interaction attained significance. On the measure of instrumental avoidance, response contingent rats avoided more than placed rats, increasing discriminability led to increased avoidance, and the method of shock X level of discriminability interaction was again significant. Post hoc analysis revealed that within the placed condition D = SD = ND and within the response contingent condition D = SD > ND. Response contingent rats made fewer crosses into the shock compartment than placed rats, and increasing discriminability led to fewer exits. The only significant result on the entry measure was the method of shock X level of discriminability interaction. Analysis of this interaction indicated that within the response contingent condition D = SD = ND and within the placed condition D = SD, SD = ND, but D > ND. Response contingent subjects spent less time in the shock compartment than did placed subjects, increasing discriminability led to decreased time spent in the shock compartment, the method of shock X level of discriminability interaction was significant as was the strain of rat X method of shock X level of discriminability interaction. Post hoc analysis of the method of shock X level of discriminability interaction indicated that within the placed condition D = SD = ND, but within the response contingent condition D > SD > ND. Analysis of the triple interaction indicated that the above interaction was also augmented by the non-significant differences between the strains of rats.

Discussion

The results of the present experiment indicate that all three of the hypothesized mechanisms may contribute to passive avoidance behavior. The consistent result that increasing the discriminability between the safe and shock compartments increases passive avoidance indicates that discriminative processes do play an important role. The consistent superiority of the subjects receiving response contingent shock over those receiving placed shock indicates that the punishment hypothesis may be viable to explain those differences, but it also may be hypothesized (Mellgren et al, 1973) that the effect of the response contingency may be to increase discriminability; or to make the associations to the shock stimulus specific rather than response specific. Blanchard and Blanchard (1968) conclude that the punishment of specific responses is not necessary to establish passive avoidance. The discrimmination alternative is given further support by the results of the instrumental avoidance measure (IEL-F) in that the method of shock delivery interacts with the level of discriminability to produce greater passive avoidance. The response which is punished for the RC groups is entering the shock compartment, which necessarily involves movement, hence movement per se should be punished. This would imply that, according to Bolles, freezing should be the dominant response, but the results of the freezing measure directly contradict this. Hence, it is implied that the effect of the shock being response contingent is to increase the effective level of discriminability between the safe and shock locations. As such, the subjects which can readily discriminate between the safe and shock locations may engage in more normal behaviors such as exploration of the safe compartment while readily avoiding the shock compartment as evidenced by the instrumental avoidance measure.

It is worthy to note that decreasing the level of discriminability not only decreases passive avoidance, but increases the amount of time spent freezing. Thus, when the subject cannot discriminate between the two compartments visually, the punishment hypothesis may be given more credence. However, the other measures such as entries, exits, and time spent in the shock compartment point to the response contingency giving rise to discriminative cues, especially the significant interaction on the entries measure, which may be conceptualized as intention step-throughs (Barcik and Ellis, 1971) and the interaction of the two factors (method of shock delivery X level of discriminability) for the time spent in the shock compartment.

Barcik (1971) hypothesized that motor activity was incompatible with passive avoidance, but failed to support that hypothesis. He reported that the animals were active on the platform while meeting the avoidance criterion. He goes on to state "the relative compatibility or incompatibility of the avoidance response (either active or passive) with which SSDR is elicited by the punishing stimulus will determine the rate at which avoidance behavior is acquired, if at all. In active avoidance, the freezing SSDR must drop out to let the flight SSDR develop whereas in passive avoidance, the flight SSDR must drop out to let freezing develop." (p. 6). This conclusion is incompatible with both his earlier statement and the results of the present experiment. While it may be necessary for the avoidance response to be an SSDR for the rapid acquisition of active avoidance, the present data imply that for the rapid acquisition of a passive avoidance response, the required response must merely be compatible with the SSDR repetoire. In fact, in the case of a highly discriminable shock object, SSDR's may be minimally apparent.

To investigate further the role of discrimination and the lack of consistent differences between the two strains of rats, experiment 2, involving more discrete cues was performed.

Experiment 2

It may be hypothesized that the relative lack of differences between the hooded and albino rats was due to the "grossness" of the visual cues. Since the apparatus provided a very confined space, it may have been possible for the albino rats to visually discriminate as well as the hooded rats. In order to test this hypothesis, the condition designed to be visually discriminable was verticle vs. horizontal black and white stripes, and the non-visually discriminable condition was again grey in both compartments. Hence, the two conditions would be equated on total brightness and any visual discrimination would be based on pattern rather than on overall brightness. In addition, the response contingent and placed manipulation were combined to complete a 2 X 2 X 2 factorial design, allowing the present study to conceptually replicate the previous study with greater emphasis on the differential visual cues.

Method

Subjects.--The subjects were 24 male albino rats of the Sprague-Dawley strain and 24 male hooded rats of the Long-Evans strain approximately 120 days old from the University of Oklahoma Colony maintained *ad lib* for food and water.

Apparatus.--The apparatus was the same as in experiment 1, but the cardboard inserts were either 1 inch wide horizontal or verticle black and white stripes, or solid grey.

Procedure.--Training. The design of the experiment was a 2 X 2 X 2 factorial. Acquisition of passive avoidance by either an albino or hooded rat was tested following either a response contingent or placed shock in a differential (striped) or nondifferential (grey) visual condition. The group abbreviations are constructed such that the strain of rat is represented by either H (hooded) or A (albino); the method of shock delivery by RC (response contingent) or P (placed); and the level of discriminability by D (striped apparatus) or ND (grey apparatus). All other procedures were the same as in the previous experiment.

Results

Unless otherwise noted, all differences are $p < .05$ or better using the analysis of variance and Tukey's procedure where appropriate. On the first test trial, hooded rats had longer total exit latencies than albino rats, response contingent rats had longer exit latencies than placed rats, and the differential visual cues subjects had longer exit latencies than the nondifferential visual cues subjects. Response contingent rats displayed less freezing than placed rats. Fig. 3 shows that on the measure of instrumental avoidance (IEL-F), hooded rats avoided better than albino rats, response contingent rats avoided better than placed rats, increasing discriminability led to increasing avoidance, and the method of shock (RC vs. P) X level of discriminability interaction was significant. Post hoc analysis indicated that for the placed condition D = ND, but for the response contingent condition D > ND. Hooded rats made fewer crossings than albino rats, response contingent rats made fewer crossings than placed rats, and increasing discriminability led to fewer crossings. Hooded rats made less entries into the shock compartment than did albinos, response contingent subjects made more entries than placed subjects, increasing discriminability led to more entries, the strain of rat X method of shock interaction was significant, as was the method of shock X level of discriminability interaction. Post hoc analysis of the strain of rat X method of shock interaction revealed that for the placed condition H = A, but for the response contingent condition H < A. Analysis of the method of shock X level of discriminability interaction indicated that for the placed condition D > ND and for the response contingent condition D = ND. Increasing discriminability led to less time spent in the shock compartment, hooded rats spent less time than albinos, and response contingent rats spent less time than placed rats in the shock compartment.

Insert Figs. 3 and 4 about here

On the 48 hr post-shock test trial, shown in Fig. 4, rats shocked in the striped pattern had longer total exit latencies than rats shocked in the homogeneous grey condition. In regard to the instrumental avoidance measure, increasing discriminability led to increased instrumental avoidance, and the method of shock X level of discriminability interaction was significant. Post hoc analysis indicated that within the placed condition D > ND and within the response contingent condition D > ND, but the difference between D and ND within the placed condition was 2.41 min and the difference within the response contingent condition was 2.97 min. Hooded rats made fewer crossings than albino rats, response contingent subjects made fewer crossings than placed subjects, and increasing discriminability involved fewer crossings. Increasing discriminability also led to fewer entries. The subjects shocked in the differential condition spent less time in the shock compartment than animals shocked in the nondifferential condition, and response contingent animals spent less time in the shock compartment than placed shock animals.

Discussion

The results of this experiment once again provide support for the hypothesis concerning the role of discrimination processes in passive avoidance behavior. The results also provide support for the hypothesis that the rather gross brightness cues in experiment 1 were equally viable for both strains. The consistent strain differences obtained in this experiment indicate that with more discrete visual cues, the visual acuity of the hooded rats enabled them to more successfully avoid the shock compartment. The lack of differences on the freezing measure combined with the differences on all other measures for the first test trial would imply that the visual superiority of the hooded rats had its most effect on the instrumental avoidance component of the behavior. Alternately, it may be hypothesized that the superiority of the hooded rats is due to their being more reactive to shock. This hypothesis seems improbable on two grounds. First, if it were true, similar differences should have been obtained in experiment 1. Secondly, Blanchard and Blanchard (1968b) reported that the amount of crouching (freezing) increases with increasing magnitude of shock. This implies that if hooded rats were more reactive to shock than albino rats. they should display more freezing, but this has been shown not to be the case in both of the present experiments.

The results of the present experiment would again imply that the freezing SSDR is elicited by relatively indiscriminable cues (equal brightness), but that the instrumental avoidance component is associated with the discriminative cues of the stimulus array, both internal and external.

General Discussion

It has been hypothesized that passive avoidance behavior may be governed by as many as three components: (1) an instrumental avoidance of the stimuli associated with shock, (2) immobility due to fear evoked by the experimental situation, and (3) a specific weakening of the response which resulted in the presentation of the aversive stimulus. It appears that the relative contributions of the three hypothesized components depend upon the discriminability of the safe and shock objects.

Barcik and Collins (1971) state that for passive avoidance to be clearly established the shock must be response contingent. Subsequent studies have shown this not to be the case. The effect of the shock being delivered contingent upon the response seems to have its effect not in the punishment of the movement response, but to increase the discriminability of the two objects. Hence, the effect of response contingent shock is to increase shock source discriminability; for if its effect was response (movement) punishment, the subjects who displayed little freezing should have had smaller exit latencies, but they did not.

If the superiority of the subjects receiving response contingent shock was due to better discrimination between the safe and shock locations, then one must hypothesize about the first and second factors. Randall and Riccio (1969) hypothesized that fear, classically conditioned to situational stimuli, produces immobility. They further hypothesized that passive avoidance appears to be based on discriminative stimuli. Since the measure of total avoidance was the total exit latency (IEL), and the classically conditioned component was represented by immobility (F), then the instrumental avoidance component must be represented by the difference (IEL-F). The present experiments have shown that the relative strengths of these two components depends upon the discriminability of the shock source. If the shock source is highly discriminable, the amount of freezing is relatively small and the amount of instrumental avoidance relatively large. If the shock object is poorly discriminable the amount of freezing will be relatively large and the amount of instrumental avoidance will be relatively small. These results are not completely consistent with Bolles' (1970) discussion of species specific defense reactions (SSDR). Bolles hypothesizes that for an avoidance response (R_a) to be rapidly acquired, it must be an SSDR. He also hypothesizes that a rat's SSDR repetoire consists of freezing, fleeing, and fighting. Since passive avoidance is often a single trial learning situation, it must be rapidly acquired; but as the IEL-F measure has shown, the prepotent behaviors need not be SSDR's. Bolles goes on to state that with the minimization of aversive stimuli, the animal is free to engage in behaviors which are not SSDR's. Hence, if the shock source is highly discriminable, the animal may successfully avoid aversive cues while engaging in other behaviors. But, if the safe and shock locations are not discriminable, the animal must revert to an SSDR behavior. Thus, subjects with a poorly discriminable shock source freeze more than subjects with a highly discriminable shock source but avoid less. This leads to the conclusion that for the rapid acquisition of an active avoidance response the required behavior may need to be an SSDR, but for the rapid acquisition of passive avoidance, the required behavior need only be compatible with the SSDR repetoire.

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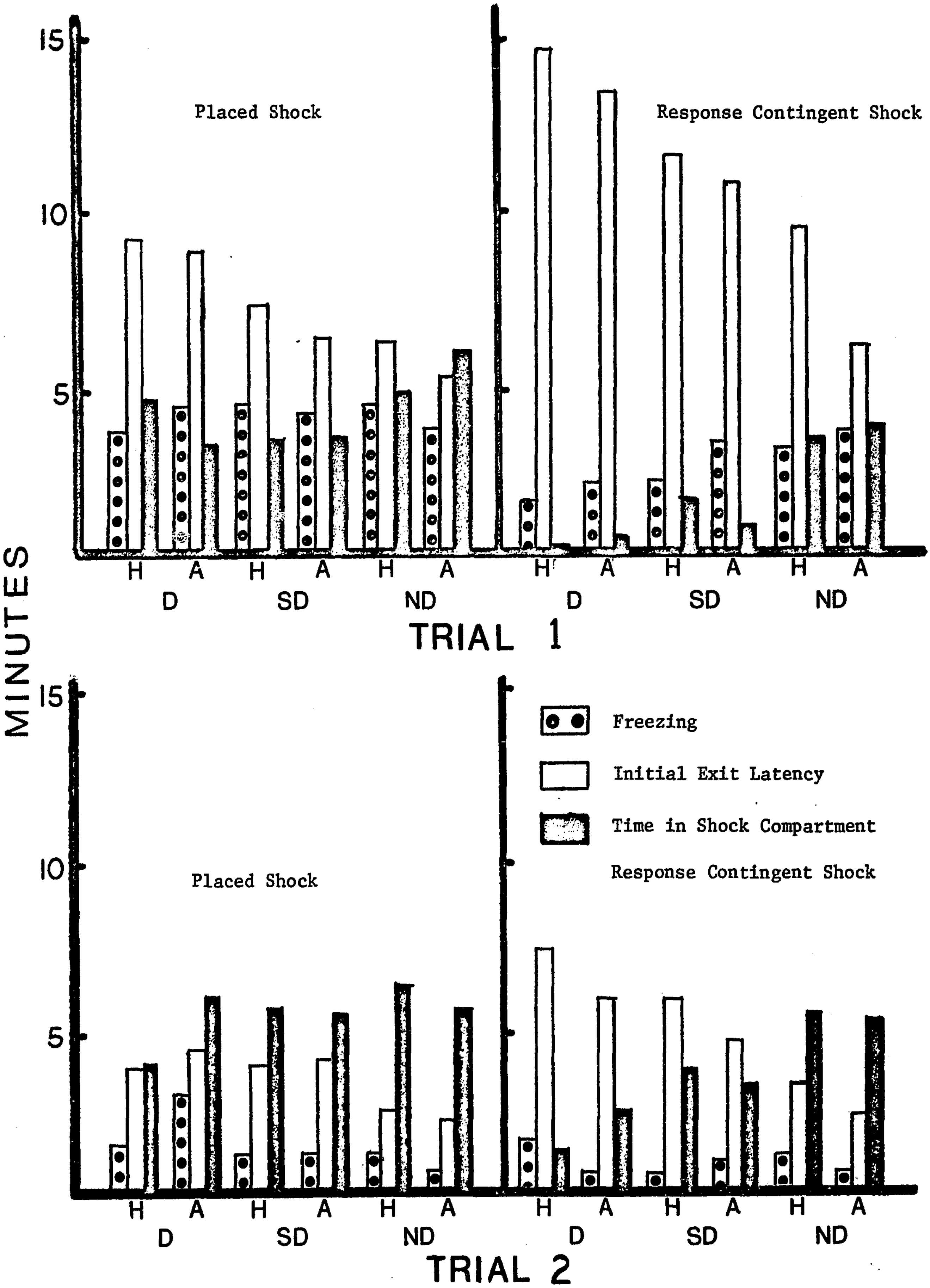
Figure Captions

Fig. 1 Mean measures of initial exit latency, freezing, and time spent in the shock compartment for both trials of Experiment 1.

Fig. 2 Mean measures of exits and entries for both trials of Experiment 1.

Fig. 3 Means measures of initial exit latency, freezing, and time spent in the shock compartment for both trials of Experiment 2.

Fig. 4 Mean measures of exits and entries for both trials of Experiment 2.



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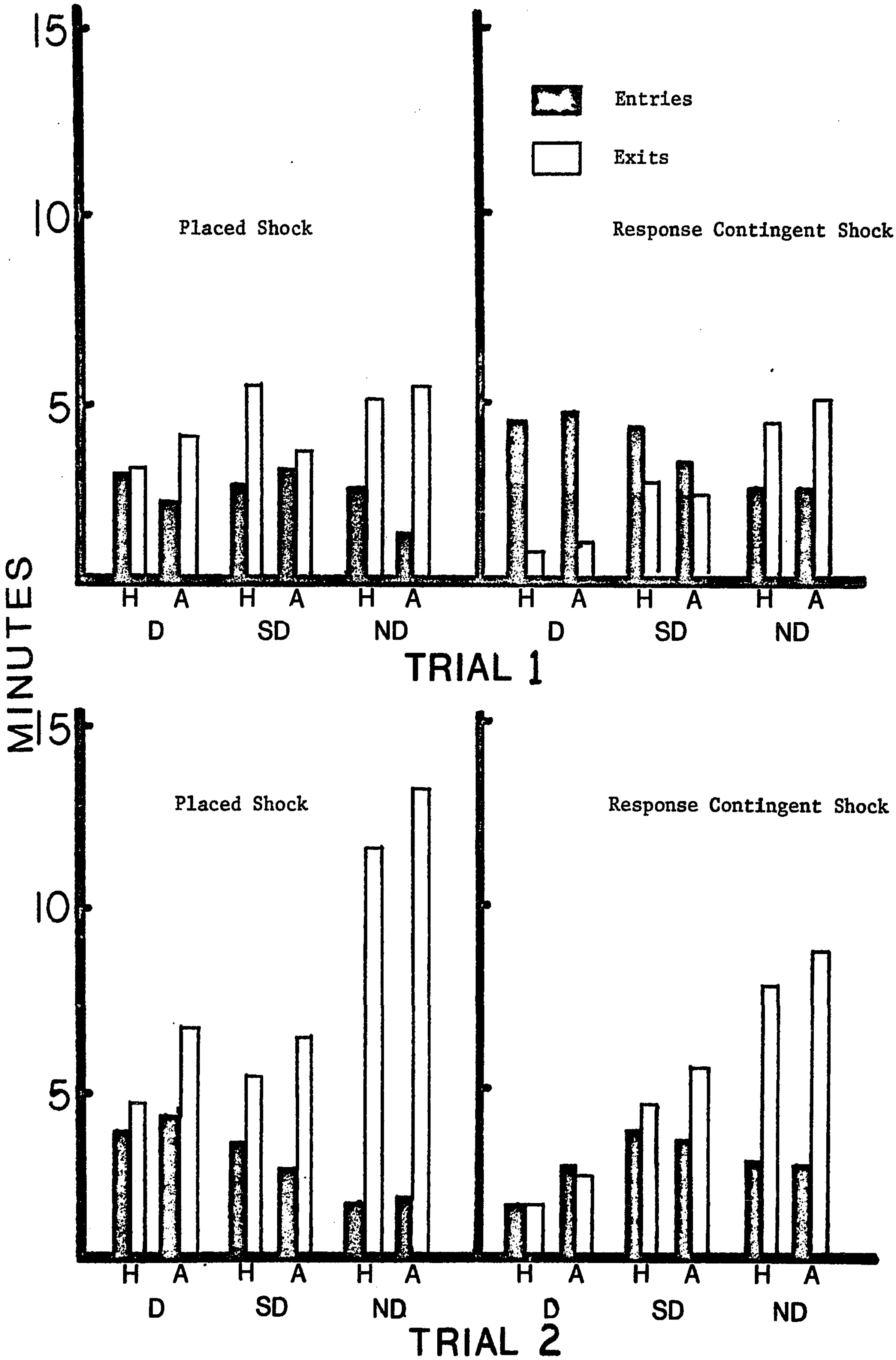
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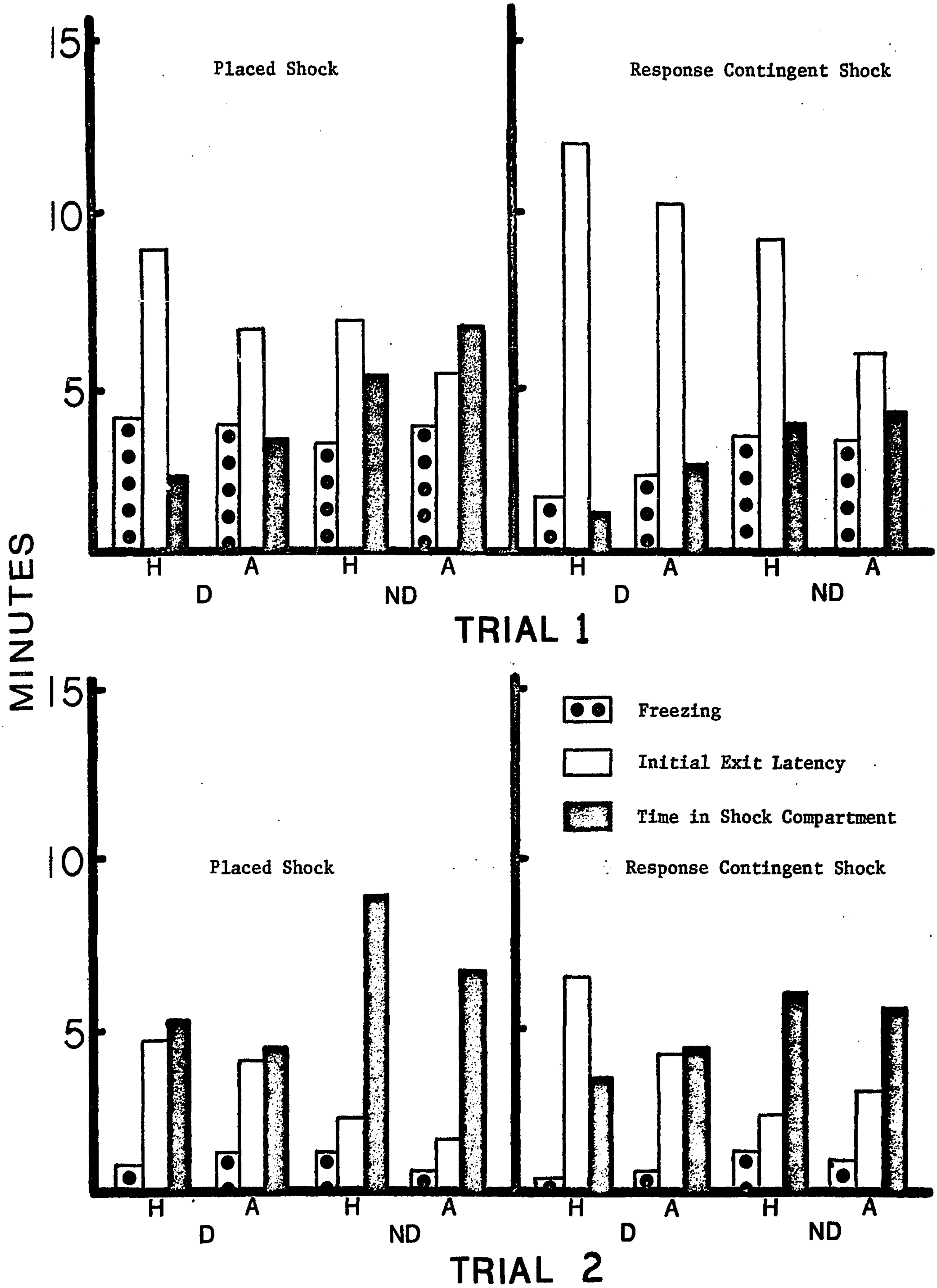

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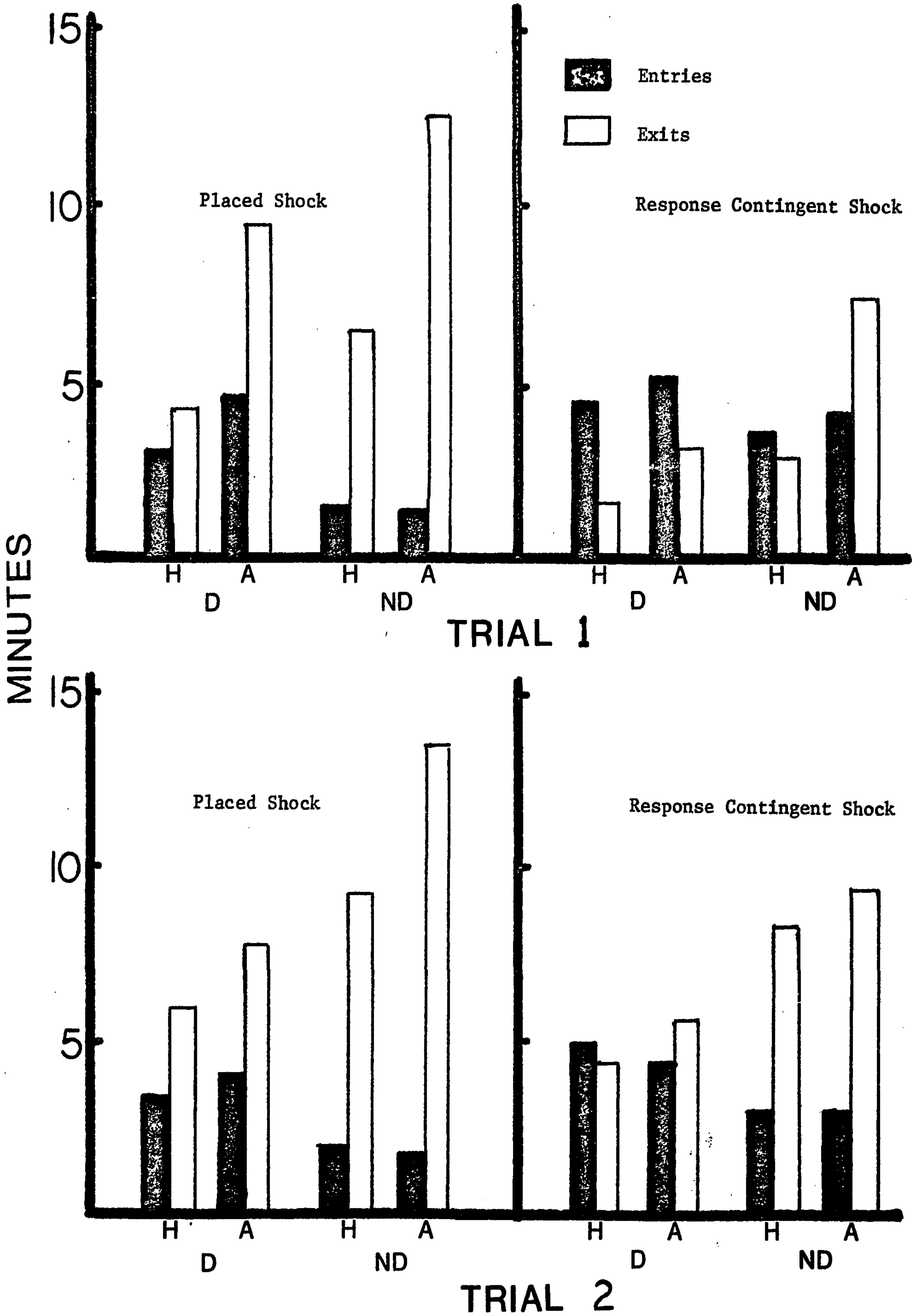
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APPENDIX A

PROSPECTUS

Acquisition of Passive Avoidance

A Review of the Literature

Many areas of psychology have utilized a passive avoidance response as a one trial learning situation in order to investigate other processes. Most notable is the area of memory formation and inhibition through the use of electroconvulsive shock, drugs, and other physical agents. These studies will not be reviewed here because they seldom discuss the nature of the response and its acquisition per se. A fairly complete review of these studies can be found in the text by Gibbs and Mark (1973).

The main problem with passive avoidance (PA) is that its not -- namely, the required response is no response at all. This is an over-simplification, but the point remains that passive avoidance is the absence of a particular response while active avoidance is the occurrence of a particular response. The main point of controversy in this area is whether PA is a learned response per se or the suppression of responses which would compete with the avoidance. The main theoretical constructs of this behavior will be the subject of this review.

Essman and Alpern (1964) have reported a number of ways to produce PA. Traditionally, PA has been viewed as instrumental learning, and in fact, the experimental contingencies in punishment and PA are the same (Mowrer, 1960). Unlike the usual punishment paradigms however, PA is most often a paradigm of only one acquisition trial such that the animal usually does not have the opportunity to discriminate response produced cues from environmental cues. This implies that classically conditioned fear to external stimuli may be more important in PA than in active avoidance. Randall and Riccio (1969) hypothesize that PA has two components: (1) an instrumental response to avoid the shock, and (2) fear classically conditioned to environmental cues. This concept of PA is supported by Blanchard and Blanchard (1970a) who hypothesize that discriminated avoidance underlies failure to contact highly discriminable shock objects and response suppression underlies avoidance of poorly discriminable sources of threat. To account for this duality, there are two general views of passive avoidance acquisition. The punishment view assumes that the most important contingency is the punishment of an emitted response. The other view emphasizes stimulus-shock contingencies which result in avoidance of specific or situational stimuli associated with shock.

The punishment view holds that passive avoidance is the result of the punishment of a specific, emitted response. Calhoun and Murphy (1969), Mellgren, Willison, and Dickson (1973), and Barcik and Collins (1971) all found that animals who had received shock upon exiting the safe location displayed more PA than animals who had been shocked after being directly placed in the shock location. Barcik and Collins (1971) stated, "In order for passive avoidance to be clearly established, the foot shock must not be too intense, and must be response contingent." (p. 21). This conclusion is echoed in Barcik (1972) and Barcik and Ellis

(1971). Essman and Sudak (1964) reported that increasing PA latencies were obtained with increasing shock duration. However, Blanchard and Blanchard (1968) concluded that punishment of a specific response is not necessary to establish PA because they found no differences between animals receiving placed and response contingent shock, but both were different from nonshocked controls. Randall and Riccio (1969) stated that the instrumental punishment effect is not the sole factor mediating the PA response. Mellgren, Willison, and Dickson (1973) hypothesize that the effect of the shock being response contingent is not one of response punishment per se but to make the safe and shock compartments more discriminable. If this is true, then the second view of stimulus-shock associations would be the more credable.

Spevak and Suboski (1969) suggest that PA is primarily the result of a conditioned emotional response (CER) rather than a specific response punishment contingency. They hypothesize that immobility is classically conditioned to apparatus cues such that the animal avoids punishment by freezing rather than learning to inhibit a specific response. This hypothesis is supported by Geller, Jarvik, and Robustelli (1970) who conclude that PA is a learned immobility to environmental stimuli which have been associated with shock. This conclusion is consistent with Kurtz and Walters (1962) who found that prior fear conditioning produced more PA in relation to no such prior conditioning. They stated that the prior fear conditioning accentuated the fear component of an approach-avoidance situation, and concluded that this was due to the generalization of fear to the situational cues. This hypothesis is not consistent with subsequent studies (Blanchard and Blanchard, 1970a,b; Mellgren and Fulwiler, 1974) which have shown that the duration of immobility may be a rather small portion of the total avoidance time.

Blanchard and Blanchard (1970a) concluded that shocks which differ in discriminability elicit different behaviors following shock. This notion was tested in the 1970b article in a discriminated vs. nondiscriminated shock study. This study concluded that discriminated avoidance measured the fear of specific stimuli while the immobility of the nondiscriminated avoidance group was an emotional response to unlocalized threat.

Studies involving shock object discriminability in PA *per se* have shown varying results. Gruber (1970a) reported no differences in response latencies in a black-white apparatus, thereby impling no discrimination; and in the Gruber (1970b) study discrimination was established to a tone but not to a light. There does, however, seem to be evidence for discrimination based upon response contingency (Mellgren *et al*, 1973; Jarvik and Essman, 1960) and shock object discriminability (Blanchard and Blanchard, 1970b). King and Glasser (1973) reported that pre-exposure resulted in more PA and suggested that the pre-exposure resulted in the animal being "better able to identify the place in the apparatus where shock occurred" (p. 818). However, Lewis, Miller, and Misanin (1968) found no effects due to pre-exposure. Similar results are reported by Dawson and McGaugh (1969). Some of these studies, especially the Blanchard's work, implicate the hypothesis that PA may be controlled by associations between stimuli and shock rather than by associations between responses and shock.

Randall and Riccio (1969) stated that while freezing (immobility) is frequently observed, the subjects also frequently continued to avoid after freezing had stopped and concluded that one component of the avoidance was based upon discriminative stimuli. Barcik and Ellis (1971) reported that their animals were active on the platform after freezing had ended and that the animals behaviors were directed away from the edge of the platform. These authors go on to conclude that generalized behavioral inhibition was not the mechanism underlying PA. Hence, it appears that the discriminability of the shock object may also contribute to PA responding.

All of these hypotheses and results must be considered in the light of Bolles' (1970) discussion of "species specific defense reactions" (SSDR). In this discussion, Bolles suggests that the effect of aversive stimulation is to restrict the responses of any animal to its innate, species specific reactions to threat. This would imply a continuum of behaviors to threat, and the ability of the animal to learn a particular behavior to avoid aversive stimuli depends upon the position of the behavior upon the continuum. Hence, he suggests that an avoidance response (R_a) can only be acquired rapidly if it is an SSDR. But, since there are typically a number of these behaviors, a particular SSDR is only learned at the expense of competing SSDR's. He states that if we assume that a rat's SSDR repetoire consists of freezing, fleeing, and fighting, it becomes clear why specific behaviors are more rapidly learned in specific situations. In a one-way avoidance paradigm, abundant support is supplied for "fleeing" because movement is the prime component of the response and is hence learned rapidly. Two-way avoidance, on the other hand, requires the animal to return to the place from which it has just "fleed", and thereby creates conflict and will be learned more slowly. Bolles summarizes his position as, "For an R_a to be rapidly learned in a given situation, the response must be an effective SSDR in that situation, and when rapid learning does occur, it is primarily due to the suppression of ineffective SSDR's." (p. 35). While this hypothesis was intended to deal with active avoidance, it is also applicable to the PA situation. If the SSDR repetoire of a rat is assumed to consist of the three previously mentioned behaviors, then the response to be learned can be predicted. Fighting, as an R_a is ineffective because there is no distinctive object producing the aversive stimulus which can be fought. Fleeing is ineffective because, on test trials, it leads the animal into the shock compartment and, in the case of response contingent shock, movement was punished. This leaves freezing as the only SSDR left, and since it produces the desired result, it is emitted. Hence, there is credence for the view that one of the components of PA is behavioral suppression.

Bolles also hypothesizes that with the minimization of shock (and presumably other aversive stimuli) one may expect a gradual return of the subjects normal response repetoire, such that is is no longer restricted to SSDR's. This hypothesis has some interesting implications for PA. Blanchard and Blanchard (1969a) suggested that immobility reactions (freezing) were elicited by situational stimuli previously paired with shock, but Blanchard and Blanchard (1969b) stated that this immobility did not seem to be elicited by discrete, specific stimuli associated with shock and hypothesized that the degree of immobility might be a function of the discriminability of the shock object or location. Hence, if the shock object was easily discriminated, the animal would be free to engage in exploration, grooming, or other behaviors which are not SSDRs. However, if the shock object cannot be discriminated by the subject, the entire situation would elicit fear, and the animal would have to revert to the appropriate SSDR, namely freezing. Blanchard and Blanchard (1970a) provide further support for this hypothesis in that they reported that a highly discriminable shock object led to little reduction in activity in the shock situation while increasing specific avoidance of the shock object. They also reported that a poorly discriminable shock object led to a decrease in activity and a degree of avoidance which was less than the subjects in the highly discriminable situation but greater than nonshocked controls. However, in this study, the subjects in the poorly discriminable situation received more shocks than those in the highly discriminable condition, so that strong conclusions could not be drawn, especially about the activity measures. It was in the light of these results and hypotheses that the study by Mellgren and Fulwiler (1974) was conducted. They hypothesized (along with others) that there were two main components contributing to PA responding: (1) an innate response which is classically conditioned to environmental stimuli (freezing), and (2) an instrumental avoidance component which could be operationalized as the total time of avoidance (IEL) minus the amount of time spent freezing (F). Hence, the measure of instrumental avoidance would be IEL-F. Their experiment utilizing this measure provided support for the hypothesis.

Hence, it would seem that PA has two basic components. The relative strengths of these components depends upon the discriminability of the shock object. If it is poorly discriminable, the animal will rely most heavily upon its SSDR repetoire and manifest little instrumental avoidance. However, if the shock object is readily discriminable, the animal will not have to rely so heavily on innate fear responses and will be able to successfully avoid the shock object while engaging in many other behaviors. Therefore, the implication is that while it may be necessary for an R_a to be an SSDR in order to be rapidly acquired in active avoidance, under appropriate conditions for PA, the animal need not revert to SSDRs, but the required response must be compatible with his repetoire of SSDRs.

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APPENDIX B

STATISTICAL TESTS

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL

EXIT LATENCY MEASURE FOR TRIAL 1 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	14.883	11.938	9.582
	Albino	13.383	10.199	6.309
Placed Shock	Hooded	9.277	7.438	6.518
	Albino	8.946	6.515	5.468

Source	MS	df	F
A (Strain)	47.612	1	2.988*
B (Method of Shock)	264.903	1	16.622**
C (Level of Discriminability)	118.202	2	7.417**
A X B	12.684	1	.807
A X C	4.258	2	.267
B X C	18.752	2	1.177
A X B X C	.897	2	.056
Error	15.937	60	
Total	22.055	71	

* $p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL

EXIT LATENCY MEASURE FOR TRIAL 2 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	7.532	6.031	3.508
	Albino	6.113	4.881	2.306
Placed Shock	Hooded	3.814	3.973	2.464
	Albino	4.889	4.018	2.031

Source	MS	df	F
A (Strain)	13.699	1	1.679
B (Method of Shock)	42.150	1	5.169*
C (Level of Discriminability)	57.659	2	7.070*
A X B	2.666	1	.327
A X C	37.321	2	4.576*
B X C	4.939	2	.606
A X B X C	2.062	2	.253
Error	8.155	60	
Total	10.589	71	

* $p < .05$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

FREEZING MEASURE FOR TRIAL 1 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	.540	2.050	3.143
	Albino	2.081	3.218	3.571
Placed Shock	Hooded	3.712	4.505	4.436
	Albino	4.737	4.145	3.793

Source	MS	df	F
A (Strain)	5.849	1	1.128
B (Method of Shock)	59.525	1	12.230**
C (Level of Discriminability)	17.561	2	3.608*
A X B	4.430	1	.892
A X C	2.927	2	.602
B X C	7.020	2	1.442
A X B X C	6.127	2	1.259
Error	4.867	60	
Total	6.038	71	

* $p < .05$
** $p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

FREEZING MEASURE FOR TRIAL 2 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	1.605	.774	1.251
	Albino	.887	1.061	.765
Placed Shock	Hooded	1.501	1.174	1.177
	Albino	2.944	1.245	.780

Source	MS	df	F
A (Strain)	8.849	1	2.784
B (Method of Shock)	3.219	1	1.008
C (Level of Discriminability)	3.552	2	1.112
A X B	3.204	1	1.003
A X C	1.494	2	.468
B X C	1.841	2	.578
A X B X C	11.736	2	3.673
Error	3.195	60	
Total	3.545	71	

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL EXIT LATENCY - FREEZING MEASURE FOR TRIAL 1 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	13.343	9.857	6.105
	Albino	11.301	6.978	2.738
Placed Shock	Hooded	5.732	2.933	2.077
	Albino	4.209	2.204	1.764

Source	MS	df	F
A (Strain)	75.344	1	10.491**
B (Method of Shock)	538.757	1	75.015**
C (Level of Discriminability)	195.128	2	27.169**
A X B	24.266	1	3.379
A X C	1.094	1	.152
B X C	40.254	2	5.605*
A X B X C	.500	2	.070
Error	7.182	60	
Total	21.735	71	

*$p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL EXIT LATENCY - FREEZING MEASURE FOR TRIAL 2 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	5.910	5.257	2.273
	Albino	5.069	4.426	1.541
Placed Shock	Hooded	2.314	2.799	1.287
	Albino	1.948	3.122	1.171

Source	MS	df	F
A (Strain)	3.306	1	.994
B (Method of Shock)	70.172	1	22.977**
C (Level of Discriminability)	41.868	2	13.709**
A X B	1.686	1	.552
A X C	.178	1	.053
B X C	13.870	2	4.542*
A X B X C	.589	2	.193
Error	3.054	60	
Total	5.146	71	

*$p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

ENTRIES MEASURE FOR TRIAL 1 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	4.667	4.167	2.167
	Albino	4.833	3.000	2.500
Placed Shock	Hooded	3.000	2.667	2.500
	Albino	2.167	3.000	1.333

Source	MS	df	F
A (Strain)	4.014	1	1.763
B (Method of Shock)	25.681	1	11.278**
C (Level of Discriminability)	11.167	2	4.903*
A X B	.124	1	.055
A X C	4.389	1	1.927
B X C	9.389	2	4.123*
A X B X C	1.167	2	.513
Error	2.277	60	
Total	3.083	71	

*$p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

ENTRIES MEASURE OF TRIAL 2 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	1.667	3.500	2.833
	Albino	2.667	3.167	2.500
Placed Shock	Hooded	3.500	3.167	1.500
	Albino	4.167	2.500	1.667

Source	MS	df	F
A (Strain)	.124	1	.036
B (Method of Shock)	.680	1	.202
C (Level of Discriminability)	5.681	2	1.689
A X B	.015	1	.004
A X C	2.792	2	.830
B X C	18.014	2	5.356*
A X B X C	.352	2	.104
Error	3.363	60	
Total	3.610	71	

* $p < .05$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

EXITS MEASURE FOR TRIAL 1 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	.500	2.500	4.500
	Albino	1.000	2.000	5.000
Placed Shock	Hooded	3.167	5.500	5.167
	Albino	3.833	3.500	5.500

Source	MS	df	F
A (Strain)	.126	1	.016
B (Method of Shock)	62.348	1	8.072*
C (Level of Discriminability)	51.389	2	6.653*
A X B	1.125	1	.146
A X C	6.167	2	.798
B X C	7.722	2	.999
A X B X C	1.167	2	.151
Error	7.724	60	
Total	9.296	71	

* $p < .05$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

EXITS MEASURE FOR TRIAL 2 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	1.667	4.500	7.833
	Albino	2.333	5.666	8.667
Placed Shock	Hooded	4.833	5.500	11.833
	Albino	6.833	6.500	13.333

Source	MS	df	F
A (Strain)	25.681	1	2.164
B (Method of Shock)	165.014	1	13.808*
C (Level of Discriminability)	274.625	2	22.979*
A X B	1.681	1	.141
A X C	.097	2	.008
B X C	20.431	2	1.709
A X B X C	124.472	2	10.415*
Error	11.951	60	
Total	24.632	71	

*$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE TIME IN

SHOCK COMPARTMENT MEASURE FOR TRIAL 1 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	.051	1.629	3.327
	Albino	.449	.890	3.820
Placed Shock	Hooded	4.837	3.326	4.961
	Albino	3.341	3.465	6.150

Source	MS	df	F
A (Strain)	10.364	1	2.059
B (Method of Shock)	101.844	1	20.229**
C (Level of Discriminability)	42.800	2	8.501**
A X B	.442	1	.088
A X C	.358	2	.071
B X C	18.196	2	3.614*
A X B X C	1.234	2	.245
Error	5.035	60	
Total	7.604	71	

* $p < .05$
** $p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE TIME IN

SHOCK COMPARTMENT MEASURE FOR TRIAL 2 OF EXPERIMENT 1

		D	SD	ND
Response Contingent Shock	Hooded	1.396	3.800	5.601
	Albino	2.370	3.022	5.704
Placed Shock	Hooded	3.890	5.916	6.628
	Albino	6.141	5.804	5.890

Source	MS	df	F
A (Strain)	.851	1	.358
B (Method of Shock)	81.564	1	34.280**
C (Level of Discriminability)	40.719	2	17.116**
A X B	1.121	1	.471
A X C	6.476	2	2.722
B X C	11.585	2	4.869*
A X B X C	44.164	2	18.564**
Error	2.379	60	
Total	6.087	71	

* $p < .05$
** $p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL

EXIT LATENCY MEASURE FOR TRIAL 1 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	12.063	9.128
	Albino	10.261	6.293
Placed Shock	Hooded	8.813	6.987
	Albino	6.735	5.445

Source	MS	df	F
A (Strain)	84.708	1	8.403*
B (Method of Shock)	134.948	1	13.386*
C (Level of Discriminability)	140.190	1	13.906*
A X B	.452	1	.045
A X C	.566	1	.056
B X C	3.433	1	.341
A X B X C	7.513	1	.745
Error	10.082	40	
Total	15.849	47	

* $p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL

EXIT LATENCY MEASURE FOR TRIAL 2 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	6.852	2.271
	Albino	4.023	2.791
Placed Shock	Hooded	4.762	2.079
	Albino	3.763	1.574

Source	MS	df	F
A (Strain)	10.787	1	3.382
B (Method of Shock)	10.475	1	3.284
C (Level of Discriminability)	85.945	1	26.942*
A X B	.488	1	.153
A X C	10.965	1	3.437
B X C	.639	1	.200
A X B X C	6.119	1	1.918
Error	3.190	40	
Total	5.384	47	

* $p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

FREEZING MEASURE FOR TRIAL 1 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	1.653	3.249
	Albino	2.717	3.081
Placed Shock	Hooded	3.985	3.333
	Albino	3.883	3.619

Source	MS	df	F
A (Strain)	.291	1	.118
B (Method of Shock)	10.577	1	4.275*
C (Level of Discriminability)	1.490	1	.602
A X B	1.021	1	.413
A X C	.114	1	.046
B X C	4.728	1	1.911
A X B X C	3.227	1	1.304
Error	2.474	40	
Total	2.562	47	

* $p < .05$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

FREEZING MEASURE FOR TRIAL 2 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	.227	1.098
	Albino	.450	.917
Placed Shock	Hooded	.795	1.166
	Albino	1.017	.863

Source	MS	df	F
A (Strain)	.001	1	.001
B (Method of Shock)	.990	1	1.298
C (Level of Discriminability)	1.815	1	2.379
A X B	.011	1	.014
A X C	.649	1	.851
B X C	.942	1	1.235
A X B X C	.011	1	.014
Error	.763	40	
Total	.743	47	

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL EXIT LATENCY - FREEZING MEASURE FOR TRIAL 1 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	10.410	5.879
	Albino	7.217	3.724
Placed Shock	Hooded	4.478	3.564
	Albino	2.853	1.841

Source	MS	df	F
A (Strain)	66.923	1	16.895**
B (Method of Shock)	141.690	1	35.769**
C (Level of Discriminability)	85.849	1	21.673**
A X B	3.469	1	.867
A X C	.470	1	.119
B X C	29.273	1	7.390*
A X B X C	.111	1	.028
Error	3.961	40	
Total	9.962	47	

* $p < .05$
** $p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE INITIAL EXIT LATENCY - FREEZING MEASURE FOR TRIAL 2 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	5.646	1.358
	Albino	3.528	1.876
Placed Shock	Hooded	3.982	1.196
	Albino	2.767	.711

Source	MS	df	F
A (Strain)	7.170	1	1.536
B (Method of Shock)	12.310	1	2.637
C (Level of Discriminability)	71.164	1	15.242**
A X B	10.004	1	2.142
A X C	9.630	1	2.062
B X C	20.975	1	4.492*
A X B X C	2.045	1	.438
Error	4.669	40	
Total	6.597	47	

* $p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

ENTRIES MEASURE FOR TRIAL 1 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	4.500	3.333
	Albino	5.167	4.333
Placed Shock	Hooded	3.000	1.667
	Albino	4.500	1.500

Source	MS	df	F
A (Strain)	10.001	1	5.042*
B (Method of Shock)	60.083	1	30.296**
C (Level of Discriminability)	8.333	1	4.200*
A X B	8.336	1	4.203*
A X C	2.804	1	1.414
B X C	10.334	1	5.211*
A X B X C	.750	1	.378
Error	1.983	40	
Total	3.814	47	

* $p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE ENTRIES MEASURE FOR TRIAL 2 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	5.000	2.667
	Albino	4.167	2.667
Placed Shock	Hooded	3.333	2.000
	Albino	3.833	1.667

Source	MS	df	F
A (Strain)	.334	1	.098
B (Method of Shock)	10.084	1	2.956
C (Level of Discriminability)	40.334	1	11.825*
A X B	.749	1	.219
A X C	2.496	1	.732
B X C	.135	1	.040
A X B X C	2.085	1	.612
Error	3.411	40	
Total	4.099	47	

*$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

EXITS MEASURE FOR TRIAL 1 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	1.667	2.833
	Albino	3.000	7.500
Placed Shock	Hooded	4.167	6.667
	Albino	9.500	12.667

Source	MS	df	F
A (Strain)	225.333	1	17.483*
B (Method of Shock)	243.000	1	18.854*
C (Level of Discriminability)	96.333	1	7.474*
A X B	21.334	1	1.655
A X C	12.001	1	.931
B X C	27.113	1	2.105
A X B X C	5.333	1	.414
Error	12.889	40	
Total	24.383	47	

*$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE

EXITS MEASURE FOR TRIAL 2 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	4.167	8.167
	Albino	5.833	9.333
Placed Shock	Hooded	6.000	9.333
	Albino	7.667	13.500

Source	MS	df	F
A (Strain)	47.999	1	4.120*
B (Method of Shock)	70.084	1	6.016*
C (Level of Discriminability)	191.999	1	16.481**
A X B	10.103	1	.865
A X C	1.334	1	.115
B X C	4.083	1	.350
A X B X C	10.183	1	.865
Error	11.650	40	
Total	17.157	47	

* $p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE TIME IN SHOCK COMPARTMENT MEASURE FOR TRIAL 1 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	1.223	3.520
	Albino	2.532	4.184
Placed Shock	Hooded	2.173	5.371
	Albino	3.385	6.750

Source	MS	df	F
A (Strain)	16.753	1	4.600*
B (Method of Shock)	30.533	1	8.384**
C (Level of Discriminability)	75.395	1	20.702**
A X B	.157	1	.043
A X C	.308	1	.085
B X C	14.507	1	3.983
A X B X C	.712	1	.196
Error	3.642	40	
Total	6.107	47	

* $p < .05$
**$p < .01$

GROUP MEANS AND ANALYSIS OF VARIANCE FOR THE TIME IN SHOCK COMPARTMENT MEASURE FOR TRIAL 2 OF EXPERIMENT 2

		D	ND
Response Contingent Shock	Hooded	3.337	6.403
	Albino	4.247	5.523
Placed Shock	Hooded	5.095	8.825
	Albino	4.423	6.969

Source	MS	df	F
A (Strain)	1.043	1	.461
B (Method of Shock)	22.114	1	9.776
C (Level of Discriminability)	56.074	1	24.789*
A X B	.533	1	.236
A X C	4.124	1	1.823
B X C	2.772	1	1.225
A X B X C	.394	1	.174
Error	2.262	40	
Total	3.778	47	

* p < :01

75

517

TABLE 7

NUMBER OF PEOPLE PER TAVERN, 1890-1910

	1890	1900	1910
CUMING	818	858	861
HAMILTON	2349	1481*	1682
KEITH	1283	1951	923*
SALINE	744	780	850

Source: Calculated from figures from; the U.S. Department of the Interior, Census Office, Population of the United States, 1890, 1900, and 1910, (Washington D.C.: Government Printing Office); DeWitt Times, Vol. 9-29; Friend Sentinel, Vol. 1-17; Western Wave, Vol. 6-26; Crete Democrat, Vol. 16-36; Wilber Republican, Vol. 4-24; Crete News, Vol. 1-3; Aurora Sun, Vol. 4-24; Cuming County Advertiser, (West Point), Vol. 7-27; West Point Republican, Vol. 21-41; Wisner Chronicle, Vol. 1-12; Wisner Free Press, Vol. 1-11; Keith County News, Vol. 5-25.

*Only for part of the year.

chose to visit it.[15]

The adult male customers in the case study areas came from both the towns and the countryside. Taverns in some towns in Hamilton and Keith counties were so popular they attracted customers from other towns in their respective counties. When Ogallala voted in prohibition in 1908 a tavern was established in nearby Paxton. One reason for its location in Paxton was apparently to attract the former Ogallala tavern customers.[16] A similar situation occurred in Lemoyne in 1910 when Ogallala again voted in prohibition.[17] The establishment of taverns in towns near Aurora also occurred as a result of Aurora's prohibition votes.[18] In both Anglo counties, then, tavern customers were drawn to wet towns from towns where taverns had been abolished. In the European counties there was no indication that tavern seekers went from the major towns to the minor towns, as the major towns retained their taverns throughout the era.

Another way of assessing the importance of the tavern in the study areas is to analyze the number of eligible customers per tavern. The number of adult males per tavern varied historically and spatially in the Post-Frontier era (Table 8). In all of the counties except Hamilton the ratios were larger at the beginning of the Post-Frontier era than they were at the end of the period. In Hamilton County the ratio was larger at the end of the era. One plausible explanation for the anomalous pattern exhibited by Hamilton County appears