# AVERSIVE SIGN-TRACKING AND BACKWARD CONDITIONING

By

DIANE BERNARD

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I dedicate my thesis to Miguel, Shellee and Jean.

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## ABSTRACT

The present series of experiments tried to provide information about the associative value of the CS in backward conditioning and further our knowledge of approach behavior (APPR$^-$) towards a CS which signals absence of an aversive US. In all experiments, the US was a foot-shock (.5 mA, 2 sec) and the CS was a platform accessible for short time periods each trial. Time spent on the platform was used as a measure of APPR$^-$ behavior.

Experiment 1 compared the effects of backward, differential, and explicitly unpaired procedures with a random procedure on the development of APPR$^-$ behavior. The results showed rapid acquisition of APPR$^-$ behavior in each of the experimental groups in comparison with the random group. In a subsequent retardation-of-acquisition test (forward pairings), all experimental groups showed gradual suppression of APPR$^-$ behavior, suggesting conditioned inhibition to the platform-CS in each of the experimental groups. Experiment 2 studied the effect of the number of backward pairings on APPR$^-$. The results showed that five or ten daily pairings were sufficient for the rapid acquisition of APPR$^-$ behavior, while one daily pairing produced WDR$^+$ behavior (a behavioral tendency opposite to APPR$^-$ behavior). In a subsequent retardation-of-acquisition test, the experimental group exposed to five daily pairings showed rapid suppression of APPR$^-$ behavior. These results were interpreted in terms of possible differential level of

conditioned inhibition to the CS produced by differential number of US-CS pairings. Experiment 3 studied the effect of ITI lengths on the development of APPR⁻ behavior in backward conditioning. A strong APPR⁻ behavior was observed when the ITI range was long (2 to 4 min), but not when ITI range was sometimes short (10 sec) and sometimes long (5 min). These results showed that the CS must reliably signal a relatively long period without shock for the development of APPR⁻ behavior. In Experiment 4, conditioned inhibition to the CS in backward pairings was evaluated independently of APPR⁻ behavior, in the context of a conditioned suppression paradigm. The results showed that US-CS pairings procedure produced less suppression of drinking than CS-US pairings, but no response acceleration in comparison with the control condition. Time spent on the platform and behavioral observations failed to provide evidence of the inhibitory properties of the CS in the backward conditioning group possibly due to extinction during testing sessions.

In conclusion, it seems that under specific conditions, the CS in backward conditioning acquires inhibitory associative value and a conditioned inhibition mechanism would be partly responsible for APPR⁻ behavior. However, temporal contiguity seems to be an essential element to APPR⁻ behavior. At a theoretical level, a modified stimulus substitution model could be considered as an alternative to a contingency model explaining APPR⁻.

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# Chapter 1

# THE SIGN-TRACKING PHENOMENON

## Sign-tracking in appetitive contexts

In Pavlovian appetitive conditioning, animals have a tendency to approach and make contact with a conditioned stimulus ($CS^+$) which signals the presentation of an appetitive unconditioned stimulus (US), such as food. Animals also have a tendency to move away from a conditioned stimulus ($CS^-$) which signals the absence of an appetitive US (Hearst, Bottjer & Walker, 1980; Hearst & Franklin, 1977; Wasserman, Franklin & Hearst, 1974). This phenomenon has been termed "sign-tracking" (Hearst & Jenkins, 1974) and relates to behavior directed towards or away from a stimulus which is part of a particular stimulus-reinforcer relation. Approach towards $CS^+$ and withdrawal from $CS^-$ have been referred to as $APPR^+$ and $WDR^-$, respectively, by Leclerc and Reberg (1980), and Leclerc (1985).

Sign-tracking has been shown to be quite a general phenomenon in appetitive conditioning (see Hearst & Jenkins, 1974; Schwartz & Gamzu, 1973 for reviews). For example, it has been observed using a variety of appetitive USs such as food (Hearst & Franklin, 1977), water (Jenkins & Moore, 1973), electrical brain stimulation (Peterson, Ackil, Frommer & Hearst, 1972), heat (Wasserman, 1973), access to a "social place" (Peele & Ferster, 1982), and sexual reinforcer (Rackham, 1971). Stimuli such as a keylight (Hearst, Bottjer & Walker, 1980), illuminated levers (Peterson, 1972), clicker (Wasserman, 1972) and white noise (Farthing, 1971) have been used successfully as $CS^+$ and $CS^-$. The phenomenon has been studied using a variety of species as subjects such as pigeons (Wasserman, Franklin & Hearst, 1974), chicks (Wasserman, 1973), monkeys (Gamzu & Schwam, 1974), rats (Peterson, 1972) and children (Sainsbury, 1971).

## Sign-tracking in aversive contexts

Although Hearst and Jenkins' (1974) original efforts were concentrated on providing evidence in support of a sign-tracking phenomenon in appetitive contexts, they did suggest that sign-tracking could most probably be extended to aversive contexts. This suggestion has been confirmed by Leclerc and Reberg (1980): Counterparts of appetitive sign-tracking were shown to consist of withdrawal behavior (or $WDR^+$) from a stimulus ($CS^+$) which signals an aversive US, and approach behavior (or $APPR^-$) towards a stimulus ($CS^-$) which signals the absence of an aversive US, such as shock.

Leclerc and Reberg (1980, Experiment 2) reported a robust aversive sign-tracking phenomenon using forward and backward conditioning procedures. The ultimate goal of their study was to compare sign-tracking responses by rats to a $CS^+$ and $CS^-$ for shock in the same experimental setting. An innovative and apparently conducive element in this study was the type of CS used. It consisted of a platform made available to the animals when the upper part of one of the chamber's wall automatically retracted. The platform was used to signal the occurrence or nonoccurrence of unavoidable, inescapable shock. Following Hearst and Jenkins' (1974) observation that the topography of the contact response to the CS often ressembles the topography of the response produced by the US, it seemed likely that the physical properties of the CS-platform would facilitate the development of aversive sign-tracking behavior by allowing jumping and/or fleeing which are the responses produced by the US.

The procedure used by Leclerc and Reberg (1980, Experiment 2) consisted of three phases: baseline, training and extinction. During training (6 sessions), one experimental group, Group BKWD, was exposed to a backward conditioning procedure while another experimental group, Group FRWD, was exposed to a forward conditioning procedure. More specifically, backward conditioning consisted of a shock (2 sec, 0.5 mA) followed, 10 sec later, by a 60-sec platform presentation and then by an intertrial interval (ITI): In this condition, the platform signaled a no-shock period. The forward conditioning procedure consisted of a 60-sec platform presentation followed, 10-sec later, by shock and then by an ITI: Here, the platform signaled shock presentation. For both experimental groups, a training session consisted of 10 shock and platform presentations with intertrial intervals averaging 3 min.

Control groups were either exposed to random (Group Rand) or shock only (Group Shock) procedures. The random procedure consisted of 10 shocks and 10 platform presentations occurring randomly. However, shock and platform never occurred simultaneously so that subjects could not avoid or escape shock by jumping on the platform. Group Shock received 10 shocks per session (no platform presentation). Conditioning sessions were followed by extinction sessions which were the same for all groups and consisted of 10 platform presentations in the absence of shock.

Training results showed that, when compared to Group Rand, Group BKWD spent significantly more time on the platform CS, and Group FRWD acquired a tendency to withdraw from the platform CS. The extinction data showed that, for Group BKWD, responding was high during early sessions and gradually decreased in later sessions. Group FRWD showed the opposite effect: Responding was low during early sessions and gradually increased as sessions progressed.

The performance of Group Rand remained approximately the same during extinction sessions as during training while that of Group Shock initially showed an increase from baseline levels followed by a decrease toward the end of extinction sessions.

Training data for Groups BKWD and FRWD were taken as evidence for $APPR^-$ and $WDR^+$ behavior and therefore as evidence for counterparts of appetitive sign-tracking in an aversive context. While previous studies had provided some positive results of $WDR^+$ behaviors (e.g., Karpicke & Dout, 1980) or reported small aversive sign-tracking effects (e.g., Barttler & Masterson, 1980), Leclerc & Reberg (1980) provided evidence for strong $APPR^-$ and $WDR^+$ behavior within the same context.

Recently, Leclerc (1985) attempted to evaluate whether a stimulus-reinforcer mechanism (platform signaling a no-shock period) or a response-reinforcer mechanism (jumping on the platform to escape the grid floor) was responsible for $APPR^-$ behavior in backward conditioning. The conditioning chambers used in Experiment 1 were the same as those described in Leclerc and Reberg (1980, Experiment 1). There were three phases: baseline, training 1 and training 2. Each baseline session consisted of ten 60-sec platform presentations while no shock was administered. In training 1, subjects were exposed to either backward, forward or random presentations of platform and shock. For all groups, the jump-up response was prevented by means of a transparent barrier which was placed in front of the platform wall, thus preventing the animals from jumping onto the platform. Training 2 consisted of removing the transparent barrier and exposing all subjects to backward pairings of shock-platform. The results showed that subjects which were exposed to backward pairings in training 1 spent more time on the platform than subjects which were exposed to forward or random procedures. These results suggested that APPR$^-$ behavior is acquired because the platform signaled a no-shock period and therefore that a stimulus-reinforcer mechanism might be responsible for the acquisition of APPR$^-$ behavior.

In another experiment, Leclerc (1985, Experiment 2b) evaluated the effect of punishment on the maintenance of APPR$^-$ behavior using an omission procedure. The results showed that APPR$^-$ behavior is very resistant to punishing operant contingencies suggesting that a stimulus-reinforcer mechanism could play an important role, not only in the acquisition, but also in the maintenance of APPR$^-$ behavior.

Leclerc (1982, unpublished work) also observed a strong APPR$^-$ behavior in the context of a differential conditioning paradigm. The experimental setting and the platform conditioning boxes were identical to the ones used by Leclerc and Reberg (1980) and by Leclerc (1985). The procedure consisted of two phases: baseline and training.

During each of the four training sessions, Group $A^+ X^-$, was exposed to 10 trials in which a 30-sec platform presentation was followed, 10 sec later, by shock, and 10 trials in which a 30-sec buzzer was never followed by shock. A second group, Group $A^-X^+$, was exposed to 10 trials in which a 30-sec buzzer was followed, 10 sec later, by shock. Platform and buzzer trials were presented in a random sequence within sessions and the inter-stimulus interval averaged 60 sec.

Subjects in Group $A^+X^-$ spent very little time on the platform which signaled shock, while subjects in Group $A^-X^+$ showed a strong APPR$^-$ behavior to the platform which signaled a period of no shock. Based on Rescorla and Wagner's (1972) model of Pavlovian conditioning, it is assumed that inhibitory associative value was acquired by the CS$^-$ (platform) in Group $A^-X^+$ and was responsible for the observed APPR$^-$ behavior. According to their model, a conditioned excitator (CS$^+$) and a conditioned inhibitor (CS$^-$) are defined in parallel but opposite fashion: A conditioned excitator signals a greater probability of US occurence than in its absence and a conditioned inhibitor signals a lower probability of US occurence than in its absence. When a neutral CS is nonreinforced in compound with an excitatory CS (CS$^+$), as in the differential conditioning procedure just described, the model assumes that the neutral stimulus will acquire inhibitory associative value. There is considerable evidence in support of this assumption (e.g., Pavlov, 1927; Rescorla & Lolordo, 1965; Bull & Overmier, 1968; Hammond, 1968).

It is not clear, however, if APPR$^-$ behavior observed in the backward conditioning procedure (Leclerc & Reberg, 1980; Leclerc, 1985) can also be attributed to inhibitory associative value of the CS. The effect of backward conditioning on behavior is controversial and different views pertaining to this issue will now be presented and discussed.

# Chapter 2

## THE NATURE OF THE CS ASSOCIATIVE VALUE IN APPR$^-$ BEHAVIOR

In his recent work, Leclerc (1985) concluded that APPR$^-$ behavior in backward conditioning was the result of two processes: One that consists of rats' natural tendency to jump when exposed to aversive stimuli (this process is similar to a species-specific defense-reaction mechanism as described by Bolles, 1970), and a second that consists of approaching (or making contact with) a reliable signal of no shock. The latter process implies that the platform became a conditioned inhibitor which, in turn, was at least partly responsible for the observed APPR$^-$ behavior. However, the associative value of the CS in a backward conditioning procedure remains an issue of controversy. The next section presents an overview of the type of problems found in dealing with backward conditioning procedures.

### The associative value of the CS produced by backward pairings

The particular sequence of events in backward conditioning has made predictions rather difficult. Since the CS in backward pairings is presented shortly after the US, it has been assumed to leave the CS associatively neutral (Mackintosh, 1974; Schwartz, 1978). In contrast, many views of conditioning have assumed that the CS acquires associative value. However, within these views, there has been disagreement as to whether the CS acquires excitatory or inhibitory value: Behavioral change has been assumed to result from backward pairings between US and CS, yielding excitatory conditioning (Heth & Rescorla, 1973; Shurtleff & Ayres, 1981; Spetch, Terlecki, Pinel, Wilkie & Treit, 1982; Keith-Lucas & Guttman, 1975) or from forward pairings between CS and the absence of US, yielding inhibitory conditioning (Moscovitch & Lolordo, 1968; Heth, 1976; Siegel & Domjan, 1971).

In a review of the literature pertaining to backward conditioning, Spetch, Wilkie and Pinel (1981) stated that "The time for disputing whether backward conditioning is possible is past... it is time for systematic exploration of the conditions under which it occurs..." (p. 174). They presented four studies to support that conditioning can be established through backward conditioning procedures. In all the studies presented, the reported effects of backward pairings resembled the effect of forward pairings. They concluded by listing three features common to studies which have successfully demonstrated (excitatory) backward conditioning: the use of aversive USs, a small number of US-CS presentations, and a surprising US.

Hall (1984) re-examined the literature pertaining to backward conditioning with the objective to determine whether backward conditioning results in conditioned excitation or inhibition. However, in his review, Hall only included studies using the traditional Pavlovian paradigm. He thus excluded studies using the conditioned emotional response paradigm which are "fraught with varying problems which make inferences about the contribution of US-CS trials to the establishment of excitatory and/or inhibitory CRs tenuous" (p. 163).

Hall stated that, in most studies, methodological inadequacies result in a failure to demonstrate inhibition effects. According to Hall, Rescorla's (1969) retardation-of-acquisition or summation tests should be used whenever the objective of a study is to measure inhibition. Basically, the retardation-of-acquisition test consists of exposing subjects first to an inhibitory conditioning procedure and then to an excitatory conditioning procedure. The retardation of excitatory conditioning in the second phase of training is used as a measure of inhibitory conditioning acquired in the first phase of training. The summation test consists of the simultaneous presentation of a known excitatory CS ($S_1$) and a possible inhibitory CS ($S_2$). If $S_2$ is a conditioned inhibitor, responding will be reduced. Hall cited three studies, two by Siegel and Domjan (1971, 1974) and one by Plotkin and Oakley (1975), in which backward pairings were shown to result in inhibitory conditioning when a retardation-of-acquisition test was used as a measure of conditioning. Hall claimed that Spetch et al. (1981) drew conclusions based on studies which were not adequately designed to demonstrate inhibitory effects (i.e. a retardation-of-acquisition test or a summation test was not used) or which did not allow clear inferences about excitatory or inhibitory conditioning (i.e. such as studies using a conditioned emotional response).

However, even the retardation-of-acquisition and summation tests should be used with caution. Some studies (Pearce, Nicholas & Dickinson, 1982; Baker & Baker, 1985) have shown, for example, that the results from a retardation-of-acquisition test may be confounded by latent inhibition and US preexposure effects. This is particularly true when a negative correlation procedure is used, as nonreinforced exposures to the CS and unsignaled shocks increase retardation. A possible mechanism of the CS and US preexposure effects is that of learned irrelevance. Because the CS or US is presented by itself, subjects are assumed to learn that the CS or US is not related to anything of significance which disrupt subsequent learning that the CS signals the US (as in a retardation-of-acquisition test).

A retardation-of-acquisition test may not be as sensitive a measure of conditioned inhibition as Hall professes it to be. However, the test remains a measure of conditioned inhibition and, keeping in mind that the results of the test may be confounded by interference phenomena, it is useful whenever the objective is to determine whether or not a specific procedure yields conditioned inhibition. Should a more sensitive measure of conditioned inhibition be necessary, as when the objective is to compare the relative "amount" of conditioned inhibition produced by several procedures, both a retardation-of-acquisition test and a summation test must be administered, the rationale being that the two tests are not influenced by the same proactive interference (Rescorla, 1969; Baker & Baker, 1985).

Although there is strong evidence supporting the contention that backward conditioning leads to conditioned inhibition, there remains two possible ways how the CS may acquire inhibitory associative value. A contingency view would emphasize that the CS signals a low probability of US presentation due to the offset of the US (Rescorla, 1967). Another point of view would describe the CS in relation to the subsequent period of time without the US: This contiguity view would emphasize the forward pairing of the CS and a no-shock period (Moscovitch & Lolordo, 1968).

The observations made by Moscovitch and Lolordo (1968, Experiment 2) support the view that forward pairing of CS and a shock-free period is responsible for behavioral change. They compared two groups of dogs exposed to a backward procedure in which the ITI averaged 2.5 min. In the first group, the minimum ITI was 2 min and the maximum ITI was 3 min. In the second group, ITIs were of random duration, ranging from 0 sec to 15 min. They reported that the CS acquired inhibitory properties in the first group but not in the second group. The authors concluded that the CS in backward conditioning acquired inhibitory properties only if it reliably predicted a period of safety. When the ITIs were of random duration, the CS was a poor predictor of safety and consequently did not acquire inhibitory properties.

Other observations make a comprehensive interpretation of backward conditioning difficult to formulate. For example, it appears that the first few backward pairings result in conditioned excitation while additional pairings produce conditioned inhibition (Heth, 1976; Pavlov, 1927; Razran, 1956). Heth (1976) used a backward conditioning procedure in which the US was a shock and the CS a 2 sec combined presentation of a light and buzzer. The amount of suppression of bar pressing produced by the CS was used as a measure of conditioned excitation acquired by the CS. Heth reported an initial decrease in bar pressing, indicating conditioned excitation, followed by an increase, indicating conditioned inhibition. Therefore, it is suggested by those data that the number of pairings would be an important variable determining the outcome of backward conditioning.

In summary, there is evidence to support the contention that the CS acquires inhibitory properties in a backward conditioning procedure. However, there is still considerable doubt surrounding the effect of this procedure and some studies (Moscovitch & Lolordo, 1968; Heth, 1976) seem to indicate that certain conditions must be met for backward pairings to yield conditioned inhibition. Consequently, it would seem premature to draw any conclusion at this time regarding the associative nature of the CS in a backward conditioning procedure such as the one used by Leclerc and Reberg (1980) and Leclerc (1985).

## Experimental work

The experiments in the present thesis were designed to provide information about the associative value of the CS in backward conditioning and further our knowledge of approach and contact behavior ($APPR^-$) elicited by a CS signaling "absence of" an aversive US. The backward conditioning procedure used in the present series of experiments was based upon the original experiments of Leclerc and Reberg (1980). However, subjects were exposed to forward conditioning trials rather than to extinction following preliminary backward training. Such forward conditioning would constitute a retardation-of-acquisition test whereby the acquisition of the CR would be retarded

(Rescorla, 1969).

The first experiment compared the effect on behavior of a backward conditioning procedure with the effect of differential, explicitly unpaired and truly random procedures known to endow the CS with inhibitory properties (Rescorla & Wagner, 1972). Approach and contact behavior elicited by the CS and the amount of conditioned inhibition acquired by the CS were measured and compared. Subjects exposed to backward, differential and explicitly unpaired conditioning procedures were expected to acquire $APPR^-$ behavior, while subjects exposed to a truly random procedure were not expected to do so. Furthermore, if $APPR^-$ behavior is due to the inhibitory properties of the CS, the retardation-of-acquisition test (Rescorla, 1969) should reveal that the CS in one or more of the conditioned inhibition procedures acquired inhibitory properties.

The second experiment investigated the role played by the number of backward pairings on the development of $APPR^-$ behavior. If a few backward pairings endow the CS with excitatory properties, as demonstrated by Heth (1976) in a conditioned suppression paradigm, subjects would be expected to withdraw from the CS, i.e. should show $WDR^+$ behavior, and not $APPR^-$ behavior. If additional pairings endow the CS with inhibitory properties, subjects would then be expected to approach and contact the CS. Furthermore, a retardation-of-acquisition test should evaluate inhibitory properties to the CS following differential number of backward pairings.

The third experiment investigated the role played by the intertrial intervals on APPR$^-$ behavior and attempted to parallel Moscovitch and Lolordo's (1968) procedural manipulations. If long ITI durations are necessary to endow the CS with inhibitory values (Moscovitch & Lolordo, 1968), then the CS in backward conditioning which reliably signals a relatively long period without shock is expected to elicit APPR$^-$ behavior whereas ITIs that are sometimes short and sometimes long in duration are not expected to produce strong APPR$^-$ behavior.

In the fourth and last experiment, a conditioned suppression procedure was used to identify the nature of the CS following exposure to backward pairings. Approach and contact behaviors were measured in testing sessions and the position of the rat in the experimental box was recorded manually during training sessions. The CS presentations would be expected to facilitate the licking response in the backward group and result in the acquisition of APPR$^-$ behavior whereas it should suppress the licking response in the forward group and result in the acquisition of WDR$^+$ behavior. Subsequent forward presentations of the platform and the US (retardation-of-acquisition test) should result in a gradual suppression of the licking response in the group previoulsy exposed to backward pairings as well as in the acquisition of $WDR^+$ behavior. The results are expected to evaluate whether the CS in backward conditioning acquires inhibitory properties.

# Chapter 3

## Experiment 1

## THE EFFECTS OF CONDITIONED INHIBITION PROCEDURES ON THE DEVELOPMENT AND PERSISTENCE OF $APPR^-$ BEHAVIOR

The aim of this study was twofold: first, to measure the rate of acquisition of the approach ($APPR^-$) behavior produced by differential, backward and explicitly unpaired conditioning procedures (training 1) and second, to measure conditioned inhibition produced by each of these procedures by means of a retardation-of-acquisition test (training 2). In training 1, subjects were either exposed to (a) differential, (b) backward, (c) explicitly unpaired, or (d) truly random conditioning procedures. Training 2 (retardation-of-acquisition test, see Rescorla, 1967) consisted of forward presentations of platform and shock. Increase in time spent on the platform (the main dependent variable) was used as a measure of the rate of acquisition of the $APPR^-$ behavior (training 1) and a decrease in time spent on the platform as a measure of the acquisition of $WDR^+$ behavior, a behavior opposite to $APPR^-$. Resistance to acquisition of the $WDR^+$ behavior in training 2 was considered an indication of the amount of conditioned inhibition to the CS acquired in training 1.

Leclerc (1982, unpublished work) observed $APPR^-$

behavior when using a differential conditioning procedure. According to Rescorla and Wagner (1972), the CS in a differential conditioning procedure acquires inhibitory properties because of the nonreinforced presentations of the CS with an excitatory CS . Similarly, the CS in an explicitly unpaired procedure acquires inhibitory properties because of nonreinforced presentations of the CS with an excitatory context (Rescorla & Wagner, 1972). Consequently, it can be argued that APPR$^-$ behavior could be produced by such procedures and its development could be attributed to the inhibitory properties of the CS. The present experiment attempted to replicate Leclerc's (1982) observations. The inhibitory properties of the CS should be apparent in training 2 (retardation-of-acquisition test) where subjects would be exposed to a positive contingency between CS and US. Such a positive (or forward) contingency is known to produce withdrawal (WDR$^+$) behavior away from the CS-platform (Leclerc & Reberg, 1980).

This experiment also attempted to verify Rescorla and Wagner's (1972) prediction pertaining to compound CSs which signal the same event. The model predicts that if the two CSs are equally salient, they will compete for associative strength. In training 1, one group was exposed to backward presentations of shock-platform only while another group was exposed to backward presentations of shock-platform/buzzer combined. In this latter group, if the platform and buzzer were equally salient, the platform would share inhibitory values with the buzzer and acquisition of $APPR^-$ behavior was expected to be acquired at a slower rate than in the group exposed to the CS-platform only. Training 2 was also expected to reveal that the amount of conditioned inhibition acquired by the platform was less in the group exposed to the compound CS. This should result in faster learning in training sessions.

Rescorla (1967) also suggested that a truly random procedure would leave the CS associatively neutral at asymptote since the CS and the US occur randomly and independently of each other. Such a procedural strategy was included in Experiment 1, and consisted of random presentations of CS and US. The rate of acquisition of $APPR^-$ behavior in this group was expected to be less than in the other groups. In training 2, this group continued to be exposed to random presentations of the CS and US (while all other groups were exposed to a forward procedure) in order to evaluate the change of behavioral tendency produced by a forward procedure.

In summary, in training 1, all experimental groups were expected to acquire $APPR^-$ behavior but procedures which included CS compounds should do so at a slower rate in comparison with the control procedure. Since it was not known, a priori, whether different amount of conditioned inhibition would be produced by the experimental procedures, no other prediction could be made about group differences in training 2.

## Method

### Subjects

The subjects were 80 naive adult male hooded rats. They had free access to food and water at all times in their home cages. They were maintained on a 12:12 light:dark cycle (lights on at 0700 h EST), and were run during the light cycle.

### Apparatus

Four 23.0 X 20.8 X 20.3 cm commercially made platform boxes (model 85200, Lafayette Instrument Co., Indiana) were used. Two of the walls and the ceiling (used as a chamber door) were made of clear Plexiglas and the two other walls were made of stainless steel. The grid floor was made of 15 parallel stainless-steel bars, 1.1 cm apart and 0.5 cm in diameter.

The apparatus also featured a platform made available to the animals when the upper part of one of the stainless steel walls automatically retracted forming an alcove measuring 12.5 X 12.5 X 20.0 cm and located 8.3 cm above the grid floor. The platform wall took approximately 2.5 sec to retract or close. Shocks were never delivered on the platform area.

Four commercially made shockers (Model 82401, Lafayette Instrument Co., Indiana) were used to deliver scrambled shock through the grid floor. The intensity of the shock was set at 0.5 mA and the shock duration was 2 sec. Masking noise of 72 dB (as measured from the inside of the conditioning chamber) was on in the experimental room during conditioning sessions. The buzzer was approximately 3 dB over background masking noise.

Timing and delivery of all stimuli presentations were controlled by a TRS-80 Model 4 computer system (Tandy Corp., U.S.A.). Time spent on the platform (the dependent variable) was recorded automatically by means of a photocell system specially designed to detect the animals' presence on the platform. A response was recorded when at least one of the two light beams over the platform area was broken and the five beams above the grid floor (and immediately next to the platform area) were unbroken.

Procedure

The procedure consisted of three phases: baseline, training 1 and training 2.

Baseline. All subjects were exposed to ten 60-sec platform presentations per daily sessions. No shocks were administered during this phase which lasted five sessions.

The intertrial intervals (ITI) averaged three minutes: The minimum ITI was 1 min, the maximum was 5 min.

Training 1. Since there can be large individual differences in rats' spontaneous tendency to jump on the platform (as observed by Leclerc & Reberg, 1980), subjects were assigned to one of five groups on the basis of their baseline performance. As in previous work (Leclerc & Reberg, 1980; Leclerc, 1985), subjects were classified as "high" responders if their average time spent on the platform when it was presented was over 21% or as "low" responders if their average time on the platform was less than 21%. A roughly equal number of high and low responders were assigned to each of the five groups (n=16 per group) to prevent the possibility of group differences before training.

For each group, the US was a scrambled foot-shock (2 sec, 0.5 mA) and the CS a 60-sec platform presentation. Each session lasted approximately 40 min and included 10 trials. Training 1 consisted of four sessions administered on four consecutive days. Time spent on the platform was the dependent variable.

Table 1 presents a summary of the particular procedure associated with each group. There were four experimental groups: Groups Diffcond (differential conditioning), BKPLB

Table 1. Summary of the procedure for each of the four experimental groups and the control group in in Experiment 1.

| Condition | Group | CS+ | CS- | CS |
|---|---|---|---|---|
| Experimental | Diffcond | buzzer | platform | - |
| | BKPLB | none | pl + buzzer | - |
| | BKPL | none | platform | - |
| | UNP | none | platform | - |
| Control | RAND | - | - | platform |

Note. pl = platform. Dash = not applicable.

(backward conditioning with the CS being the combined presentation of platform and buzzer), BKPL (backward conditioning with the CS being the platform only), and UNP (unpaired presentation of the CS-platform). There was one control group: Group RAND (random).

Group Diffcond was exposed to a differential conditioning procedure which included two different types of trials. One type of trials (positive trials) consisted of a 60-sec buzzer presentation ($CS^+$) followed by a 10-sec interstimulus interval and shock onset. The other type of trials (negative trials) consisted of a 60-sec platform presentation ($CS^-$) which signaled a shock-free period which varied between 60 and 180 sec. There were five positive and five negative trials which were distributed randomly in each session.

Group BKPLB was exposed to a backward conditioning procedure. Each trial consisted of shock presentations followed, 10 sec later, by simultaneous 60-sec presentations of platform and buzzer. The minimum intertrial interval was 60 sec and the maximum was 5 min, the average being 3 min.

Group BKPL was also exposed to a backward conditioning procedure. This group differed from Group BKPLB only in that shock was followed by 60-sec presentations of platform alone, i.e., no buzzer.

Group UNP was exposed to 10 platform and 10 shock presentations. Platforms and shocks were programmed so that they were never presented in close temporal contiguity. The interstimulus interval averaged 85 sec, the minimum being 10 sec and the maximum 3 min.

Group RAND was exposed to 10 random presentations of shock and 10 random presentations of platform programmed independently in each session. However, shocks were never delivered during platform presentations so that subjects could not escape shock by jumping on the paltform. The minimum interstimulus interval was 5 sec and the maximum 100 sec.

<u>Training 2 (Retardation-of-acquisition test)</u>. Following the last day of training 1, all subjects (except those in Group RAND) were exposed to a forward conditioning procedure. Each trial consisted of 60-sec platform presentations ($CS^+$) followed, 10 sec later, by shock. A session consisted of 10 trials, the intertrial intervals averaging 3 min (minimum of 1 min and maximum of 5 min). Training 2 lasted six sessions. For Group RAND, training 2 consisted of a continuation of treatment received in training 1, i.e., exposure to random presentations of shock and platform.

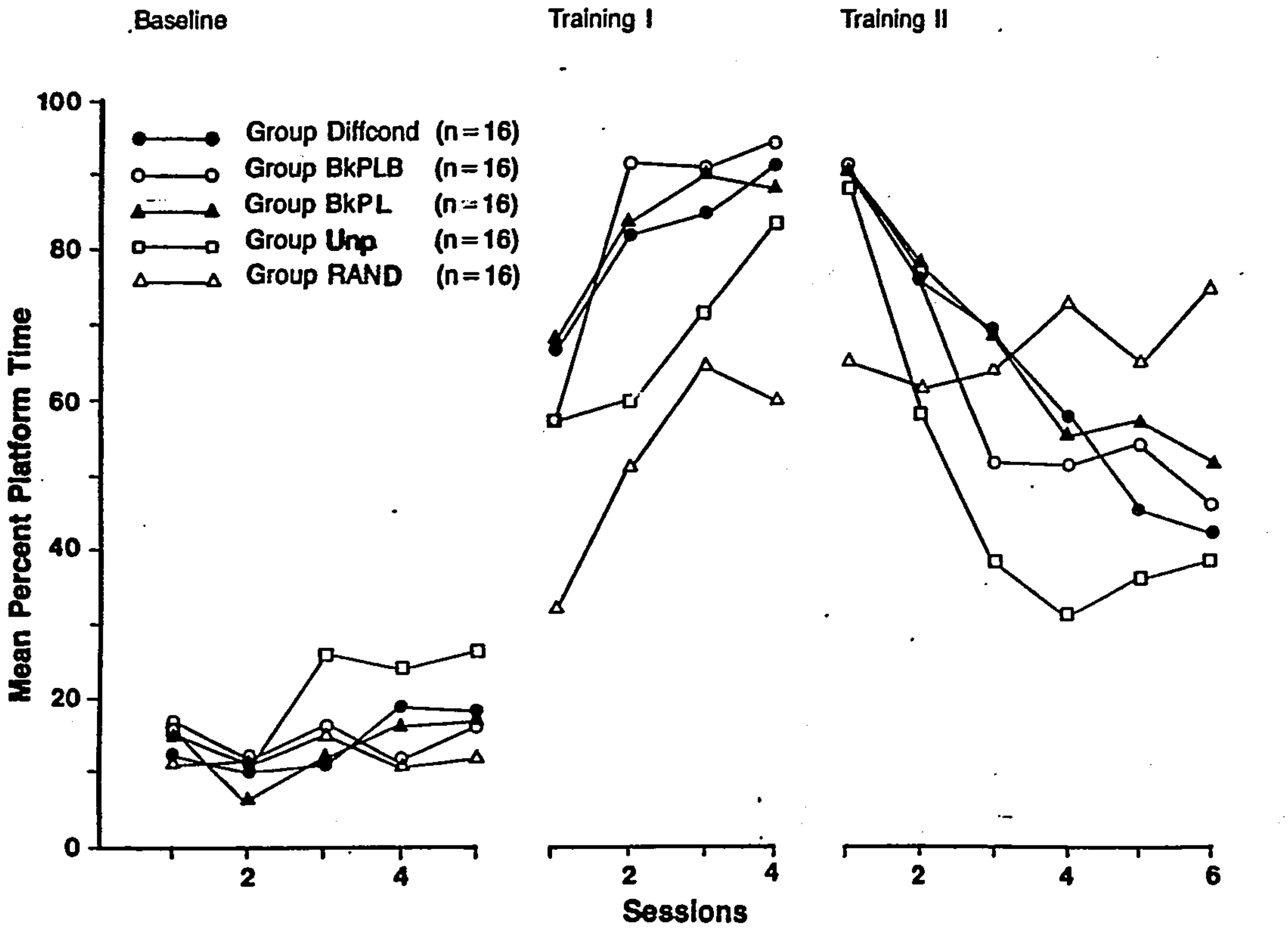
# Results

Figure 1 shows the average percentage of time spent on the platform for each of the groups during each session of baseline, training 1 and 2 (see Appendices 1 to 5 for data for the various groups, and Appendix 6 for a summary of the statistical analyses made on the baseline, training 1 and 2 data). The results from each phase were analysed using a two-way analysis of variance and Tukey's ratios (Kirk, 1968) were calculated to make group comparisons when appropriate. A rejection level of .05 was used for all analyses.

Baseline. A 5(Groups) x 5(Sessions) analysis of variance revealed a significant main effect of Sessions [$F$ (4,300) = 2.48]. This significant effect reflects a small but reliable increase in time spent on the platform for all subjects in later baseline sessions. There were no significant differences among the groups.

Training 1. As shown in Figure 1, the four experimental groups, Groups Diffcond, BKPLB, BKPL and UNP, spent more time on the platform than the control group, Group RAND. Time spent on the platform increased for all groups as sessions progressed. A 5(Groups) x 5(Sessions) analysis of variance indicated a significant main effect of Groups

Figure 1. Mean percentage of total time spent on the platform for each group during each session of baseline, training 1 and 2 in Experiment 1.


Baseline
Training I
Training II
Group Diffcond (n=16)
Group BkPLB (n=16)
Group BkPL (n=16)
Group Unp (n=16)
Group RAND (n=16)
Mean Percent Platform Time
100
80
60
40
20
0
2
4
2
4
2
4
6
Sessions

[$F$ (4,75) = 7.71], and of sessions [$F$ (3,225) = 43.65]. Group comparisons revealed that Group RAND spent significantly less time on the platform than the other groups.

In order to evaluate whether groups differed in terms of their rate of acquisition of APPR$^-$ behavior, time spent on the platform for the first two platform presentations of the first session was compiled for each group. A 5(Groups) x 1(Trial) analysis of variance failed to indicate a significant difference among groups, although Groups BKPLB and RAND showed a tendency to spend less time on the platform than the other groups.

In order to evaluate the number of backward and forward pairings received by subjects in Group RAND, interstimulus intervals (ISIs) were compiled. It was found that, during training 1, there were seven instances when the shock preceeded platform presentations by 10 sec (backward pairings), and five instances when platform preceeded shock by 10 sec (forward pairings). This information provided support for the "truly random" nature of the procedure used.

<u>Training 2</u>. Figure 1 shows that on Day 1 of training 2, all groups maintained the same level of performance as on the last day of training 1. In all groups exposed to the forward procedure, time spent on the platform gradually

declined as the training sessions progressed.

A 5(Groups) x 6(Sessions) analysis of variance showed a significant main effect of Sessions [$F$ (5,375) = 30.43] and a significant interaction [$F$ (20,375) = 3.73]. Tests of simple main effects revealed that Group RAND (exposed to a "truly random" procedure in training 2 as in training 1) was the only group which showed no significant change in time spent on the platform throughout the sessions, the overall mean percentage time for the six days being 67.4%. For all other groups (Groups Diffcond, BKPLB, BKPL and UNP), time spent on the platform gradually decreased throughout training 2. Between groups comparisons revealed that Group RAND spent significantly more time on the platform than Group UNP on Days 4 and 6. No other comparisons were found to be significant.

## Discussion

Training 1. The first goal of this study was to compare the rate of acquisition of APPR$^-$ behavior produced by conditioning procedures known to yield conditioned inhibition. The analyses failed to indicate any significant differences among experimental groups. Therefore, we can only conclude that in the present experimental paradigm we were unable to detect possible differential effects of differential, backward and explicitly unpaired procedures.

All procedures produced APPR$^-$ behavior, and its acquisition was as rapid for subjects exposed to backward pairings of platform and shock as for subjects exposed to differential and unpaired conditioning procedures.

The performance of subjects in the two backward groups (Groups BKPLB and BKPL) was rather unexpected in that both groups spent a comparable amount of time on the platform and the rate of acquisition of APPR$^-$ behavior was similar in the two groups. These results suggest that the addition of the buzzer during platform presentation did not produce a decrease in the associative value of the platform, as would have been predicted from Rescorla and Wagner's (1972) model. According to their formal model, learning on any given trial can be expressed as follows:

$$\Delta V = \alpha\beta(\lambda - V_T)$$

where $\Delta V$ represents the change in associative strength that occurs as a result of conditioning; $\alpha$ and $\beta$ are constants representing the salience and intensity of the CS and US, respectively; $\lambda$ is the asymptote of conditioning that the US can support; $\Delta V$ is the total associative strength of all the stimuli in the context. When conditioning involves compound stimuli, each stimulus equally shares the total associative strength of the compound and the growth of associative strength is:

$$\Delta V_B \text{ (buzzer)} = X(\lambda - V_T)$$
$$\Delta V_P \text{ (platform)} = Y(\lambda - V_T)$$

The only difference lies in the values of the constant X and Y, part of which is determined by the salience of the CS: if $X = Y$, then $\Delta V_B$(buzzer) = $\Delta V_p$(platform). However, if $X = Y$, then $\Delta V_B$(buzzer) $<$ or $>$ $\Delta V_p$(platform).

Perhaps associative strength was not shared equally by the platform and the buzzer because the platform, having auditory, visual and tactual components, was a more salient stimulus than the buzzer. In cases where one stimulus is more salient than the other, the model predicts that the more salient stimulus will acquire more associative strength than the less salient stimulus. This process would resemble an overshadowing mechanism (Kamin, 1968). Such an interpretation of the results can explain, at least partly, why the performance of the two backward groups, Groups BKPLB and BKPL, was similar. There was, however, no independent evaluation of an overshadowing mechanism in this experiment.

The results also showed that subjects in all experimental groups displayed similar behavioral tendencies early in training 1. It seems that two trials were sufficient to endow the CS with some associative value in all the groups.

From a conditioned inhibition analysis of $APPR^-$ behavior, the rapid acquisition of this behavior is surprising since conditioned inhibition is considered to be a relatively slower process than conditioned excitation

(Rescorla & Wagner, 1970). Perhaps, in the present aversive sign-tracking preparation, behavioral changes required less CS conditioning than in other preparations (such as in conditioned suppression). For example, since it has been proposed that APPR$^-$ behavior involves responses which are part of the animals' defense repertoire (Leclerc, 1985), it is possible that a CS (i.e., the platform), which supports such behavior, would be more readily associated with a non-shock and safety period than would a more neutral CS.

Training 2. The second goal of the study was to measure and compare the amount of inhibitory conditioning produced by the differential, backward and explicitly unpaired conditioning procedures. Subjects in all groups were expected to slowly acquire WDR$^+$ behavior in training 2, thus revealing the CS inhibitory properties acquired during training 1 (Rescorla & Wagner, 1972). There was a rapid decline in time spent on the platform in all experimental groups and the statistical analysis failed to indicate differences among groups. This may be taken to indicate that a similar mechanism of action was present in those procedures.

The results also showed that time spent on the platform in the control group was maintained throughout the sessions and therefore, that time spent on the platform increases to a certain level of performance with repeated exposures to noncontingent platform and shock presentations (training 1) and then is maintained constant if exposure is continued. The level of performance reached by the control group was quite high (mean percentage time was 67.4%) and possibly reflecting the natural tendency of animals to flee from a place of danger (the grid floor). The high level of performance of the control group is at least partly responsible for the lack of significant differences between the control group and the experimental groups.

An important observation is that time spent on the platform in Group UNP declined more rapidly than in Groups Diffcond, BKPLB and BKPL, although a significant difference among groups was not found. It would appear that the CS in Group UNP did not acquire as much inhibitory properties in training 1 as it did in the other experimental groups. A possible explanation is that although Group UNP was exposed to unpaired CS and US presentations, the time periods between CS and US were sometimes very short (e.g., 10 sec). Consequently, Group UNP could have been exposed to a certain number of forward trials in training 1 which could have reduced the amount of inhibition acquired by the CS. In training 2, the CS could then have acquired excitatory properties more readily than in other groups.

<u>Procedural and theoretical limitations in Experiment 1</u>

CS-only (platform) and US-only (shock) procedures were not included. A CS-only (no shock) procedure would provide some information on the percentage of time spent on the platform which could be attributed to the rats' natural tendency to jump on the platform in the absence of shocks. A US-only (no platform) procedure would allow an assessment of how fear of the context alone was responsible for $APPR^-$ behavior. A Group CS and a Group US were not included in Experiment 1 since data from such groups were previously reported by Leclerc and Reberg (1980).

Leclerc and Reberg (1980, Experiment 1) included a CS-only group as a point of reference about $APPR^-$ behavior in the absence of shock. The procedure consisted of two phases: training and extinction. During training, one experimental group, Group BKWD, was exposed to a backward conditioning procedure while the other experimental group, Group FRWD, was exposed to a forward conditioning procedure. There were two control groups. Group RAND received random shock and platform presentations and Group CS-only received platform presentations but no shock. During extinction, all groups were exposed to platform presentations only (no shocks).

Training results indicated that Group BKWD spent significantly more time on the platform than Group FRWD while Groups RAND and CS-only spent about 50% of the time on the platform. Data can be taken as evidence that performance above 50% is due to conditioning.

In another experiment, Leclerc and Reberg (1980, Experiment 2) included a shock-only control group during training to assess (in Extinction sessions) how much time spent on the platform could be attributed to escape from the grid floor where shock was administered. Experiment 2 essentially replicated Experiment 1 just described above.

Extinction results showed that Group BKWD spent more time on the platform than the other groups, including Group SHOCK (shock-only), for the first 15 extinction sessions. This data indicated that while fear of the context is responsible for APPR$^-$ to a certain degree, it certainly does not account for the high percentage of time spent on the platform by Group BKWD.

Objections may also be raised as to the truly random nature of our Group RAND especially since it differed from Group UNP only in the minimum and maximum ITI. For our random procedure, we followed the model in which the CS equally predicts the US and its absence. We therefore chose a minimum interval of 5 sec and a maximum of 100 sec between shock and platform to allow for some backward and some forward pairings. For our unpaired procedure, we chose a minimum interval of 10 sec and a maximum of 180 sec between shock and platform to decrease the probability of backward and forward pairings. Problems in obtaining a truly random procedure had been acknowledged by Leclerc and Reberg (1980, Experiment 1). However, the results in

Experiment 1 seemed to support that we were successful in designing a truly random procedure.

Another limitation of Experiment 1 was the overall lack of control for latent inhibition and US preexposure effects. Latent inhibition may have developed in all of the experimental groups in training 1 since platform presentations were not reinforced (platform presentations were followed by a period without shock). A US preexposure effect may have resulted also in all groups in training 1, except Group Diffcond, because the US was not signalled. Consequently, the results from the retardation-of-acquisition were likely confounded by latent inhibition and US preexposure effects. Because there was no control, it was not possible to determine to what extent the retardation of acquisition of $WDR^{+}$ behavior could be attributed solely to conditioned inhibition. However, it seemed logical to assume that, since all groups (except Group Diffcond) were exposed to the same sources of confounding effects, any differences among groups in the degree of inhibition measured by the retardation-of-acquisition test could be attributed to the conditioning procedure. Retardation of acquisition in Group Diffcond was also comparable to that of the other experimental groups.

# Chapter 4

## Experiment 2

## THE EFFECTS OF THE NUMBER OF PAIRINGS ON THE DEVELOPMENT AND PERSISTENCE OF APPR$^-$ BEHAVIOR IN BACKWARD CONDITIONING

The results of Experiment 1 indicated that differential, backward and explicitly unpaired conditioning procedures result in the development of APPR$^-$ behavior. When groups exposed to these procedures are then exposed to a forward conditioning procedure, WDR$^+$ behavior is developed very slowly, thus suggesting that a similar mechanism of action is responsible for APPR$^-$ behavior, and such a mechanism could be conditioned inhibition. Experiment 2 attempted to focus more directly on the question of the associative value of the CS in the backward conditioning procedure.

The results of several studies are conflicting in that they have reported that backward conditioning could yield conditioned excitation, or conditioned inhibition, or both. Some authors (Pavlov, 1927; Heth, 1976) have suggested that backward conditioning could involve a two-stage process: the CS is excitatory in the early stages of training but gradually acquires inhibitory properties in later stages of training. Heth (1976) has presented experimental evidence to support this view.

Heth (1976) used a backward conditioning procedure in which the US was a shock and the CS a 2 sec compound presentation of light and buzzer. The amount of suppression on bar pressing produced by the CS was used as a measure of acquired fear of the CS, indicating conditioned excitation. Heth reported that, early in training, the CS had acquired conditioned excitation, but with additional training, it had developed conditioned inhibition properties. These results indicate that conditioned inhibition in a backward procedure would be a function of the number of US-CS pairings.

Post-hoc analysis of the results in Experiment 1 did not allow any conclusions to be drawn regarding the possibility of such a two-stage conditioning process in the groups which had been exposed to backward conditioning. Experiment 2 was designed to look more specifically at the existence of a two-stage conditioning process in the particular backward conditioning procedure used in the present preparation. Also, it was believed that the results of Experiment 2 would provide additional information about the minimum number of trials required for the development of $APPR^-$ behavior.

The results of a preliminary study conducted with these goals in mind indicated that possibly as few as three backward pairings (administered one a day) were sufficient to produce a high level of $APPR^-$ behavior. However, the group exposed to only one backward pairing per session was also exposed to 9 "random" presentations of CS and US within the same sessions. A closer look at the programmed random presentations of CS and US revealed that the average time intervals following each event turned out to be quite long (56.2 sec). Consequently, the random presentation of CS and US could better be described as "explicitly unpaired" presentations of CS and US. Since, as reported in Experiment 1, explicitly unpaired presentations of CS and US produce effects on behavior which are similar to those produced by a backward conditioning procedure, it seemed likely that the rate of acquisition of $APPR^-$ behavior was influenced by the combined effect of backward pairings and of the "random" CS and US presentations. Experiment 2 attempted to eliminate sources, other than backward pairings, contributing to inhibitory conditioning.

In Experiment 2, groups were exposed to either 1, 5, or 10 backward presentations of shock and platform per daily session while control groups were exposed to either 1, 5, or 10 random presentations of shock and platform per daily session. If, as suggested by Heth (1976), the first few backward pairings endow the CS with excitatory properties, then the group exposed to 1 daily backward pairing should not acquire $APPR^-$ behavior, and instead should show $WDR^+$ behavior. Acquisition of $APPR^-$ behavior should be slow in the group exposed to 5 daily backward pairings. However, by the end of the training sessions, this group should spend significantly more time on the platform than the control group exposed to 5 daily random presentations of CS and US. Acquisition of APPR$^{-}$ behavior should be very rapid in the experimental group exposed to 10 daily presentation of US-CS and subjects should spend significantly more time on the platform than the control group exposed to 10 daily random presentations of CS and US. During training 2 (Retardation-of-acquisition test), all subjects were exposed to CS-US forward pairings. It was expected that subjects previously exposed to 1 daily backward pairing would not show any retardation in the acquisition of WDR$^{+}$ behavior whereas subjects previously exposed to 5 and 10 daily backward pairings would show persistence in APPR$^{-}$ behavior, indicating retardation in WDR$^{+}$ acquisition.

## Method

### Subjects

The subjects were 48 naive adult male hooded rats. They had free access to food and water at all times in their home cages. They were maintained on a 12:12 light:dark cycle (lights on at 0700 h EST), and were run during the light cycle.

Apparatus

The experimental setting, the CS and US were identical to the ones used in Experiment 1.

Procedure

The procedure consisted of three phases: baseline, training 1, and training 2.

Baseline. Subjects were exposed to ten 60-sec platform presentations per daily session. Intertrial intervals lasted a minimum of 60 sec and a maximum of 300 sec. There were five such sessions during this phase.

Training 1. Subjects were distributed in six groups, each with a roughly equal number of "high" and "low" responders (determined using the same criteria as in Experiment 1).

For each group (N=8), the US was an electric foot-shock (2 sec, 0.5 mA) and the CS was a 60-sec platform presentation. Training 1 lasted for 7 days.

Three of the six groups were experimental groups exposed to backward conditioning and differed only in the number of exposures to backward pairings per daily session. The first group, Group BK1, was exposed to 1 backward presentation of the US-shock and CS-platform per session; the second group, Group BK5, was exposed to 5 backward presentations of US-shock and CS-platform; the third group, Group BK10, was exposed to 10 backward presentations of the US-shock and CS-platform. For these three groups, the backward conditioning procedure consisted of the presentation of the US-shock followed, 10 sec later, by a 60-sec presentation of the CS-platform. The intertrial intervals averaged 3 min, with a minimum of 60 sec and a maximum of 300 sec. A session lasted approximately 5 min, 22 min or 43 min for Groups BK1, BK5 and BK10 respectively.

The three other groups were control groups exposed to a truly random procedure and also differed only in the number of exposures to the CS and US per daily session. Groups RD1, RD5, and RD10 were exposed to 1, 5, and 10 random presentations of CS and US per daily session, respectively.

For the three control groups, the truly random procedure consisted of random presentations of the US-shock and of the CS-platform. However, to ensure that subjects exposed to random presentations of CS and US would also be exposed to forward and backward presentations of CS and US, as it should in a truly random procedure, backward and forward pairings were always included in each session. For the seven sessions of training 1, Group RD1 was exposed to a minimum of 1 and a maximum of 2 backward trials, a minimum of 1 and a maximum of 2 forward trials and a minimum of 3 and a maximum of 5 random presentation of CS and US (for a total of 7 exposures to the CS-platform and 7 exposures to the US-shock); Group RD5 was exposed daily to 1 backward trial, 1 forward trial and 3 random presentations of CS and US; Group RD10 was exposed daily to 2 backward trials, 2 forward trials and 6 random presentations of CS and US. For each group, presentations of forward and backward trials were dispersed randomly within each session. Each session averaged duration was 5 min for Group RD1, 22 min for Group RD5 and 43 min for Group RD10.

Training 2. Twenty-four hr after the completion of training 1, all subjects were exposed to a forward conditioning procedure. The procedure consisted of the presentation of the CS-platform followed, 10 sec later, by the US-shock. Groups BK1 and RD1 were exposed to 1 forward daily presentation of platform and shock; Groups BK5 and RD5 were exposed to 5 forward daily presentations of platform and shock; Groups BK10 and RD10 were exposed to 10 forward daily presentations of platform and shock. The session duration for each group was as in training 1.

The forward procedure, which has shown to produce $WDR^+$ behavior (a behavioral tendency opposite to $APPR^-$ behavior) in the previous experiment, was introduced as part of a retardation-of-acquisition design.

# Results

Figures 2, 3 and 4 show the average time spent on the platform for each experimental group compared to its control group during each of the three phases of the experiment (see Appendices 7 to 12 for data for the various groups, and Appendices 13, 14, and 15 for a summary of the statistical analyses made on the baseline, training 1 and 2 data from each experimental group and its control group). Figure 5 shows the average time spent on the platform for each of the experimental group following exposure to 7 backward pairings in training 1 (see Appendix 16 for data for each group, and Appendix 17 for a summary of the statistical analysis). Figure 6 shows the average time spent on the platform for Group BK5 and Group BK10 following exposure to 30 backward pairings in training 1 (see Appendix 18 for data for each group, and Appendix 19 for a sum ary of the statistical analysis). The results were analysed using two-way analyses of variance and Tukey's ratios (Kirk, 1968) were calculated to make group comparisons when appropriate. The rejection level used was .05 for all analyses.

Baseline. Generally, time spent on the platform increased from the first baseline session to the subsequent ones. The 2(Groups) x 5(Sessions) analyses of variance

Figure 2. Mean percentage of total time spent on the platform for Group BK1 compared to its control group, Group RD1, during each session of baseline, training 1 and 2 in Experiment 2.

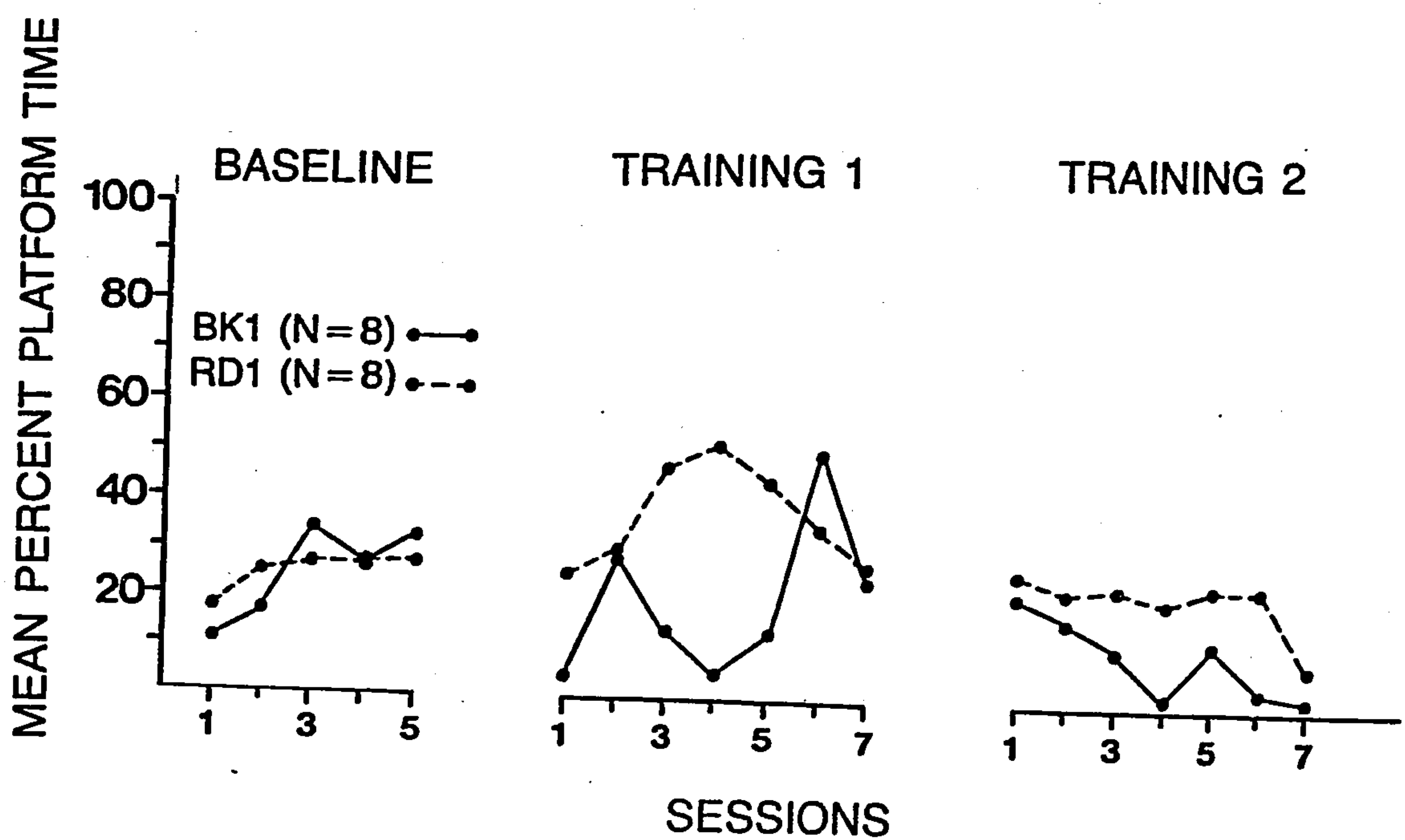

MEAN PERCENT PLATFORM TIME
100
80
60
40
20
BASELINE
TRAINING 1
TRAINING 2
BK1 (N=8)
RD1 (N=8)
1
3
5
7
SESSIONS

Figure 3. Mean percentage of total time spent on the platform for Group BK5 compared to its control group, Group RD5, during each session of baseline, training 1 and 2 in Experiment 2.

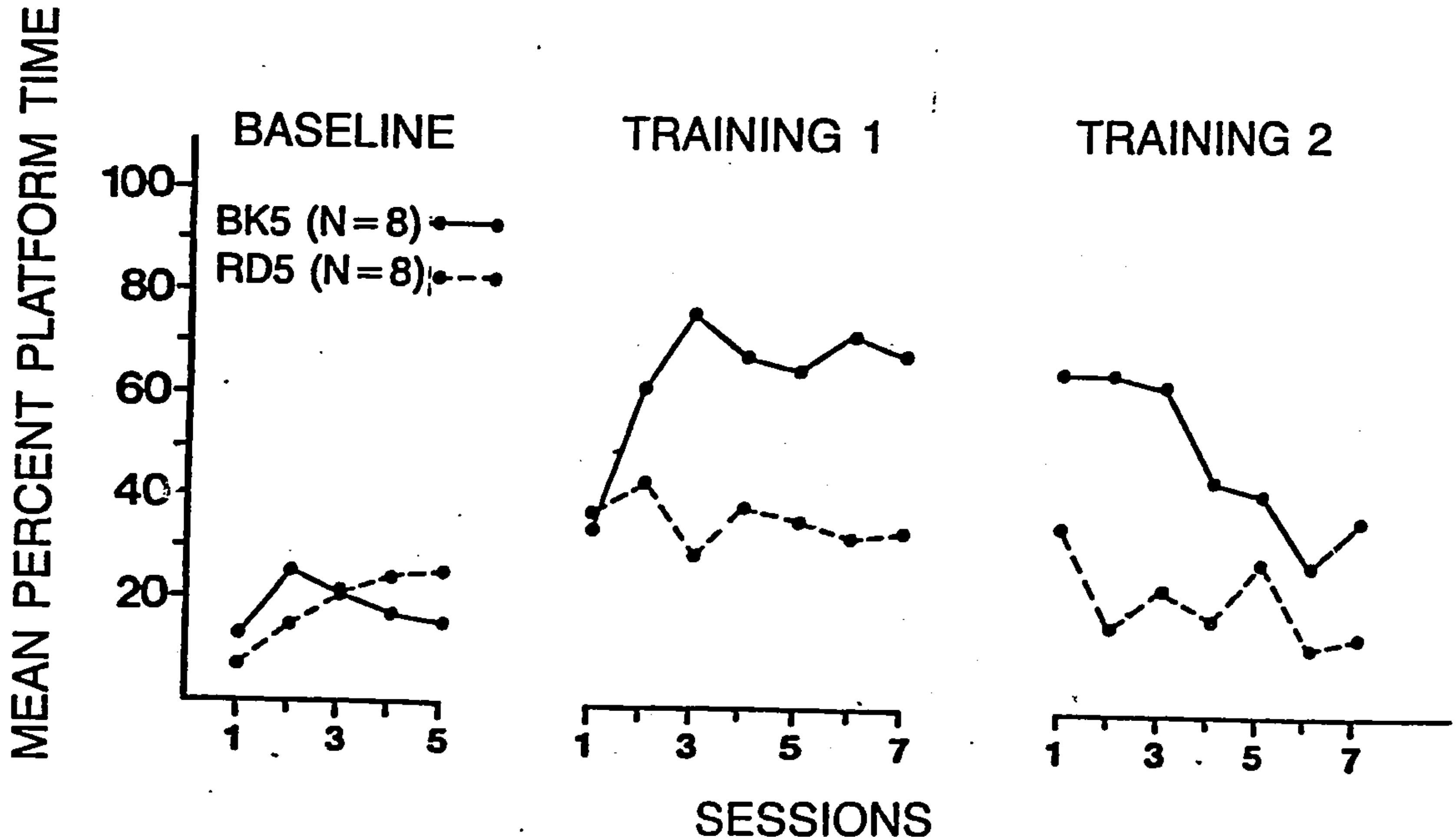

MEAN PERCENT PLATFORM TIME
100
80
60
40
20
BASELINE
TRAINING 1
TRAINING 2
BK5 (N=8)
RD5 (N=8)
1
3
5
7
SESSIONS

Figure 4. Mean percentage of total time spent on the platform for Group BK10 compared to its control group, Group RD10, during each session of baseline, training 1 and 2 in Experiment 2.

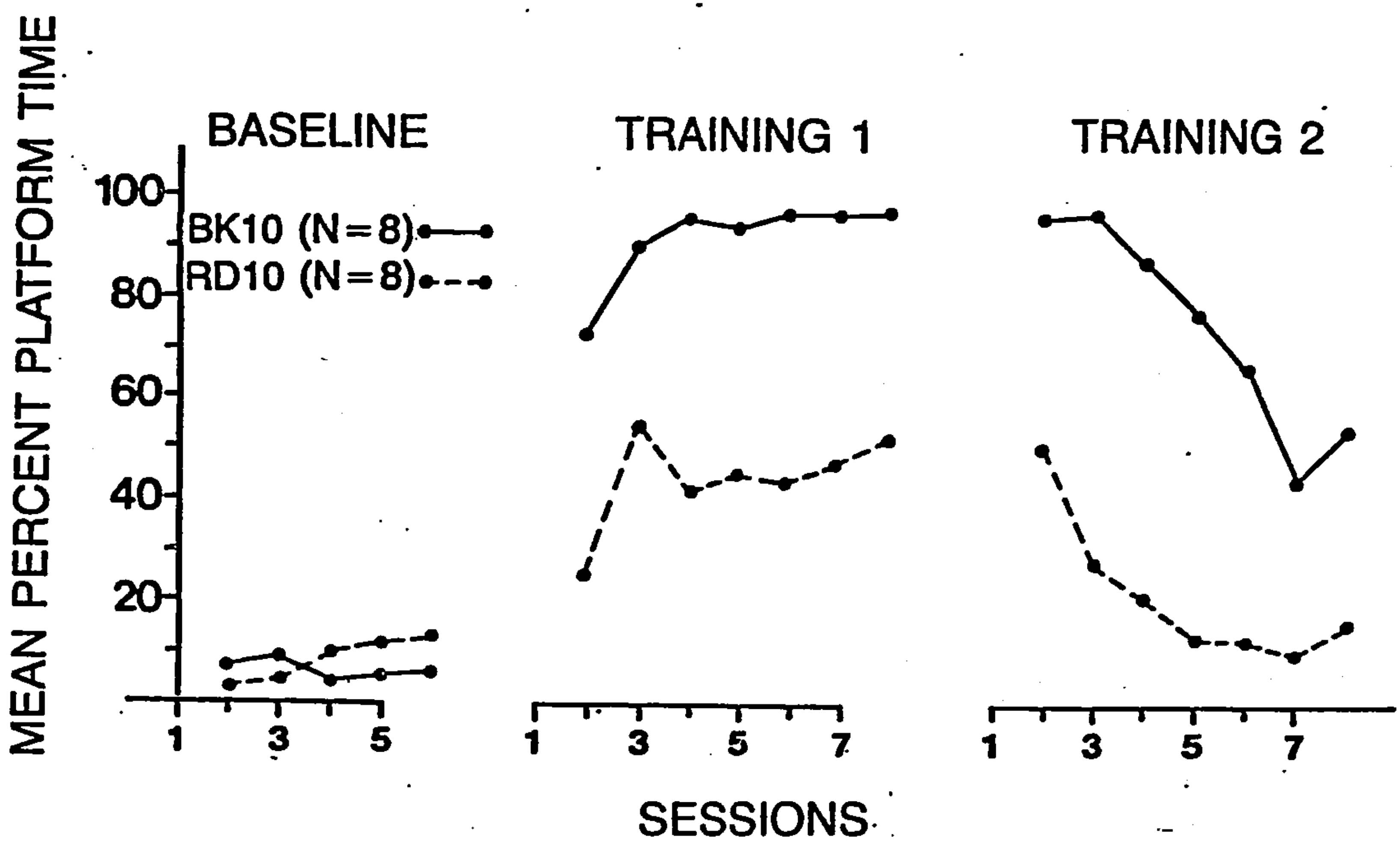

MEAN PERCENT PLATFORM TIME
BASELINE
TRAINING 1
TRAINING 2
BK10 (N=8)
RD10 (N=8)
100
80
60
40
20
1
3
5
7
SESSIONS

Figure 5. Mean percentage of total time spent on the platform for each experimental group during each of the first 7 trials of training 1 in Experiment 2.

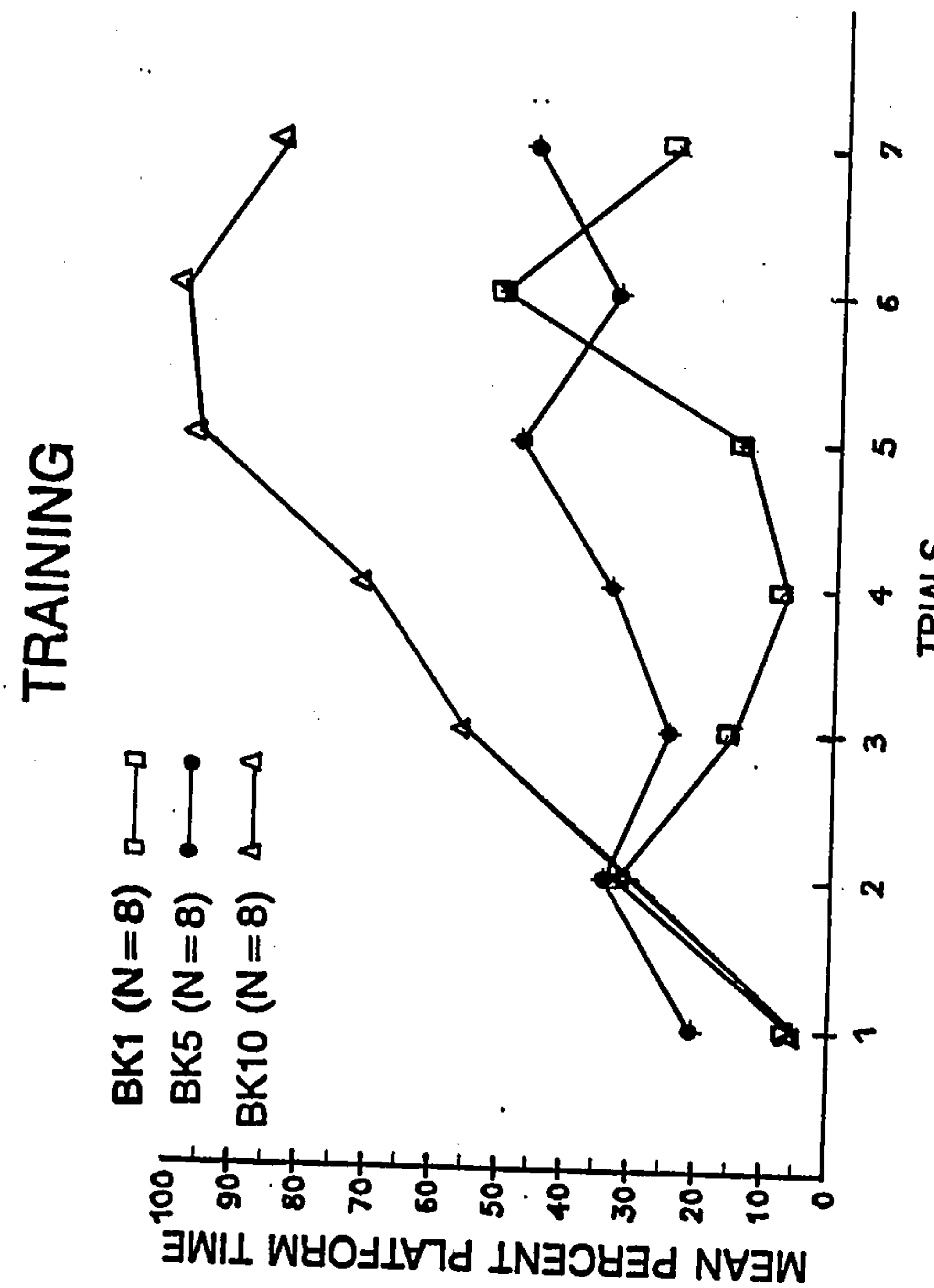
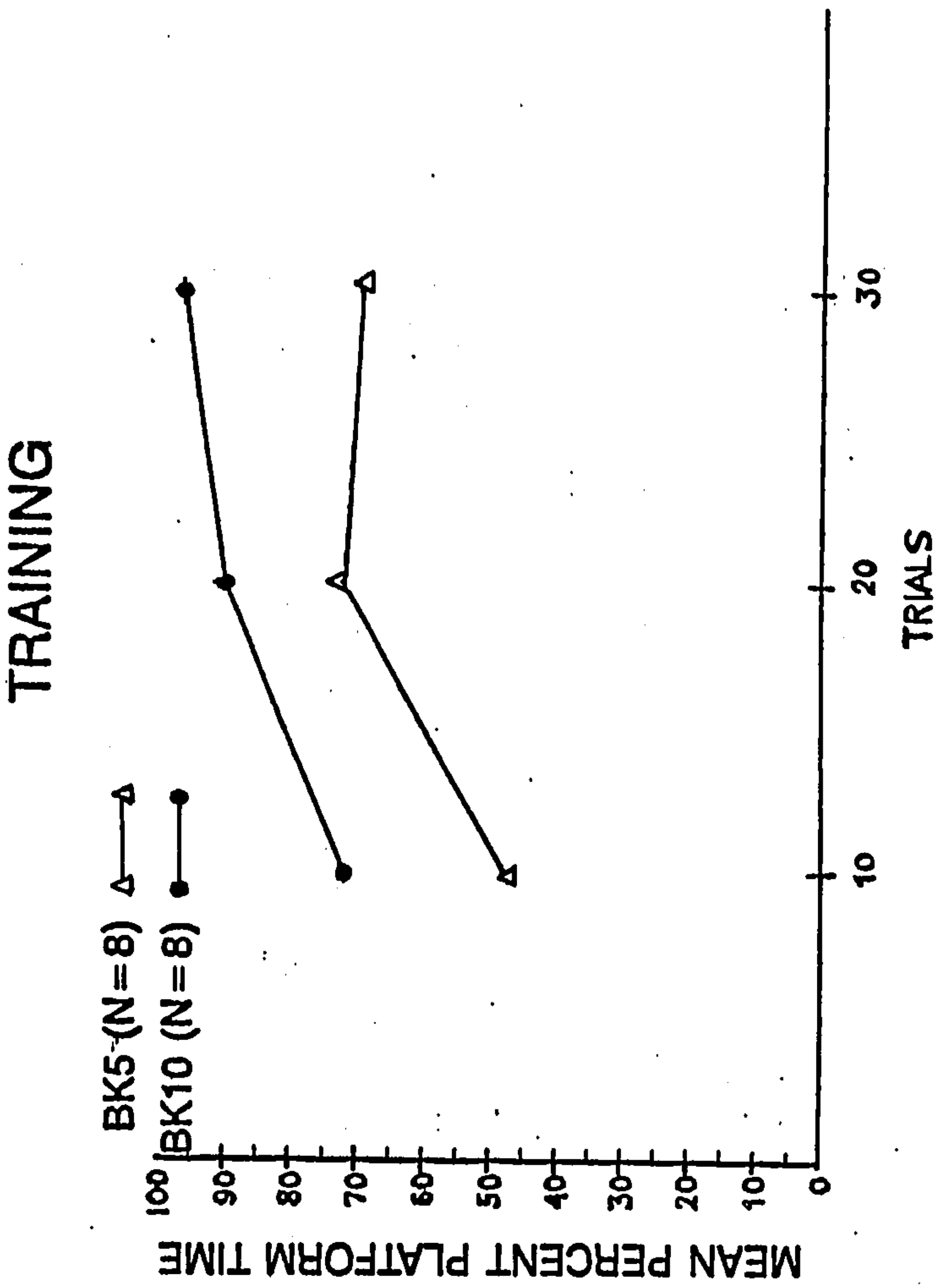

TRAINING
BK1 (N=8)
BK5 (N=8)
BK10 (N=8)
MEAN PERCENT PLATFORM TIME
0
10
20
30
40
50
60
70
80
90
100
TRIALS
1
2
3
4
5
6
7

Figure 6. Mean percentage of total time spent on the platform for Groups BK5 and BK10 during the first thirty trials of training 1 in Experiment 2.


TRAINING
BK5 (N=8)
BK10 (N=8)
MEAN PERCENT PLATFORM TIME
0
10
20
30
40
50
60
70
80
90
100
10
20
30
TRIALS

performed to compare each experimental group to its proper control group revealed no significant effect of Session, Group, or Interaction.

Training 1. As shown in Figure 2, experimental Group BK1 spent less time on the platform than its control group, Group RD1. A 2(Groups) x 7(Sessions) analysis of variance revealed no significant main effect of Group or Session but a significant Interaction, [$F(6,84) = 2.74$]. Tests of simple main effects revealed that Group BK1 spent significantly less time on the platform than Group RD1 on Day 4 of training. However, this pattern of behavior was not maintained on the following days. On days 5 and 6, time spent on the platform increased in Group BK1 and on the last day of training (Day 7), Group BK1 and RD1 spent an equal amount of time on the platform.

As shown in Figure 3, experimental Group BK5 spent more time on the platform than its control group, Group RD5. A 2(Groups) x 7(Sessions) analysis of variance revealed no significant main effect of Group or Session but a significant Interaction, [$F(6,84) = 2.57$]. Tests of simple main effects indicated that Group BK5 spent significantly more time on the platform than Group RD5 on Days 3, 6, and 7.

As shown in Figure 4, experimental Group BK10 also spent more time on the platform than its control group,

Group RD10. A 2(Groups) x 7(Sessions) analysis of variance revealed a significant main effect of Groups, [$F(1,14) = 11.75$] and a significant main effect of Sessions, [$F(6,84) = 5.39$], but no significant Interaction. Group BK10 spent more time on the platform than Group RD10 from the very first session and throughout training 1. In Group RD10, time spent on the platform on the first day of training was slightly above that of the last day of baseline and increased on the second day of training. However, on the third day, time spent on the platform went down and remained at a much lower level than that of Group BK10.

As shown in Figure 5, performance of the three experimental groups was compared after 7 backward trials representing the total number of sessions in training 1 for Group BK1. Group BK10 spent significantly more time on the platform following 7 backward trials presented within a session than Group BK1 following the same number of trials but presented one per session. A 3(Groups) x 7(Sessions) analysis of variance revealed a significant main effect of Groups,

[$F(2,21) = 4.87$], a significant main effect of Sessions, [$F(6,126) = 9.03$], and a significant Interaction, [$F(12,126) = 3.63$]. Group comparisons indicated that Group BK10 spent significantly more time on the platform than Group BK1 on trials 4, 5, and 7. Group BK10 also spent significantly more time on the platform than Group BK5 on trial 6 but this tendency was not maintained and the two groups spent a comparable amount of time on the platform on trial 7.

As shown in Figure 6, performance of Group BK5 and Group BK10 was also compared after exposure to 30 backward trials representing 6 sessions for Group BK5 and 3 sessions for Group BK10. Group BK10 spent significantly more time on the platform than Group BK5. A 2(Groups) x 3(Sessions) analysis of variance revealed a significant main effect of Groups [$F(1,14) = 4.84$], and a significant main effect of Sessions, [$F(2,28) = 8.34$], but no significant Interaction. Group comparisons indicated that Group BK5 and Group BK10 differed only on the last block of 10 trials, that is, following exposure to 30 backward trials.

In summary, $APPR^-$ behavior was readily produced when 10 US-CS pairings a day were used, was produced more slowly with 5 pairings a day, but was not produced when there was only 1 pairing a day.

<u>Training 2</u>. As shown in Figure 2, time spent on the platform in Groups BK1 and RD1 was maintained at a level comparable to that of baseline during all of training 2. A 2(Groups) x 7(Sessions) analysis of variance indicated that there were no significant effects of Groups, Sessions or Interaction.

As shown in Figure 3, on Days 1, 2, and 3 of training

2, time spent on the platform in Group BK5 was comparable to that spent on the last day of training 1. On Day 4, performance decreased and this pattern was maintained during the remaining sessions (except for Day 7 where there was a slight increase). Performance of Group RD5 was maintained at an averaged baseline level throughout training 2. A 2(Groups) x 7(Sessions) analysis of variance revealed only a significant main effect of Sessions, [$\underline{F}(1,14) = 6.02$].

As shown in Figure 4, on Days 1 and 2 of training 2, Group BK10 maintained a level of performance comparable to that of the last day of training 1. On Day 3, time spent on the platform decreased and continued to decrease over the next three sessions, but slightly increased on the last day. Performance of Group RD10 on Day 1 was also comparable to that of the last day of training 1. However, performance declined steadily on the following sessions. From days 4 to 7, performance had returned to baseline levels. A 2(Groups) x 7(Sessions) analysis of variance revealed a significant main effect of Groups, [$\underline{F}(1,14) = 17.67$], and a significant main effect of Sessions, [$\underline{F}(6,84) = 8.34$], but no significant Interaction.

In summary, the forward procedure in training 2 produced $WDR^+$ behavior in all groups, and only Group BK10 showed strong resistance to develop such behavior.

# Discussion

Data from training 1 seemed to support Heth's (1976) contention that a few backward pairings will result in the CS acquiring excitatory properties. Exposure to repeated pairings generates inhibition. Group BK1 acquired $WDR^+$ behavior: On Day 4, this group spent significantly <u>less</u> time on the platform than its control group, Group RD1. This difference, however, was not maintained in subsequent sessions, due to the fact that time spent on the platform increased in Group BK1. Group BK5 acquired $APPR^-$ behavior: but a significant difference was not obtained between that group and its control group, Group RD5, until the third session of conditioning. Group BK10 showed rapid acquisition of $APPR^-$ behavior as indicated by a high level of time spent on the platform from the very first session of conditioning. This level was maintained throughout training 1.

While the results indicate that the number of pairings is a variable which affects acquisition of $APPR^-$ behavior, the number of pairings per session seem to be a variable which affects the rate of acquisition of $APPR^-$ behavior. As indicated by the analyses which compared the performance of the experimental groups in training 1, 7 backward trials presented in one session would produce $APPR^-$ behavior whereas 7 backward trials presented one a day would result in $WDR^+$ behavior. Moreover, 30 backward trials presented 10 a day would produce significantly more $APPR^-$ behavior than 30 backward trials presented 5 a day.

Some studies (Kaplan, 1984; Ewing, Larew & Wagner, 1985) have examined the effects of manipulations of ITI duration on sign-tracking behavior in an appetitive context using trace conditioning procedures. Kaplan (1984), for example, exposed five groups of pigeons to a 12 sec CS (green key light) followed after a 12 sec gap by a 3 sec access to grain. The five groups differed in the duration of the ITI which averaged 15, 30, 60, 120, or 240 sec. Kaplan reported that an approach behavior was acquired with ITI averaging more than 60 sec while a withdrawal behavior was acquired with ITI averaging less than 60 sec. Kaplan concluded that, in a trace conditioning procedure, when the ISI (gap between the CS and US) is held constant, the CS can acquire inhibitory or excitatory values depending on the duration of the ITI.

The effect of massed versus spaced trials was also studied by Ewing, Larew and Wagner (1985) using a conditioned emotional response. In Experiment 1, rats were exposed in training to two CSs, one CS (CS1) preceded by a short ITI (60 sec), the other CS (CS2) preceded by a long ITI (600 sec). Testing sessions consisted in presenting each of the two CSs, unreinforced, while the subjects were bar pressing for food. Suppression ratios indicated significantly more suppression to CS2 than to CS1. The authors concluded that short ITIs can result in a decrease in conditioned excitation and also suggest involvement of inhibitory backward conditioning.

Perhaps in a parallel fashion, in an aversive context, massed trials in a trace conditioning procedure would produce conditioned inhibition while spaced trials would produce conditioned excitation. In our backward conditioning procedure, 10 trials per session may have had a comparable effect to massed trials, that is, contributed to inhibitory conditioning while 1 and 5 trials per session may have had a comparable effect to spaced trials, that is, contributed to excitatory conditioning. This effect might explain, in part, why 30 backward trials produce more conditioned inhibition in Group BK10 (exposed to 10 trials per session) than in Group BK5 (exposed to 5 trials per session).

Another possible way to explain our results would be to look at the effect that 10 trials per session as compared to 5 and 1 trials per session may have had on contextual conditioning. Baker, Singh and Bindra (1985) suggested that the growth of conditioned inhibition to a CS is mediated by the development of strong excitation to the context. According to the same authors, the context would have acquired strong excitatory properties in our backward procedure because it was the only cue signaling the US.

Baker et al. reported on several manipulations that modified contextual conditioning but not on the number of trials per session. It seems logical to assume however that 10 trials per session would produce more excitatory contextual conditioning and therefore more conditioned inhibition to the CS than 5 and 1 trials per session.

The data from training 2 (retardation-of-acquisition test) showed that time spent on the platform in Group BK1 was comparable to that of its control group, Group RD1, that is, Group BK1 continued to display $WDR^{+}$ behavior. Performance of subjects in Group BK1 indicated that learning the signaling value of the CS in the forward conditioning procedure (training 2) was not retarded by previous conditioning in training 1. This suggests that although the sequence of events during training 1 and 2 was different, the CS retained the same associative value, conditioned excitation, in the two phases.

Group BK5, when compared to its control group, Group RD5, showed some resistance to the acquisition of $WDR^{+}$ behavior. However, there were no significant differences between the two groups which might indicate that, while 5 daily backward pairings are sufficient for $APPR^{-}$ behavior to develop, it might not be sufficient for the CS to acquire inhibitory properties.

Group BK10 showed significantly more resistance to acquire $WDR^+$ behavior than its control group, Group RD10. Such performance would indicate that the CS acquired inhibitory properties in training 1.

Altogether, the present results indicated that 1 daily backward presentation produces $WDR^+$ behavior while 5 and 10 daily backward presentations produce $APPR^-$ behavior. However, 10 daily backward presentations would be required for the CS to acquire inhibitory properties.

# Chapter 5

## Experiment 3

## THE EFFECTS OF ITI DURATION ON THE DEVELOPMENT AND PERSISTENCE OF APPR$^-$ BEHAVIOR IN BACKWARD CONDITIONING

The results obtained in Experiment 2 would suggest that the number of pairings is a determining factor in the development and persistence of APPR$^-$ behavior in backward conditioning. The CS acquires inhibitory associative value provided that there are repeated US-CS pairings. In an effort to further investigate the associative value of the CS in backward conditioning, the effect on the development and persistence of APPR$^-$ behavior of another variable, ITI duration, was studied.

Moscovitch and Lolordo (1968, Experiment 2) compared the effects of ITIs of long duration to the effects of ITIs of random durations on the associative value of the CS in backward conditioning. Two groups of dogs were exposed to backward pairings in which the ITIs averaged 2.5 min. In the first group, ITIs were 2, 2.5 or 3 min. In the second group, the CS was followed at any time from 0 sec to 15 min by the shock of the succeeding trial. Following backward conditioning, CS presentation during Sidman avoidance responding resulted in decreased rates in the first group but not in the second group. Moscovitch and Lolordo concluded that the CS in backward conditioning acquires inhibitory properties only if it reliably predicts a period of safety. When ITIs are of random duration, the CS is a poor predictor of safety and, therefore, does not acquire inhibitory properties. Conditioned inhibition in backward pairings would result from a forward association between the CS and a period of safety rather than between the CS and US termination.

In this experiment, two groups of rats were exposed to backward pairings (training) in which the ITIs averaged 3 min. The two groups differed from each other in that, in the first group, the minimum ITI was 2 min while in the second group, the minimum ITI was 10 sec. If, as suggested by Moscovitch and Lolordo (1968), long ITI durations make the CS a good predictor of safety resulting in conditioned inhibition, then the first group should rapidly develop $APPR^-$ behavior in training. Similarly, if random ITI durations make the CS a poor predictor of safety, then the second group should not develop $APPR^-$ behavior. Extinction testing followed training sessions in order to evaluate the persistence of $APPR^-$ behavior in the absence of shock.

# Method

## Subjects

The subjects were 16 naive adult male hooded rats. They had free access to food and water at all times in their home cages. They were maintained on a 12:12 light:dark cycle (lights on at 0700 h EST), and were run during the light cycle.

## Apparatus

The experimental setting and conditioning boxes were identical to the ones used in the previous experiments.

## Procedure

The procedure consisted of three phases: baseline, training and extinction.

Baseline. Subjects were exposed to ten 30-sec platform presentations per daily sessions. There were 5 baseline sessions and the intertrial intervals averaged 3 min, with a minimum ITI of 1 min and a maximum of 5 min.

Training. A roughly equal number of "high" and "low" responders (determined by performance during baseline sessions) were distributed in two groups (N=8) in which ITI durations averaged 3 min. However, the two groups differed in that, for the first group, Group BKav, the minimum ITI duration was 2 min and the maximum was 4 min, while for the second group, Group BKshlg, the ITI duration was 10 sec in five trials and 5 min in the remaining 5 trials. Short ITIs (10 sec) and long ITIs (5 min) were distributed randomly throughout each training session in Group BKshlg.

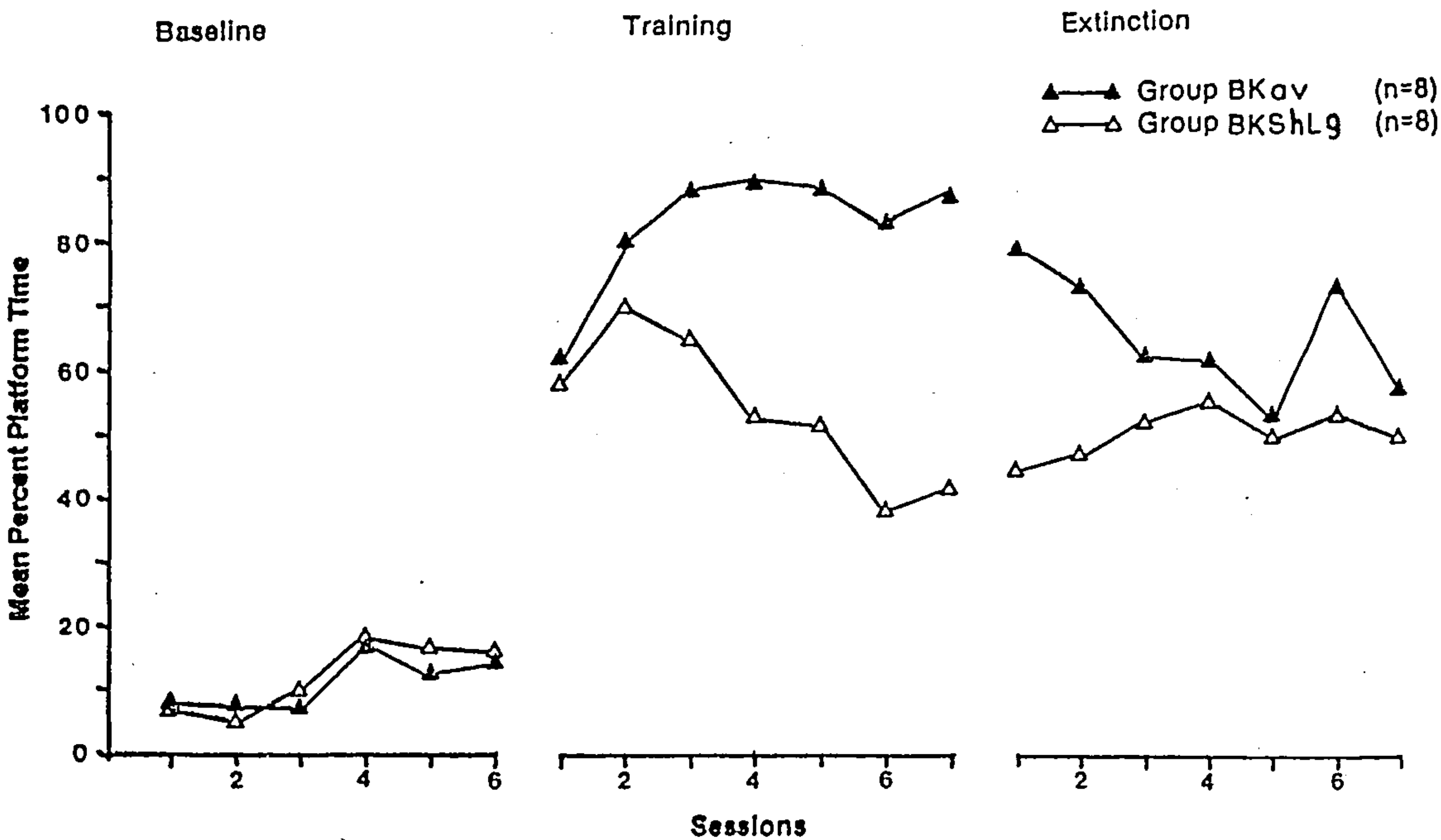
For each group, the US was a foot-shock (2 sec, 0.5 mA) and the CS was a 30-sec platform presentation. The first testing session started 24 hr after the last baseline session. Each daily training session lasted approximately 30 min and included 10 backward presentations of platform and shock. Training lasted 7 days.

Extinction. Twenty-four hr after the last training session, extinction testing began. Each daily session consisted of ten 30-sec platform presentations. There were 7 sessions of extinction trials. Shock was never presented in these sessions. The minimum ITI was 1 min and the maximum was 5 min, the average being 3 min.

## Results

Figure 7 shows the average time spent on the platform for each group during the three phases of the experiment (see Appendices 20 and 21 for data for each of the two

Figure 7. Mean percentage of total time spent on the platform for each group during each session of baseline, training and extinction in Experiment 3.



Baseline
Training
Extinction
Group BKav (n=8)
Group BKShLg (n=8)
Mean Percent Platform Time
100
80
60
40
20
0
2
4
6
2
4
6
2
4
6
Sessions

groups, and Appendix 22 for a summary of the statistical analyses made on the baseline, training and extinction data). A two-way analysis was performed on each phase of the experiment and a rejection level of .05 was used.

Baseline. A 2(Groups) x 6(Sessions) analysis of variance revealed a significant main effect of Sessions, [$F$(5,70) = 3.87], indicating an increase in time spent on the platform with repeated baseline sessions.

Training. On Days 1 and 2 of training, subjects in Groups BKav and BKshlg spent a comparable amount of time on the platform. However from Day 3, time spent on the platform continued to increase in Group BKav while it began to decrease in Group BKshlg. This pattern of behavior was maintained until the last day of training. A 2(Groups) x 7(Sessions) analysis of variance showed a significant main effect of Session, [$F$(6,84) = 2.22] and Interaction, [$F$(6,84) = 3.18]. Tests of simple main effects revealed that, on Days 4, 5, 6, and 7 (last day), Group BKav spent significantly more time on the platform than Group BKshlg.

Extinction. On the first extinction session, Group BKav spent less time on the platform than it had on the last day of training and this decline in performance was maintained for 5 consecutive sessions. On Day 6, performance went up but declined again on the next day (last session). Group BKshlg showed the opposite pattern of behavior. On the first extinction session, subjects spent more time on the platform, and a small but gradual increase was maintained until Day 4. On Days 5, 6, and 7, performance remained stable. However, the difference in performance between the two groups failed to reach statistical significance and therefore, the rate of extinction would have been similar. A 2(Groups) x 7(Sessions) analysis of variance did not indicate significant main effects of Groups, Sessions or Interaction.

## Discussion

The present data replicated Moscovitch and Lolordo's (1968) observations that ITI duration has an effect on what the subjects learn about US/CS relations. In Group BKav, the platform reliably signaled a period without shock and as a result, would have acquired inhibitory properties reflected by the development of $APPR^-$ behavior. In Group BKshlg, the platform did not reliably signal a period without shock and as a result, $APPR^-$ behavior did not develop in that group. There was, in Group BKshlg, a tendency to approach the platform early in training, but this may reflect the rats' natural tendency to jump and/or flee to a non-shock area when the US is a shock administered through a grid floor (Leclerc, 1985).

A closer look at individual performances of the subjects in each of the two groups revealed another difference between Groups BKav and BKshlg. All subjects in Group BKav gradually acquired APPR$^-$ behavior as training progressed. On the last day of training, time spent on the platform for all but one subject was over 70%. However, there was much variability in performance among subjects in Group BKshlg. On the last day of training, time spent on the platform for three subjects was over 70%, while time spent on the platform for four subjects was under 10%. Such variability among subjects might be an inevitable effect of the poor predicting value of the CS when ITIs are sometimes short and sometimes long.

The present results also support Moscovitch and Lolordo's (1968) contention that inhibition in backward conditioning results from a forward pairing between CS and a "safety period" rather than from backward pairings per se between the CS and US termination. This view implies that ITI duration would not have any effect on behavior if behavior resulted from the formation of an association between the CS and US termination. That APPR$^-$ behavior developed in Group BKav but not in Group BKshlg provide strong evidence that the CS in backward pairings acquires inhibitory properties only when it reliably predicts a safety period.

During extinction sessions, $APPR^-$ behavior in Group BKav decreased rather slowly when compared to Group BKshlg who stayed, more or less, at a performance level similar to what it was at the end of training. However, the results from extinction sessions failed to indicate a significant difference between the two groups perhaps partly because of variability in performance among subjects in Group BKshlg. For example, comparing performance of the first and last day (Day 7) of extinction in Group BKshlg revealed that time spent on the platform increased for four subjects and decreased for three subjects. The within group differences might account for the unexpected overall stability of Group BKshlg's performance in extinction. Moreover, group differences may have become apparent with more extinction sessions. Leclerc and Reberg (1980, Experiment 2), for example, observed that it took 16 extinction sessions for $APPR^-$ behavior to return to baseline level.

# Cnapter 6

## Experiment 4

## APPR$^{-}$ BEHAVIOR AND CONDITIONED SUPPRESSION FOLLOWING BACKWARD CONDITIONING

The results of Experiment 1 suggested that conditioned inhibition is a likely mechanism responsible for the development and persistence of APPR$^{-}$ behavior, and the results of Experiments 2 and 3 provided parametric information which specify the conditions under which the inhibitory associative value of the CS can develop in our particular backward conditioning procedure. In this last experiment, Experiment 4, an attempt was made to evaluate more directly the associative value of the CS using a test of conditioned suppression and a test of the CS-produced behavioral tendencies.

The experiment consisted of three basic phases similar to the ones used in the work previously presented: a baseline in which all subjects were exposed to non-reinforced presentations of the CS-platform; training 1 in which subjects received either forward, backward or random pairings of shock and platform; and training 2 in which all subjects received forward pairings of platform and shock. In addition to this general design, a conditioned suppression procedure (referred to as test 1) was included between training 1 and 2 and presented again after each session of training 2. Furthermore, a test of CS-produced behavioral tendencies (referred to as test 2) was made concurrently with suppression testing sessions. The animal's position in relation to the platform was monitored throughout this experiment (except in test 1), and provided independent information about the animal's behavioral tendencies during conditioning sessions. There were three main dependent variables: the suppression ratio (in test 1), time spent on the platform (in test 2), and the rat's position in the experimental box.

The predictions for test 1 were as follows: At the completion of conditioning sessions (in training 1), data should reveal that, in comparison with the group exposed to random pairings, the group previously exposed to forward platform-shock conditioning will show suppression of the licking response, while the group previously exposed to backward training will show little suppression in responding. Also, after each session of training 2 (forward platform-shock pairings), data should reveal that, in comparison with the group exposed to random training, the rate of the licking response will continue to be suppressed in the forward group but this $CS^+$ suppression effect should be retarded in the group previously exposed to backward training.

The predictions for test 2 were as follows: After training 1, data should reveal that, in comparison with the group exposed to random training, subjects in the group exposed to forward training will spend little time on the platform while subjects in the group exposed to backward training will spend increasing time on the platform. After each session of training 2, data should reveal that in comparison with the group exposed to random training, subjects in the group exposed to forward training will continue to spend little time on the platform while the group exposed to backward training will show a gradual decrease in time on the platform.

The predictions for the behavioral observations were as follows: In training 1, data should reveal that, in comparison to the group exposed to random training, subjects in the groups exposed to forward training will show a gradual tendency to withdraw from the platform while subjects in the group exposed to backward training will show a gradual tendency to approach the platform. In training 2, data should reveal that, in comparison with the group exposed to random training, subjects in the group exposed to forward conditioning will show a tendency to withdraw from the platform. Subjects exposed to backward conditioning should gradually acquire the tendency to withdraw from the platform.

# Method

## Subjects

The subjects were 24 naive adult male hooded rats. They had free access to food at all times in their home cages. However, access to water was prohibited 24 hr prior to sessions of test 1 (test of the licking response) at which time the animals would be given free access to water for 30 min daily following the testing session.

## Apparatus

The experimental boxes used were the same as described in the previous experiments except for two modifications. The first modification consisted of installing in each box a transparent Plexiglas barrier to cover the platform wall. The barrier prevented the animals from making contact and/or jumping on the platform while allowing them to see and hear the platform opening and closing (see Leclerc, 1985, for a description of a similar experimental setting). The barrier was used throughout the experiment except during testing sessions of the APPR$^-$ behavior (test 2). The second modification consisted of inserting in each chamber a stainless-steel drinking tube which protruded about five cm inside the chamber on the wall facing the platform. Water bottles were attached to the outside walls of the chamber by means of coiled wires. A stainless-steel plate measuring 14 x 20 cm was placed on the grid floor to provide for a complete circuit when the rat was in contact with the drinking tube. The plate and the tube were connected to a drinkometer circuit. Each .5 sec period during which the rat made contact with the drinking tube was programmed to be recorded as a single count.

The drinking tube modifications were made to the experimental chambers for all testing sessions of the licking response (test 1). During training sessions and testing sessions of the $APPR^-$ behavior (test 2), the drinking tube and associated apparatus were removed from the chambers.

Timing and delivery of all stimuli presentations as well as the recording of time spent on the platform was done in the same fashion as described in Experiment 1. Rats were run four at a time in four separate chambers.

Procedure

Table 2 shows the different phases in the procedure. There were three basic phases: baseline, training 1, and training 2. In addition, a conditioned suppression procedure (test 1) and a test of CS-produced behavioral tendencies (test 2) were made after training 1 and after each session of training 2.

Table 2. Summary of the different phases and of the procedure for each of the two experimental groups and the control group in Experiment 4.

| Phase | Group | CS | CS+ | CS- | US |
|---|---|---|---|---|---|
| | | Stimulus | | | |
| Baseline Step 1 | all groups | tube | - | - | - |
| Baseline Step 2 | | pl | - | - | - |
| Baseline Step 3 | | tube+pl+ Plexi | - | - | - |
| Training 1 | BK | - | none | pl+Plexi | shock |
| | FD | - | pl+Plexi | none | shock |
| | RD | pl+Plexi | none | none | shock |
| Test 1 | all groups | tube + pl + Plexiglas | | | none |
| Test 2 | all groups | platform only | | | none |
| Return session | all groups | same as Training 1 | | | shock |
| Training 2 | BK | - | pl+Plexi | - | shock |
| | FD | - | pl+Plexi | - | shock |
| | RD | - | pl+Plexi | - | shock |
| Test 1a | all groups | tube + pl + Plexiglas | | | none |
| Test 2b | all groups | platform only | | | none |

*Note.* Dash = not applicable. Pl = platform; Plexi = Plexiglas.

a Test 1 was administered after each day of Training 2.

b Test 2 was administered after each day of Training 2.

Baseline. Baseline sessions were divided into three steps: the first step consisted of habituation training with the drinking tube; the second step consisted of exposure to non-reinforced platform presentations; the third step consisted of non-reinforced platform presentation with the Plexiglas barrier and the drinking tube being presented in order to assess possible effects of platform presentations per se on the licking response. All subjects were exposed to the three steps which lasted for a total of 8 days. Prior to all sessions involving the licking response, subjects were deprived of water for twenty-four hr and were provided access to water in their home cages for 30 min following each session. The following section is a more detailed description of each step.

Step 1: Water deprived subjects were placed in the experimental chambers for 30 min periods where they could drink freely from the tube protruding from the wall inside the chamber. Each .5 sec contact made with the drinking tube was registered as one count. The total number of counts representing the total drinking time of each subject was registered automatically. There were two sessions in step one and all subjects were drinking from the tube by the end of the second session. No CS or US were presented during those two sessions.

Step 2: Drinking tubes were removed from the conditioning boxes. Subjects were exposed to ten 30-sec platform presentations. Time between platform presentations averaged 3 min. Baseline for time spent on the platform lasted for three daily sessions.

<u>Step 3</u>: Following the last session of step 2, animals were again deprived of water. Twenty-four hr later, drinking tubes were reinserted in the chambers, Plexiglas barriers were installed (to prevent animals from jumping on the platform) and subjects were placed in the chambers. Total drinking time for each rat was registered automatically as in phase 1. Ten sec of licking with no pauses of more than 2 sec resulted in an automatic 10-sec presentation of the platform. Minimum duration for each trial was 20 sec and the session ended when the rat had been exposed to 5 platforms (see Coulombe & White, 1982 for a similar suppression procedure). The measure used was Kamin's suppression ratio (Annau & Kamin, 1961) which is calculated by using the total number of counts registered 10 sec prior to each platform presentation and during each platform presentation (total number of counts during platform presentations divided by the total number of counts prior to platform openings and during platform presentations). A ratio near .0 would indicate that the platform CS decreased the rate of the licking response while a ratio near .5 would indicate that the platform CS had no effect on the licking response.

Training 1. Before the first training session, subjects were distributed in three groups (N=8), BK, FD or RD. Two criteria of performance were taken into consideration for distribution: average time spent on the platform (step 2 of baseline) and the average suppression ratio (step 3 of baseline). As was done in previous experiments (see Experiment 1 for details), a roughly equal number of "high" and "low" platform responders were distributed in each of the three groups. Care was taken to distribute in each group a roughly equal number of subjects whose drinking behavior was suppressed by platform presentations. (It is important to note here that by the third session of phase three, the licking behavior of only two subjects seemed to be slightly suppressed when the platform was presented).

For all three groups, training 1 started 24 hr after the completion of the baseline phase. The CS, here, was a 30-sec platform presentation with the Plexiglas barrier positioned to prevent the jump-up response. The US was a 2 sec electric foot-shock (0.5 mA). Training 1 lasted four consecutive days (see Leclerc, 1985, for a similar experimental paradigm).

The first group, Group BK, was exposed to a backward conditioning procedure consisting of 10 presentations of the shock-US, each followed, 10 sec later, by a 30-sec presentation of the CS-platform. The second group, Group FD, was exposed to a forward conditioning procedure consisting of ten 30-sec platform presentations each followed, 10 sec later, by the shock-US. For both groups, Group BK and FD, the minimum intertrial interval was 60 sec and the maximum 300 sec, for an average of 3 min. The third group, Group RD, was exposed to a truly random procedure. Each session consisted of two backward trials, two forward trials and 6 random presentations of platform and shock. Backward trials, forward trials and presentations of platform and shock were distributed randomly during each session (for the rational and details about this procedure, refer to Experiment 2). The ITIs ranged from a minimum of 60 sec to a maximum of 180 sec.

Test 1 (measurement of the licking response in a conditioned suppression procedure). Following the last session of training 1, all animals were deprived of water for 24 hr. The following modifications (described in the section on apparatus) were made to each experimental chamber: a stainless-steel drinking tube was inserted in the wall, a stainless-steel plate was placed on the grid floor, and the Plexiglas barrier was installed.

For all groups, (BK, FD and RD), test 1 consisted of 10-sec platform presentations triggered automatically when a rat licked continuously for 10 sec (the procedure has been described in details in step 3 of Baseline). The session ended when the rat had been exposed to 5 platform presentations. The dependent variable was the number of .5 sec contacts with the drinking tube. It should be noted that no shock was administered in test 1.

Test 2 (measurement of time spent on the platform in an extinction procedure). Immediately following test 1, all animals were provided with water in their home cages. The following day, the drinking tube, stainless-steel plate and Plexiglas barrier were removed from each chamber. Test 2 consisted of ten 30-sec platform presentations, with a minimum of 60 sec and maximum of 300 sec (average time of 3 min) between presentations. No shock-US was presented during the testing session. The dependent variable was time spent on the platform when it was accessible to the subjects.

Return to training 1 conditions. Following the two days of testing (test 1 and test 2), Groups BK, FD, and RD were exposed, for one session, to the same conditioning procedures as during training 1: Group BK was exposed to a backward conditioning procedure; Group FD was exposed to a forward conditioning procedure; Group RD was exposed to a truly random conditioning procedure. This session was included to ensure that time was not a variable affecting the possible retardation effect in training 2.

Training 2 (Retardation-of-acquisition test): Forward conditioning. Twenty-four hr following the "return to training 1" session, Groups BK, FD, and RD were exposed to a forward conditioning procedure consisting of ten 30-sec platform presentations followed, 10 sec later, by a shock-US. As in training 1, jumping on the platform was prevented by a Plexiglas barrier. Twenty-four hr following each session of training 2, test 1 was administered; twenty-four hr following test 1, test 2 was administered (the procedures used in tests 1 and 2 were described previously). There were a total of 4 sessions of training 2 as well as 4 sessions of each test, tests 1 and 2. Tests 1 and 2 were administered after each training session rather than following the four days of training in order to evaluate the development of $WDR^+$ behavior in each group.

Tests 1 and 2 were administered on alternating days for each group in order to counterbalance for a possible effect of test order. For example, 24 hr following the first session of training 2, Group BK was exposed to test 1 and the following day (48 hr following the first session of training 2), to test 2. Then, 24 hr following the second session of training 2, Group BK was exposed to test 2 and the next day (48 hr following the second session of training 2), to test 1.

Behavior observations and recording. During all phases of the experiment (except in test 1), an observer recorded manually the rats' positions in the experimental chambers. The Plexiglas wall of the experimental chamber that was facing the observer was divided vertically in three equal sections by means of narrow strips of masking tape. Position 0 was "on" the platform, position 1 was "near" the platform, position 2 was "middle", and position 3 "far" from the platform. The tip of the rat's nose defined the position of the animal in relation to its proximity to the platform.

During training 1, training 2 and test 2, a tape recorder was turned on with every platform opening. A "beep" on the recorder indicated to the observer the specific time to record the position of the rat in the chamber. The rats were run four at a time but two rats only were observed on a trial. The position of the first rat was recorded 2 sec and 10 sec after platform opening; the position of the second rat was recorded 20 sec and 28 sec following platform opening. At the next trial, the position of the two other rats were recorded in the same manner. The positions of each rat were recorded for a total of 10 times per session (twice per trial every second trial). During four nonconsecutive sessions, a second observer also recorded the subjects' positions in the chambers. The observations of the two observers were then compared and reliability indexes were calculated.

# Results

Data are presented according to the three main dependent variables: the suppression ratios, the time spent on the platform and the rats' positions on the grid floor in relation to the platform. Table 3 presents a summary indicating where data analyses on each of the dependent variables revealed significant and nonsignificant differences among groups.

## 1. Suppression ratios (test 1).

Figure 8 shows the mean suppression ratio obtained on the last day of baseline, in the testing session following 4 days of training 1, and in each of the four testing sessions following 1, 2, 3, and 4 days of training 2 (see Appendix 23 for data for each of the three groups, and Appendix 24 for a summary of the statistical analysis). A 3(Groups) x 6(Sessions) analysis of variance was used to analyse the results and Tukey's ratios (Kirk, 1968) were used to make group comparisons when appropriate. A rejection level of .05 was used for all analyses.

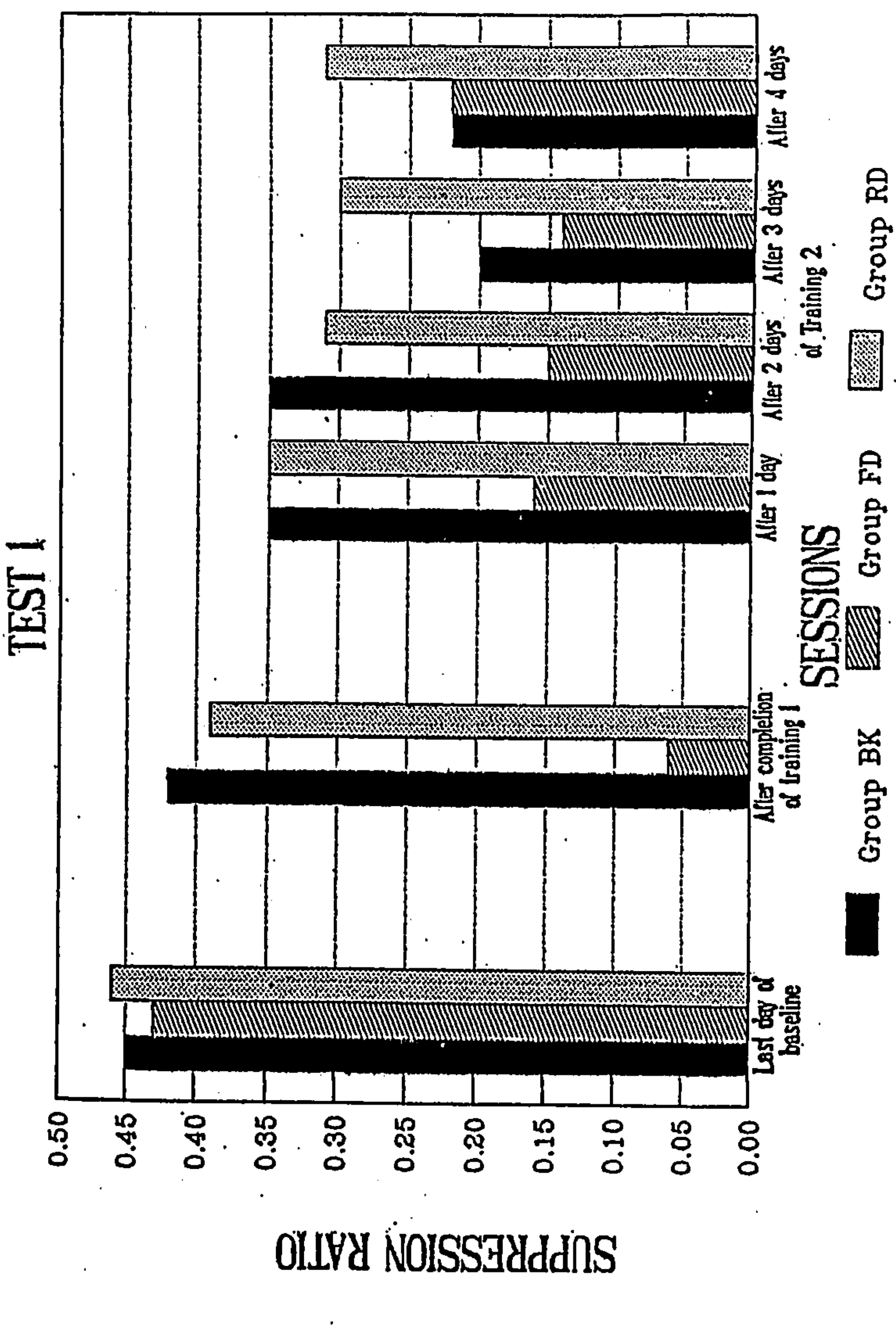
On the last day of baseline, presentation of the platform had little effect on behavior: Rats in all groups spent as much time licking the tube during platform presentations as they did prior to platform presentations. In the testing session after completion of training 1,

Table 3. Summary indicating where statistical analyses revealed significant and nonsignificant results for each of the three dependent variables in Experiment 4.

| Phase | | Test 1 | Test 2 | Position |
|---|---|---|---|---|
| Baseline | Step 2 | - | NS | NS |
| | Step 3 | NS | - | - |
| Training 1 - after completion | | S | NS | NS |
| Training 2 - after 1 day | | S | NS | NS |
| | 2 days | S | NS | NS |
| | 3 days | NS | NS | NS |
| | 4 days | NS | NS | NS |

Note. Analyses were not applicable.

Figure 8. Mean suppression ratio for each group on the last day of baseline, in test 1 after completion of training 1 and in each of the testing session after 1, 2, 3, and 4 days of training 2 in Experiment 4.

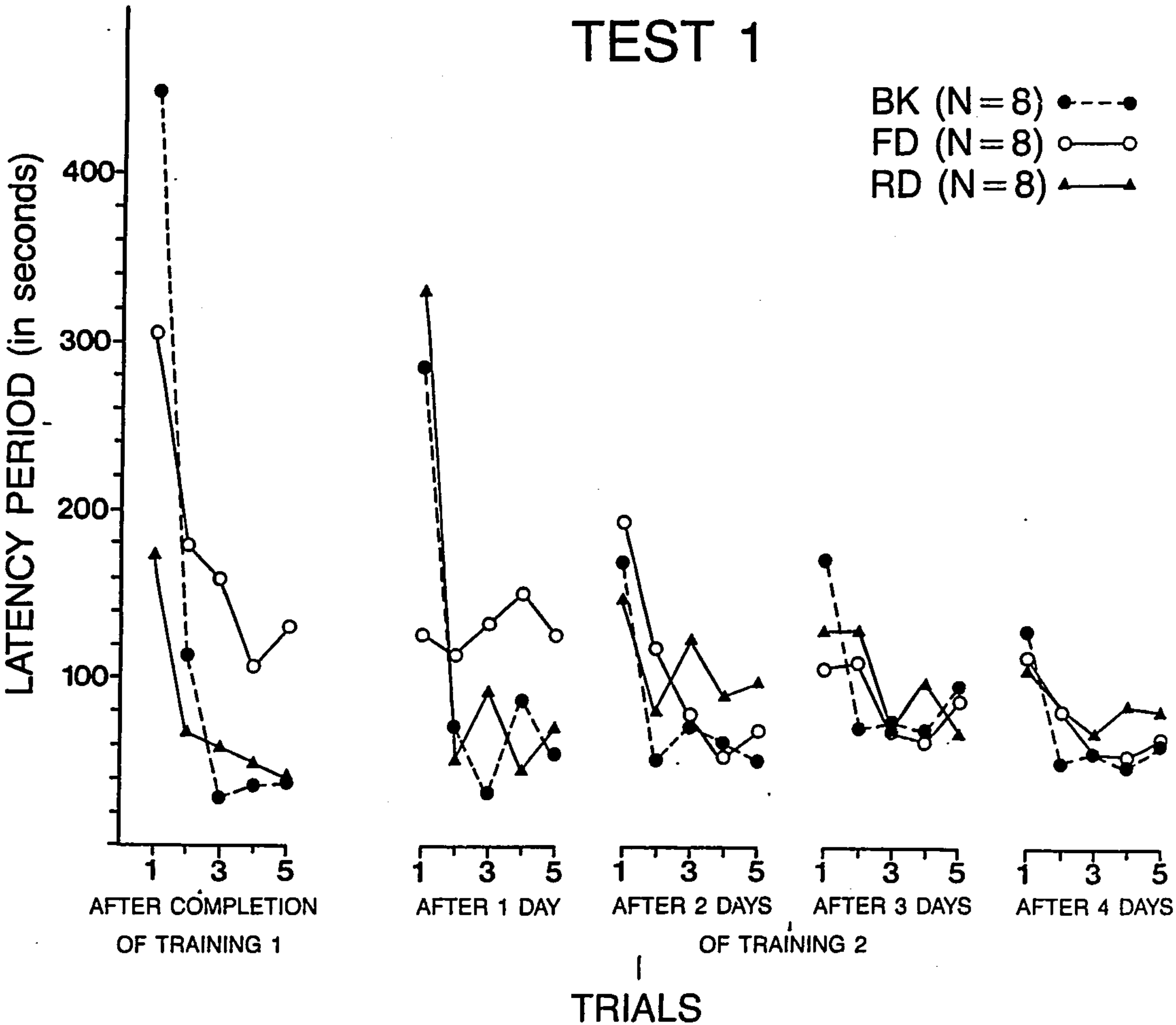

TEST 1
SUPPRESSION RATIO
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Last day of baseline
After completion of training 1
After 1 day
After 2 days
After 3 days
After 4 days
of Training 2
SESSIONS
Group BK
Group FD
Group RD

presentations of the platform suppressed the licking response in Group FD but not in Groups BK and RD. In the testing sessions after each day of training 2, presentations of the platform seemed to lose some of its suppressing effect in Group FD. However, for the first two testing sessions (training 2), the licking response continued to be significantly more suppressed in that group than in Groups BK and RD. By the third and fourth (last) testing sessions, platform presentations was suppressing the licking response at comparable rates in all groups. A 3(Groups) x 6(Sessions) analysis of variance indicated a significant main effect of Groups, [$F(2,21) = 8.69$], of Sessions, [$F(5,10) = 16.74$], and of interaction, [$F(10,105) = 4.04$].

<u>Post-hoc data analyses of the first latency period (time delay between the onset of the trial and the first platform presentation) and the latency periods between each subsequent platform presentations.</u>

Further analyses were done in suppression testing session in an attempt to investigate the possible effect of contextual control in each of the groups. Figure 9 shows the time to the first platform presentation following the rat's entry in the box (first latency period) and the latency periods between subsequent platform presentations in the suppression testing session following 4 days of

Figure 9. Mean total time (in seconds) for the first latency period and subsequent latency periods for each group in test 1 after completion of training 1 and in each of the testing sessions after 1, 2, 3, and 4 days of training 2 in Experiment 4.


TEST 1
BK (N=8)
FD (N=8)
RD (N=8)
LATENCY PERIOD (in seconds)
400
300
200
100
1
3
5
AFTER COMPLETION OF TRAINING 1
AFTER 1 DAY
AFTER 2 DAYS
AFTER 3 DAYS
AFTER 4 DAYS
OF TRAINING 2
TRIALS

training 1, and in each of the four testing sessions following 1, 2, 3, and 4 days of training 2 (see Appendices 25 to 29 for data for the testing session after completion of training 1 and for each testing session following 1, 2, 3, and 4 days of training 2; see Appendices 30 to 34 for a summary of the statistical analyses made on the testing session after completion of training 1 and on each testing session following 1, 2, 3, and 4 days of training 2 data). The results of each testing session were analysed using a 3(Groups) x 5 (Trials) (trials were substituted for sessions) analysis of variance, followed, when appropriate, by comparisons using Tukey's ratio. The rejection level used was .05.

After completion of training 1. The first latency period was significantly longer in Group BK than in Group RD. Moreover, the latency periods between subsequent platform presentations decreased significantly in Group BK and FD but not in Group RD. A 3(Groups) x 5(Trials) analysis of variance revealed a significant main effect of Groups, [$F(2,4) = 8.34$], a significant main effect of Trials, [$F(4,84) = 20.48$], and a significant Interaction, [$F(8,84) = 2.94$] .

Training 2.

After 1 day of training 2. The first latency period was significantly longer than the latency periods between subsequent platform presentations in both Groups BK and RD but not in Group FD. A 3(Groups) x 5(Trials) analysis of variance revealed a significant main effect of Trials, [$F(4, 84) = 7.13$], and a significant Interaction, [$F(8,84) = 2.27$].

<u>After 2 days of training 2</u>. The first latency period was significantly longer than the latency periods between subsequent platform presentations in all groups (Groups BK, FD and RD). A 3(Groups) x 5(Trials) analysis of variance revealed a significant main effect of Trials, [$F(4,84) = 10.48$].

<u>After 3 days of training 2</u>. The first latency period was significantly longer than the third and fourth latency periods only (time between the second and third platform presentation and between the third and fourth platform presentation) in all groups (Groups BK, FD and RD). A 3(Groups) x 5(Trials) analysis of variance revealed a significant main effect of Trials, [$F(4,84) = 3.22$].

<u>After 4 days of training 2</u>. The first latency period was significantly longer than the latency periods between subsequent platform presentations in all groups (Groups BK, FD and RD). A 3(Groups) x 5(Trials) analysis of variance revealed a significant main effect of Trials, [$F(4,84) = 4.40$].

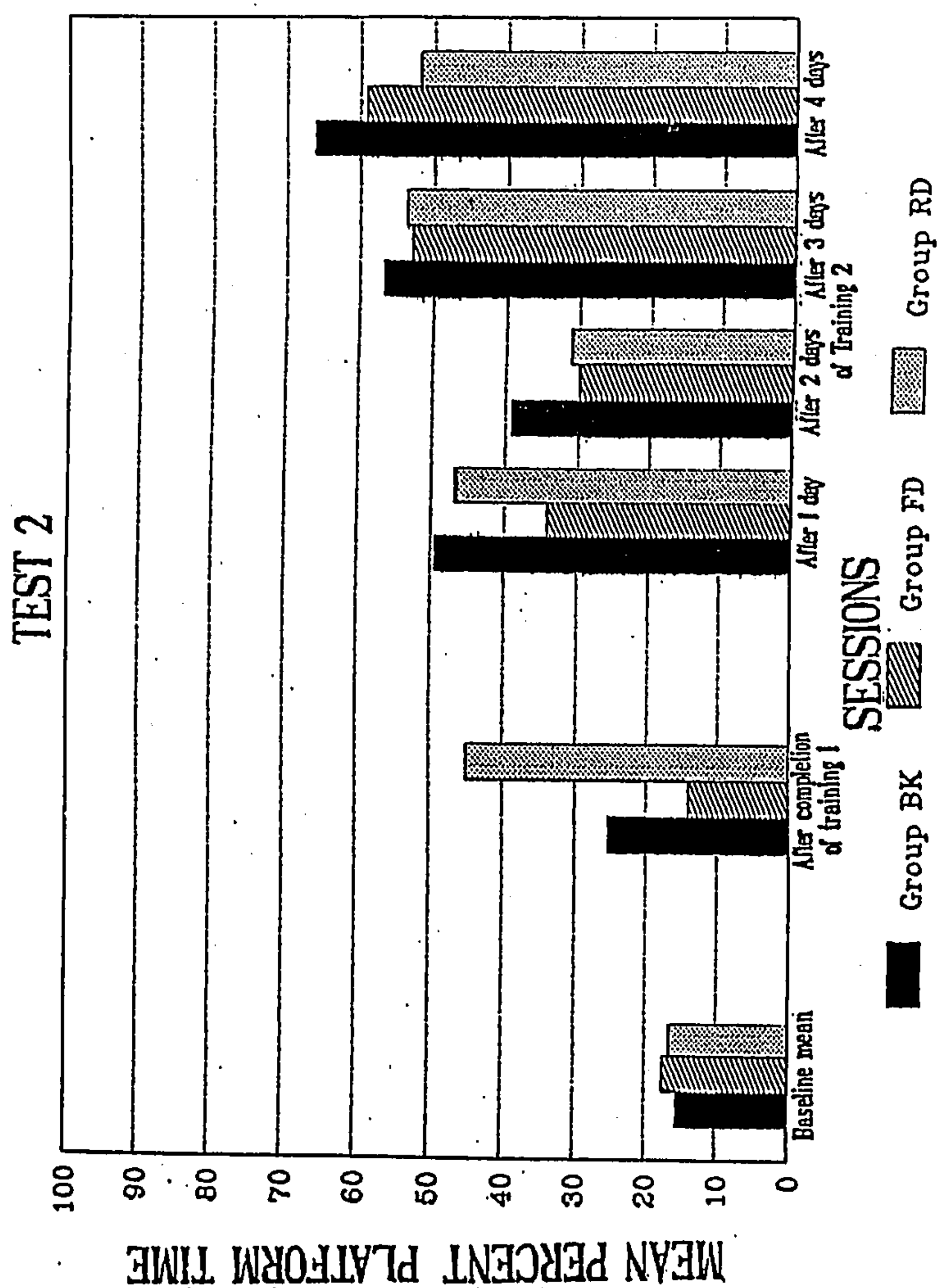
In summary, after each of the four days of training 2, the first latency period was longer than subsequent latency periods in all groups except after the first day of training 2 where this effect was not observed in Group FD.

2. Time spent on the platform (test 2).

Figure 10 shows the mean percentage of total time spent on the platform for each group in baseline, in testing sessions following 4 days of training 1 (there were no data collected during training 1 sessions since the jump-up response was prevented), and in each of the four testing sessions following 1, 2, 3, and 4 days of training 2 (see Appendix 35 for data for each of the three groups, and Appendix 36 for a summary of the statistical analysis. The results were analysed using a 3(Groups) x 6(Sessions) analysis of variance followed, when appropriate, by Tukey's ratios. A rejection level of .05 was used.

During the last day of baseline, all subjects spent very little time on the platform. In the testing session following completion of training 1, all subjects continued to spend little time on the platform. In the testing sessions of training 2, all subjects spent more time on the platform with repeated sessions. For the two last testing sessions (after 3 days and after 4 days of training 2), all subjects spent significantly more time on the platform than in the testing session following completion of training 1. A 3(Groups) x 6(Sessions) analysis of variance indicated a significant main effect of Sessions only, [$F(3,10) = 15.25$].

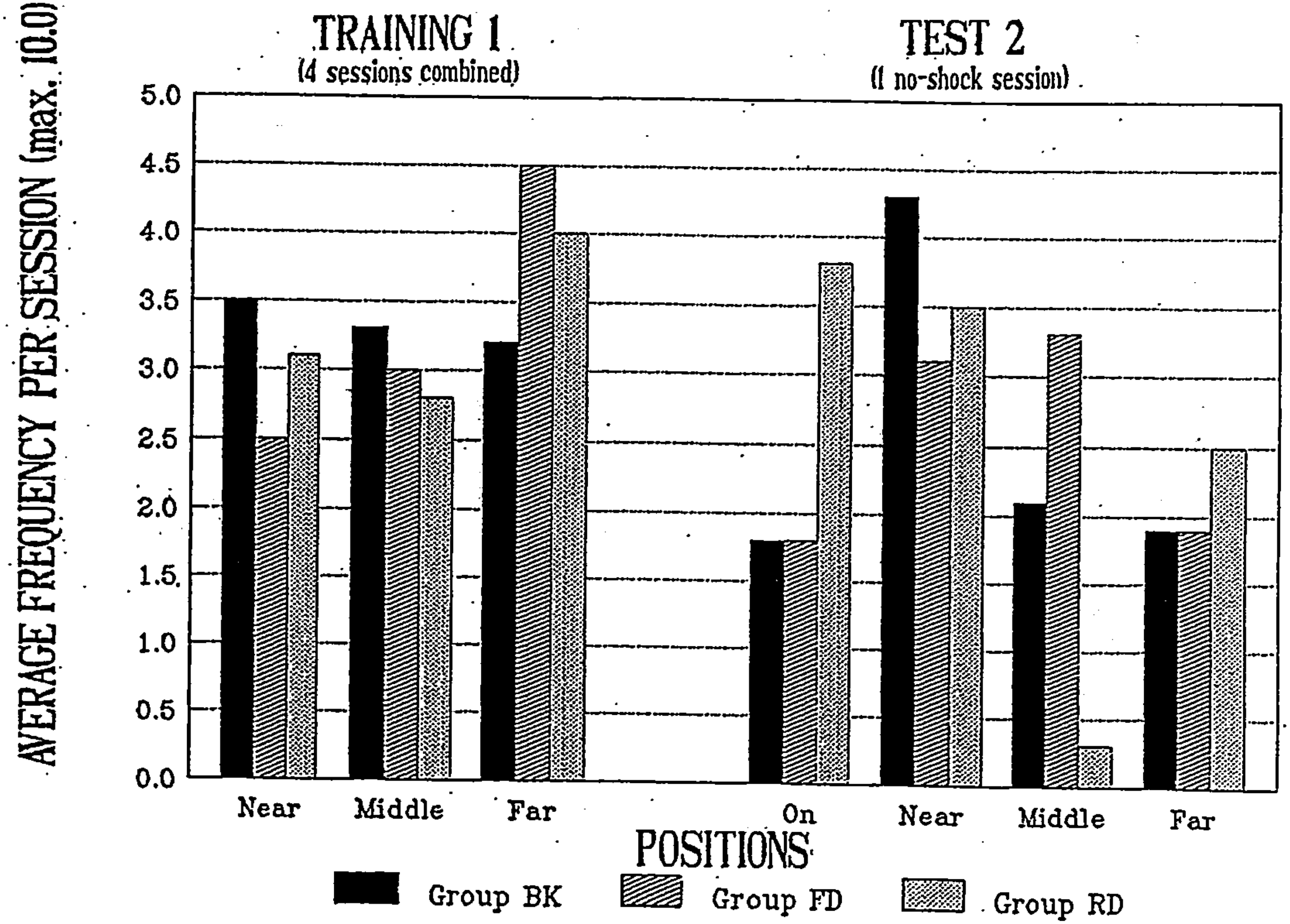
Figure 10. Mean percentage of total time spent on the platform for each group during baseline, test 2 after completion of training 1 and test 2 after 1, 2, 3, and 4 days of training 2 in Experiment 4.


TEST 2
MEAN PERCENT PLATFORM TIME
100
90
80
70
60
50
40
30
20
10
0
Baseline mean
After completion of training 1
After 1 day
After 2 days
After 3 days of Training 2
After 4 days
SESSIONS
Group BK
Group FD
Group RD

3. Behavioral observations.

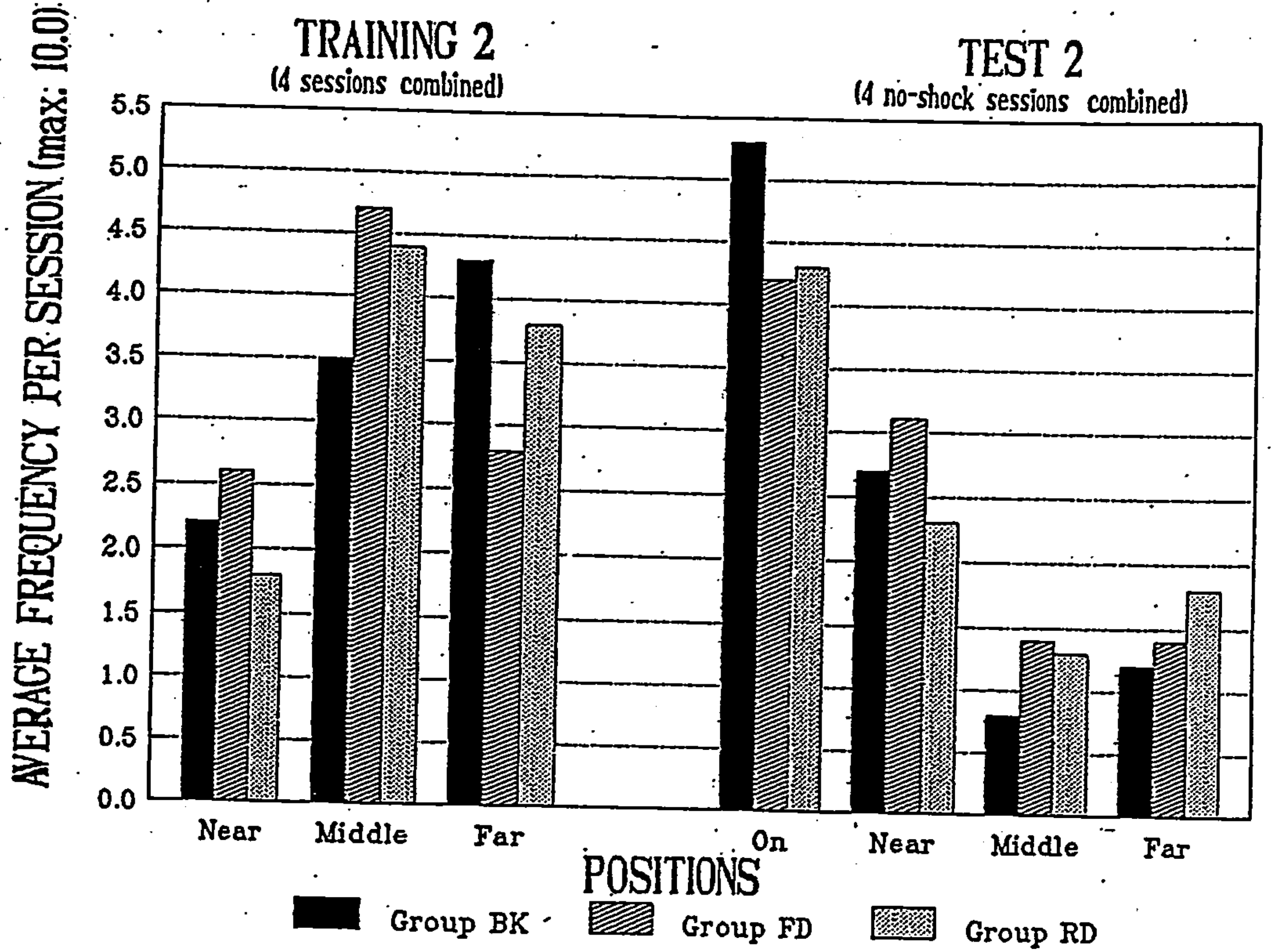
Figure 11 shows the average frequencies in positions 1, 2, and 3 for each group during training 1 (4 days collapsed) and the average frequencies in positions 0, 1, 2, and 3 for each group during test 1 after completion of training 1 (see Appendix 37 for data for each group). Figure 12 shows the average frequencies in positions 1, 2, and 3 for each group during training 2 (4 days collapsed) and the average frequencies in positions 0, 1, 2, and 3 for each group during test 2 after each day of training 2 (4 days collapsed; see Appendix 38 for data for each group). For each rat, the total number of observations for each position was transformed into a single score using Dual Scaling (Nishisato, 1980), (see Appendices 39 and 40 for the transformed unweighted scores for each group for training 1, test 2 after completion of training 1, training 2, and test 2 following each day of training 2). This method not only allows the transformation of a discrete variable to a continuous variable but each score indicates, on a scale, a rat's preference for a particular position compared to the general tendency of the group (D. Coulombe, personal communication, April 1988). A 3(Groups) x 1(Session) analysis of variance was performed on the unweighted scores obtained with the Dual Scaling method for each phase of the experiment (training 1 and 2), for test 2 after completion of training 1 and test 2 in training 2 (4

Figure 11. Average frequency in position 1 (near), 2 (middle), and 3 (far) for each group during the four days of training 1, and average frequency in position 0 (on), 1 (near), 2 (middle), and 3 (far) for each group during test 2 after completion of training 1 in Experiment 4.



TRAINING 1
(4 sessions combined)
TEST 2
(1 no-shock session)
AVERAGE FREQUENCY PER SESSION (max. 10.0)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Near
Middle
Far
On
Near
Middle
Far
POSITIONS
Group BK
Group FD
Group RD

Figure 12. Average frequency in position 1 (near), 2 (middle), and 3 (near) for each group during the four days of training 2, and average frequency in position 0 (on), 1 (near), 2 (middle), and 3 (far) for each group during test 2 after each day of training 2 in Experiment 4.



TRAINING 2
(4 sessions combined)
TEST 2
(4 no-shock sessions combined)
AVERAGE FREQUENCY PER SESSION (max: 10.0)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Near
Middle
Far
On
Near
Middle
Far
POSITIONS
Group BK
Group FD
Group RD

days collapsed; see Appendix 41 for a summary of the statistical analyses made on training 1, on the testing session after completion of training 1, and on the testing sessions after each day of training 2 data).

A reliability index was calculated for each rat's position data. This was based on 40 trials (four nonconsecutive sessions of 10 trials). Reliability indexes varied from 94% to 100%.

Training 1. The rats in all groups showed no preference for either position 1, 2, or 3. A 3(Groups) x 1(Session) analysis of variance did not indicate a significant difference among groups.

Test 2 (after completion of training 1). The rats in all groups showed a tendency to spend more time in positions 0 (on) and 1 (near) than in positions 2 and 3. A 3(Groups) x 1(Session) analysis of variance did not indicate a significant difference among groups.

Training 2 (forward conditioning). The rats in all groups showed a preference for positions 2 (middle) and 3 (far). A 3(Groups) x 1(Session) analysis of variance did not reveal any significant difference among groups.

Test 2 (in training 2). All rats showed a tendency to spend more time in positions 0 (on) and 1 (near) than in positions 2 and 3. A 3(Groups) x 1(Session) analysis of variance did not indicate a significant difference among groups.

# Discussion

The results will be discussed in the order in which they were presented: A discussion pertaining to the results from the suppression ratios and from the post-hoc analysis of the latency periods will be presented first, followed by a discussion of the time spent on the platform and of the behavioral observations.

1. Suppression ratios.

After completion of training 1. The results indicated that the CS suppressed the rate of the licking response in Group FD but not in Groups BK and RD, thus suggesting that the CS in Group FD acquired excitatory associative value but not in Groups BK and RD. The results also indicated that Group BK developed little suppression to the CS suggesting that the CS could have been inhibitory. However, the animals in Group BK did not show less suppression to the CS than the animals in Group RD. Consequently, while our conditioned suppression procedure was successful in showing the excitatory value of the CS in the forward procedure, it failed to provide a clear indication of the inhibitory value of the CS in the backward procedure.

Training 2. The prediction that exposure to backward pairings in training 1 would retard the subsequent suppression of the licking response in training 2 was only partially confirmed by the present data. On the one hand, platform presentations did suppress the licking response significantly more in Group FD than in Groups BK and RD for the first two testing sessions. On the other hand, platform presentations continued to suppress the licking response at comparable rates in both Groups BK and RD. Consequently, the retardation effect observed in Group BK can not necessarily be attributed to the conditioning to which it was exposed in training 1.

A reason for the lack of differences in suppression ratios in Groups BK and RD might have been related to difficulties inherent to a conditioned suppression procedure. Hall (1984) and Hurwitz and Davis (1983) argued that because several problems are encountered in a conditioned suppression procedure, suppression ratios can only provide a gross estimate of directionality. For instance, Hurwitz and Davis stated that both CS and pre-CS rates may change because of the conditioned suppression procedure. Since CS rates are measured relative to pre-CS rates in suppression ratios, a shift in pre-CS rates confounds interpretation of the ratio. For example, an increase in both pre-CS and CS-rates of licking, would result in suppression ratios being approximately .5.

Primarily because suppression ratios did not give a clear indication of the associative value of the CS in our backward procedure, latency periods were used as another measure to acquire more information on the effect of CS presentation during suppression testing sessions. A definition of latency period, the rational for choosing this measure, predictions on how groups should differ, and a discussion of the results from the post-hoc data analyses will be presented next.

First latency period (time delay between the onset of the trial and the first platform presentation) and the latency periods between each subsequent platform presentations in suppression testing sessions (test 1).

The first latency refers to the time period when the rat was placed in the experimental chamber until the first platform presentation. Subsequent latency refers to the time period when the platform closed until the next platform opened. It was assumed that the more fear associated with the context, the longer it would take a rat to start licking and therefore that the first latency period would provide with an estimate of the initial level of fear associated with the context (Baker, Singh & Bindra, 1981). It was further assumed that the latency period between CS-presentation would continue to measure the level of fear associated with the context. Although the first latency period and subsequent latency periods may not be totally comparable at a conceptual level because certain conditioning elements may be present in one period and not in the other, it was felt that such a measurement strategy could be justified because the context was the same throughout the session.

Disruption of the licking response was reflected by latency periods because platform presentation was dependent on the rat licking continuously for 10 sec with no pauses of more than 2 sec. A long latency period would indicate that the rat was not licking or licking with pauses of more than 2 sec (described in details in the section on the procedure). A short latency period (minimum time being 20 sec) would indicate that the rat licked continuously for 10 sec.

One can indeed make predictions about how the groups should differ on these measures in the suppression testing session after completion of training 1. According to Rescorla and Wagner's (1972) model of conditioning, the context would acquire all of the excitatory conditioning in both Groups BK and RD because it provides the only cue for the US. However, the CS would acquire inhibitory value in Group BK because it signals a period of no shock while it would remain associatively neutral in Group RD because it does not reliably signal the US or a period of no shock. In Group FD, the CS would come to acquire all of the excitatory conditioning and block conditioning of the context.

Furthermore, nonreinforcement in the testing session should reduce fear of the context (Rescorla & Wagner, 1972; Baker, Singh & Bindra, 1981). This effect should be of consequence in Group BK but not for the other groups since a background of excitation is necessary for the expression of conditioned inhibition but not for the expression of conditioned excitation (Rescorla, 1979; Kaplan & Hearst, 1985). Extinguishing the context might therefore be expected to reduce the ability for inhibition to manifest itself behaviorally in Group BK.

Therefore, the predictions after completion of training 1 would be that (1) in Groups BK and RD, the first latency period would be longer than in Group FD but (2) only in Group BK, the duration of the latency periods would decrease significantly within a session.

In training 2, which consisted of forward conditioning, the context would acquire a minimal amount of excitation in all groups (Rescorla & Wagner, 1972) and the effect of nonreinforcement on the expression of the conditioned response would be minimal. However, because of training 1, Group BK would be expected to show retardation of acquisition, Group FD would continue to show the same behavior as in training 1 and Group RD would be expected to show rapid acquisition. The predictions, after 1 day of training 2, would be that (1)in Group BK, the first latency would continue to be longer than in Group FD and the duration of subsequent latency periods would again decrease significantly during the session (2) in Group FD, the latency periods would continue to remain constant throughout the session and (3) in Group RD, the first latency period would decrease to a level comparable to other latency periods within the session. After 4 days of training 2, there would no longer be differences among groups.

<u>After completion of training 1</u>. The results from the post-hoc analyses revealed significantly more contextual excitation in Group BK than in Group RD. Results also showed that the level of contextual excitation was higher in Group FD than in Group RD but the difference was not significant. Latency periods decrease significantly within the testing session in both Groups BK and FD. Thus most of the predictions based on Rescorla and Wagner's (1972) model were confirmed except that for the associative properties of the context in our Group RD.

Patterson and Overmier (1981) reported similar results about contextual associations. The experiment consisted in three phases: (1) training dogs on a Sidman avoidance schedule then (2) exposing the dogs to aversive conditioning using excitatory, inhibitory or truly random procedures and (3) testing of the manipulable background stimulus (a tone) by presenting it while the dogs were responding on the avoidance schedule. The tone increased the rate of responding after serving as a contextual stimulus in the group exposed to inhibitory conditioning but had little effect in the groups exposed to excitatory and truly random conditioning. The authors concluded that, as predicted by Rescorla and Wagner's (1972) model, contextual stimuli in an inhibitory procedure are excitatory while in an excitatory procedure, contextual stimuli are associatively neutral. However, in contrast to the prediction that contextual stimuli would be excitatory in a truly random procedure, they would be neutral.

Additional support for an increased aversiveness interpretation of the context in conditioned inhibition procedures has been provided by Fanselow (1980). Basically, the experimental procedure consisted in exposing rats to a signal (tone) negatively correlated with shock in one side of a choice apparatus and to shock only in the other side of the apparatus. Daily sessions lasted 66 min and were divided into four periods of 16.5 min. Each period was divided into 33 intervals of 30 sec each. There were five shocks presented randomly during a period and each shock was presented at the start of an interval. Rats spent two periods in the signaled side of the shuttle box and two periods in the unsignaled side. The two periods in the signaled side consisted in presenting the tone for 7 30-sec intervals, each predicting a minimum of 150 sec without shock. Preference tests consisted in removing the partition and allowing the rats to move about freely in the shuttle box for 8 min just prior to conditioning on Days 1, 4, 7 and 10. Fanselow assumed that rats would spend less time on the side with more contextual fear based on findings on sign-tracking experiments (Karpicke, Christoph, Peterson and Hearst's, 1977) that rats move away from fear cues. A tilting floor mechanism was used to measure automatically the time spent on each side of the apparatus.

Results indicated that the rats prefered the side where shock alone had been presented. Typically, rats have been reported to choose signaled over unsignaled unescapable shock situations and several theoretical interpretations such as the preparatory-response and the safety signal hypotheses have been proposed to explain this finding. Fanselow proposes the contextual-fear hypothesis (Rescorla & Wagner, 1972) to explain why rats did not choose the signaled side as would have been predicted by most current theories. Basically, the contextual-fear hypothesis assumes that a safety signal attenuates extinction of contextual fear during the ITI and consequently the context acquires a high level of fear. Therefore, according to the contextual-fear hypothesis, the context was more aversive on the signaled than the unsignaled side which explains why the animals chose the unsignaled side.

In summary, Rescorla and Wagner's (1972) model and previous studies (Patterson & Overmier, 1981; Fanselow, 1980) are providing both theoretical and empirical backgrounds in our understanding of our present data. More specifically, the platform CS in our backward conditioning procedure signaled a shock-free period just as the tone CS in Fanselow's negative correlation group. Platform presentations would have attenuated extinction of contextual fear during ITIs. This would provide a theoretical explanation why the context in our backward procedure acquired a high level of contextual excitation. In Group BK, the significant decrease in latency periods as the session progressed suggested that contextual excitation may indeed have extinguished rapidly because of nonreinforcement in the testing session. The effect of a progressively less "fearful" context would have been an increase in the rate of licking independently of CS presentations. As mentionned earlier, an increase in pre-CS rates confounds interpretation of suppression ratios. Perhaps the suppression ratios showed more suppression of the licking response than expected in Group BK for this reason.

A decrease in latency periods was also observed in Group FD and was not predicted originally. However, the first latency period indicated a higher level of contextual excitation than expected and consequently, it is not surprising that an effect of extinction would also be evident in that group as a result of nonreinforcement in the testing session. As predicted by Rescorla and Wagner's model, extinction of contextual fear did not reduce the ability of the CS to suppress licking as indicated by suppression ratios. Such results provide further support to the assumption that contextual excitation is not necessary for the expression of conditioned excitation.

Training 2. Post-hoc analyses did not reveal any significant differences among groups from the very first testing session suggesting that the level of contextual fear was comparable in the three groups after the very first day of training 2. The results did indicate a general main effect of trials (except in Group FD after one day of training 2): The duration of latency periods decreased significantly during each testing session. Such a decrease replicates the effect observed in Group FD in the testing session after completion of training 1: Forward conditioning seems to produce some contextual excitation which extinguishes during testing sessions. However, independently of this effect, the CS seemed to have retained its excitatory value throughout a session as suppression ratios indicated suppression in all groups.

In summary, the data on latency periods after completion of training 1 suggested a high level of contextual excitation in Group BK which extinquished rapidly during a testing session. Extinction of background excitation would have reduced the ability for inhibition to manifest itself. The level of contextual excitation in Group FD was not significantly lower than in Group BK suggesting a fairly high level of excitation. An effect of extinction of contextual excitation was also observed in that group but did not seem to be accompanied with extinction of excitatory conditioning to the CS. Latency periods suggested that contextual association might have been neutral in our random group. In the testing session after each day of training 2, data on latency periods indicated extinction of contextual excitation in all groups but a continued effect of CS presentation was indicated by suppression ratios.

In conclusion, results provided evidence that an excitatory background is necessary for the expression of conditioned inhibition but failed to provide clear evidence of the associative value of the CS in the backward conditioning procedure. The effect of fear of the context on the development of APPR$^-$ behavior is not clear at this time. It seems likely that fear would produce APPR$^-$ behavior, more fear being translated by an increase in such behavior. Data on time spent on the platform should provide us with relevant information about APPR$^-$ tendency.

Time spent on the platform

After completion of training 1. Group BK showed a tendency to spend more time on the platform than Group FD but the difference was not statistically different. Perhaps this was due partly to the fact that performance level was very low in all groups. Nevertheless, the present results are in contrast with those obtained by Leclerc (1985). In Leclerc's (1985) study, subjects were exposed to a backward, forward or random conditioning procedure in which the CS was a platform and the US a shock. The jump-up response was also prevented by means of a Plexiglas barrier during training 1. During training 2, all subjects were exposed to a backward conditioning procedure. Leclerc (1985) found that previous exposure to backward presentations of the platform facilitated the acquisition of $APPR^-$ behavior when rats were given access to the platform in subsequent backward training.

Perhaps a facilitative effect was not observed here because of procedural differences: In this experiment, $APPR^-$ behavior was measured in the context of an extinction procedure (i.e., platform alone presentations), while in Leclerc's (1985) study, it was measured in the context of backward conditioning. As previously observed by Leclerc (1979, Experiment 2), extinction testing following mere exposure to backward, forward, or random pairings of shock and platform did not allow for group differences (on the time-spent-on-the-platform variable), and therefore was not considered a sensitive transfer test. The present data could also be explained in terms of the lack of test sensitivity of the procedure.

In training 2. The prediction that forward pairings would produce a gradual decline in time spent on the platform for Group BK while maintaining performance of Group FD at a low level was not confirmed by the present results. After the second day of training 2, the results indicated a tendency in Group BK which was consistant with the predictions but significant differences among groups were not obtained. Moreover, all groups showed a gradual increase in time spent on the platform as testing sessions were repeated.

A reason why the predicted differences among groups were not obtained might again have been because the overall performance was quite low in all groups. For example, time spent on the platform in Group BK was 25.3 % after training 1. Consequently, to obtain the predicted decrease in training 2, subjects in Group BK would have had to stop responding.

The increase in the level of performance with repeated testing sessions might have been a result of an extinction process due to nonreinforcement during testing sessions, all rats spending more and more time on the platform as the platform gradually lost associative values. Another possible explanation for the increase in performance level in testing sessions may be that, while the CS-platform with the Plexiglas barrier acquired excitatory properties during training sessions because it was associated with shock, the CS-platform alone (without the barrier) in testing sessions acquired inhibitory properties because it was associated with absence of shock.

3. Behavioral observations.

Rats in all groups did not show a preference for either positions 1, 2, or 3 throughout training 1. In comparison to Group RD, Group BK did not show the expected tendency to spend more time in position 1 ("near") and Group FD to spend more time in position 3 ("far") in training 1. In test 2 after completion of training 1, all groups showed a tendency to spend more time in position 1 ("near").

In training 2, behavioral observations showed the expected tendency to withdraw from the platform: Groups BK, FD, and RD showed a preference for position 2 ("middle") and for position 3 ("far") with exposure to forward training. However, in tests 2 (after each of the four sessions of training 2), all groups showed a tendency to spend more time "on" the platform or in position 1 ("near").

It is not clear why subjects showed the predicted

$WDR^+$ behavior in training 2 and yet, in tests 2 (after each session of training 2) showed $APPR^-$ behavior. Extinction due to nonreinforcement during testing sessions or conditioned inhibition to the CS-platform were proposed, in the previous section (Section 2. Time spent on the platform), as reasons for the increase in the level of time spent on the platform in tests 2. Since we are referring here to the same phenomenon, the same reasons would apply and therefore will not be presented again.

In summary, data from our conditioned suppression procedure clearly showed that a backward conditioning procedure yields a high level of contextual fear but did not clearly support a conditioned inhibition view. Rescorla and Wagner's (1972) model was useful in providing a theoretical explanation why Groups BK and RD did not differ in suppression testing sessions. During training sessions, the context in Group BK would have acquired excitatory value being the only cue for the US and extinction of this contextual fear during ITI would have been attenuated because of the presentation of the safety signal (the platform). Moereover, during testing sessions, nonreinforcement in Group BK would have resulted in decreasing contextual fear, reducing the ability for inhibition to manifest itself behaviorally.

Data from time spent on the platform and behavioral observations did not support a sign-tracking point of view, likely because of lack of sensitivity of our procedure. Nevertheless, the following conclusions can be drawn: Fear of the context does not seem to contribute to the acquisition of APPR$^-$ behavior. Moreover, preventing the animals from jumping on the platform during training sessions hinders the manifestation of APPR$^-$ behavior when subsequent testing sessions are nonreinforced but not in subsequent reinforced sessions (Leclerc, 1985). These observations add to our understanding of APPR$^-$ behavior and will be discussed further in the following chapter.

# Chapter 7

The general objective of the previous experiments was to identify the mechanism responsible for $APPR^-$ behavior in a backward conditioning procedure. Overall, the experimental data presented here tended to support the contention that $APPR^-$ behavior results from inhibitory properties acquired by the CS in backward conditioning. Data from Experiment 1 showed that the CS in US-CS pairings produces as much $APPR^-$ behavior as the CS in differential and explicitly unpaired conditioning procedures. Since, in other contexts, both differential and explicitly unpaired conditioning procedures have been known to produce conditioned inhibition, perhaps a similar mechanism of action is present in backward conditioning. Alternatively, conditioned inhibition might be only one of the mechanisms responsible for $APPR^-$ behavior in our particular experimental preparation.

Data from Experiment 2 showed that daily exposure to a single US-CS pairing produces $WDR^+$ behavior while daily repeated US-CS pairings produce $APPR^-$ behavior. Data from Experiment 3 showed that US-CS pairings produce $APPR^-$ behavior only when the CS reliably signals a shock-free period. Other studies in which different experimental environments and procedures were used have also shown that conditioned inhibition in backward conditioning depends on the same two factors, namely repeated exposure to US-CS pairings (Heth, 1976) and a shock-free period following CS offset (Moscovitch & Lolordo, 1968).

In Experiment 4, the three predictions made pertaining to Group BK were not confirmed: (1) there was as much suppression in that group as in the control group (2) there were no strong APPR$^-$ behavior and (3) subjects did not spend more time "near" the platform. An extinction process in testing sessions (test 1 and test 2) was suggested as a reason why the predictions were not confirmed. This suggestion was supported by the results obtained from latency periods. The rapid decline in the time between platform presentations as a testing session progressed was interpreted in terms of extinction of excitatory value of the context. This process would have had little effect on the licking response in Group FD because the excitatory CS, independently of the associative value of the context, continued to suppress licking. Extinction of contextual excitation would have affected the licking response in Group BK because the inhibitory CS was dependent upon contextual excitation: A CS can not inhibit fear when there is no fear to inhibit. The two other measures used in Experiment 4 to measure APPR$^-$ behavior (time spent on the platform and positions in the experimental box), may also have been affected by extinction due to nonreinforcement in testing sessions. As discussed previously (Discussion, Experiment 4), this suggestion is supported by previous observations made by Leclerc (1979, 1985).

Alternatively, one could claim that our suppression ratios indicated that the CS in our backward procedure did not acquire or acquired very little conditioned inhibition. Baker and Baker (1985) have claimed that, particularly in the case of a negative correlation procedure, inhibition acquired by the CS is a summed effect of latent inhibition and US preexposure effects.

Baker and Baker trained rats on a VI schedule for food then exposed them to context conditioning consisting of shock presentations in the negative correlation group and signaled shock presentations in the signaled group. Following this, the negative correlation group was exposed to shock only or clicker only on alternating days. The signaled shock group was exposed to signaled shock or clicker only on alternating days. This training was followed by a retardation test which consisted in reinforced light presentations (rather than reinforced clicker presentations). By using a novel stimulus, the authors wanted to verify if retardation of acquisition expected to occur in the negative correlation group could be attributed to latent inhibition and US preexposure effects. The signaled shock group would also be expected to show some retardation of acquisition because of latent inhibition but would be expected to condition faster because signaling the shock would have blocked the US preexposure effect. As predicted, the signaled shock group conditioned faster than the negative correlation group. Baker and Baker concluded that, in a retardation test, differences in rates of acquisition reflect differences in the level of associative value acquired by the CS but also latent inhibition and US preexposure effects.

Our backward conditioning procedure has much in common with a negative correlation group: The US is unsignaled and the CS signaled a period of no-shock. Therefore, it is possible that during conditioning sessions, nonreinforced CS presentations and unsignaled US presentations resulted in latent inhibition and US preexposure effects. The retardation test might have shown slower conditioning in Group BK because of the combined effect of inhibitory conditioning to the CS, latent inhibition and US preexposure.

In order to discriminate between these interference phenomenon and conditioned inhibition, Rescorla (1969) suggested that both a retardation and a summation test be administered. Chances are that a stimulus which passes both tests is a conditioned inhibitor. Only a retardation test was used in the present series of experiments mainly because a summation test was not easily conceivable in our paradigm. Nevertheless, this omission may present as a weakness and limits the assumptions which can be made concerning the associative value of the CS in our backward procedure.

More information might have been provided by direct observations of the rats' behavior with some modifications to the method of observations used in Experiment 4. For example, recording a rat's position fifteen times (every 2 sec) during CS presentation, rather than twice, might have considerably increased the accuracy of the information provided by recording the position of the rat in the experimental box. The addition of other behavioral categories such as freezing, rearing, and orientation towards the CS might have provided some indication of what the rat was doing during CS presentation. In turn, such behavioral observations might even have provided some indication of the associative value of the CS.

Recording of the rat's behavior might specially have been important in conditioned suppression testing. Extinction of contextual excitation was suggested as an explanation why CS-platform presentations did not produce an acceleration of licking in Group BK but aversive sign-tracking would also have produced this effect. The prediction that CS presentations would facilitate licking in Group BK was based on the assumption that, in a conditioned suppression procedure, an excitatory CS suppresses licking because it elicits fear while an inhibitory CS facilitates licking because it inhibits fear.

however, from a sign-tracking point of view, an opposite effect might be expected depending on the location of the CS relative to the licking tube: An inhibitory CS, located far from the licking tube, might suppress licking because it elicits APPR$^-$ behavior. In Experiment 4, licking tubes were installed on the wall opposite to that of the CS-platform. Therefore, if platform presentations elicited orienting or tracking behaviors in Group BK, it would have prevented these animals from licking the tube. Although no direct observation of this prediction was made here, it finds support in some studies in which the animals were observed systematically.

The physical location of CS in relation to the manipulandum was previously identified as a factor which exerts a strong influence on conditioned suppression in rats (e.g. Karpicke, Christoph, Peterson & Hearst, 1977). The authors reported that a visual CS which signaled shock produced more suppression of operant responding when it was located near the manipulandum than when it was located far. Results were interpreted in sign-tracking terms: Animals have a tendency to move away from signals of aversive USs, such behavior being incompatible with the instrumental response. According to the authors, this would provide an account of why a visual excitatory CS will produce a different magnitude of suppression depending on its physical location in relation to the manipulandum.

Perhaps, in a parallel fashion, the location of a visual inhibitory CS, in relation to the manipulandum, affects the magnitude of conditioned facilitation. A CS which signals absence of shock might facilitate operant responding when it is located near the manipulandum but not when it is located far from the manipulandum. In Experiment 4, CS-platform presentations may not have facilitated licking because the platform was located far from the licking tube.

Karpicke et al. (1977) also suggested that a complete account of conditioned suppression should consider the effect of CS presentations on both the emotional response and on CS-directed behaviors. Furthermore, Willigan, Emmett, Cote, and Ayres (1987) suggested to include not only CS-directed behaviors but also the animals' general behavior. For example, in conditioned suppression testing, suppression accompanied by freezing would provide evidence for excitatory conditioning, but if suppression was accompanied by movements such as walking around, sniffing, approaching the CS, excitation would be questionable. This suggestion found support in Ayres, Haddad, and Albert's (1987) observations of freezing following one-trial backward conditioning which was accompanied by suppression.

Fanselow's (1980) experiment described earlier (Discussion, Experiment 4) suggests that an aversive context may exert a strong influence on sign-tracking behaviors. He reported that animals showed an aversion to the side where shock-free periods were signaled which could be interpreted as withdrawal behaviors from a $CS^-$. Such results stand in contrast with the findings reported in the present series of experiments where approach behaviors were consistently observed toward a $CS^-$. Our experimental paradigm differed in many ways from the one used by Fanselow. Two of these differences, the CS and the testing procedure used, will be discussed to provide a possible explanation for the conflicting results.

Fanselow used a tone CS. Auditory signals have been shown to support little or no sign-tracking behaviors because such stimuli are not easily located by the animals. Localizability of the CS is usually a condition which must be met for sign-tracking behaviors to occur (Hearst & Jenkins, 1974). In our experiments, we used a platform CS. As mentioned previously, a platform may have been quite conducive to sign-tracking behaviors because of its auditory, visual and tactual components.

The context can be analysed in the same way as any other CS (Baker, Singh & Bindra, 1980), and therefore can be assumed to elicit sign-tracking behavior as any other CS. The results reported by Fanselow can be reconciliated with the predictions made from an aversive sign-tracking point of view if it is assumed first that the context produced withdrawal behavior because it reliably signaled the US and second that the context rather than the tone produced sign-tracking behavior because its physical properties were more conducive to sign-tracking. Perhaps, as well, animals' tendency to withdraw from an aversive context is simply much stronger than that of approaching a signal of no danger.

The overall picture is a little more complex however since in both of Fanselow's groups (the group exposed to the negatively correlated signal and the group exposed to shock only) the context was aversive and therefore should have produced withdrawal behaviors in both groups. This brings us to the discussion of the second difference between Fanselow's paradigm and ours which may account for some of the differences. Fanselow's testing procedure consisted in presenting the animals with a choice between two excitatory contexts, one assumed to have acquired a higher level of excitation that the other. The animals chose the side that had acquired less excitatory value. It is not clear, in such a situation, what the predictions would be from a sign-tracking point of view but it is likely that the results reported by Fanselow would not contradict those predictions.

In our testing situation, the animals did not have a choice but to remain in the aversive context but we did observe that they persistently tried to escape from the experimental boxes by pushing with their nose against the

Plexiglas door, specially during ITIs. If the animals in the backward group would have had a choice between approaching (jumping on) the platform or withdrawing from the context, they would have likely chosen the later, perhaps even it it only meant going to a less aversive context.

Fanselow's work was discussed here mainly because it has some interesting implications about aversive sign-tracking. First, it implies that the context, just as any other CS, may produce sign-tracking behaviors. Such being the case, one may wonder about possible interactions between the signal value acquired by the context and by a discrete CS during a conditioning session. The results in Fanselow's experiment may be taken to suggest that a "weak" $CS^-$ (because of its modality, localizability and other physical properties) presented together with a "strong" $CS^+$ would result in withdrawal from the $CS^+$ rather than approach toward the $CS^-$. Second, it implies that when confronted with two excitatory signals that have acquired different levels of excitation through conditioning, the animals will approach the lesser of the two excitatory signals. It would be most interesting to test the above predictions using the experimental paradigm described in this thesis.

In summary, it is possible that an inhibitory CS elicits several types of behavior, which, in conditioned suppression testing, interferes with the operant response. Furthermore, perhaps a localizable (i.e., visual) inhibitory CS elicits CS-directed behavior. In cases where the visual inhibitory CS is located far from the response manipulandum, CS-directed behavior might interfere with the operant response. Direct observations and recording of the rat's behavior during conditioned suppression testing may have provided some information on these points. Finally, perhaps the context can also elicit sign-tracking behavior which interferes with the acquisition of discrete CS-directed behavior. This might occur in much the same way as stimuli compete for available conditioning strength.

Present data and theoretical implications

Most contemporary learning theories do not present models that can easily account for sign-tracking behaviors, excitation following one backward trial and inhibition with repeated trials. Each theory presents particular strengths and weaknesses, some focusing more upon behavioral changes observed during conditioning, others on the learning processes underlying those behavioral changes. It was discussed earlier how predictions of associative models such as Rescorla and Wagner's (1974) can account for the role played by the context in our backward procedure and how such pairings can produce conditioned inhibition. The model fails however to predict excitation from one daily backward pairing and also fails to predict CS-directed behaviors. Dickinson's (1980), Pearce and Hall's (1980) and Wagner's (1981) models will now be discussed to present alternative theoretical explanations to our results.

Dickinson's and Pearce and Hall's models are two of the few contemporary models of conditioning which can offer some account for sign-tracking behavior. In these models, behavioral changes during conditioning are assumed to reflect learning and as such to provide valuable information as to the nature of the learning process.

Dickinson's model is based on the principle of stimulus-substitution and two assumptions are critical for an account of sign-tracking. The first is that exposure to a CS and to a US or exposure to a CS in the absence of the US results in the formation of excitatory links between the CS and US or between the CS and absence of the US. This assumption stands in contrast with Rescorla and Wagner's (1974) model where it is assumed that exposure to a CS and absence of the US results in the formation of an inhibitory link between representations of the CS and the US. It is particularly because of this assumption that Rescorla and Wagner's model can not easily account for $APPR^-$ behavior elicited by the $CS^-$.

The second critical assumption in Dickinson's model is that the form of the response elicited by the CS and by the US will be similar. According to Dickinson, when a CS signals a US, two independent excitatory links are formed between representations of the two sitmuli: one that represents the encoding of the sensory-perceptual properties of the US, the other that represents the encoding of the affective (or motivational) value of the US. When the CS signals no US, not only are the same two independent excitatory links formed but also an excitatory link between the representations of the CS and the absence of the US. This third excitatory link would represent encoding of an opposite affective value to that of the US itself. Thus the model predicts that a CS paired with absence of shock will acquire positive affect and therefore elicit approach behavior. In our backward conditioning procedure, an excitatory link would have been formed between the CS platform and the shock-free period resulting in $APPR^-$ behavior, a behavior reflecting an opposite affective value to fear.

Dickinson's model offers an account of $APPR^-$ behavior without making reference to a conditioned inhibition mechanism. However, from this account it is not clear how processing of the US might have taken place since it is assumed in the model that a link between a CS and US can only occur in a forward fashion. Clearly Dickinson's model emphasises the importance of contiguity in our experimental paradigm and implies that $APPR^-$ behavior may develop in a fashion similar to $APPR^+$ behavior, both resulting from forward associations between the CS and absence of the US and the CS and the US respectively.

Pearce and Hall's (1980) model also focus upon behavioral changes during conditioning. This model shares some of the same assumptions as Dickinson's model which stand in contrast to Rescorla and Wagner's (1974) model. For example, exposure to a CS which signals absence of the US is assumed to result in the formation of a representation which is independent of that established by a CS which signals a US, and the CS, not the US, is assumed to be processed to the extent that it has been paired with a surprising event.

An assumption unique to Pearce and Hall's (1980) model and which also contrast with Rescorla and Wagner's (1974) model is that CS-US pairings decrease CS associability. Associability of the CS can best be defined in terms of response-eliciting properties of the CS. During conditioning, CS associability is assumed to be high for the first trial and to decrease with repeated CS-US pairings. At asymptote, CS associability is assumed to be zero.

Following Pearce and Hall's (1980) model, orienting responses (OR) toward the CS have been used to provide a behavioral index of the amount of attention the CS receives and therefore of the level of associability of the CS (Pearce & Kaye, 1985). It is important to specify here that

OR is defined in terms of approaching and contacting the CS and therefore in terms of behaviors referred as sign-tracking behaviors in this thesis.

In the first of a series of experiments, Pearce and Kaye (1985) measured the strength of the OR in an inhibitory procedure using a light as the CS and food as the US. During Stage 1 of the experiment, the experimental group, Group $L^-$, was exposed to 10 sec light presentations and food. Delivery of food never occured during light presentations and was withheld for one minute after termination of light presentations. There were two control groups, Group $L^o$ and Group RC. Group $L^o$ was also exposed to light presentations but food was withheld during Stage 1. Group RC was exposed to random presentations of light and food. During Stage 2, all groups were exposed to light presentations which signalled the delivery of food constituting a retardation test.

According to Pearce and Hall's (1980) model, during Stage 1, the strength of the OR to the light should be at a high level initially and ultimately decline in all groups. However, the strength of the OR in Group $L^-$ should persist longer than in Groups $L^o$ and RC, reflecting processing of the CS which is essential for conditioning to take place. During Stage 2, the OR should recover in all groups because of the surprising element of the CS signalling the US but recovery should be slower in Group $L^-$ because of conditioning in Stage 1. From a sign-tracking point of view, the opposite predictions can be made for Stage 1. Not only would the strength of the OR (approaching and contacting the CS) be expected to decrease in Group $L^-$ but a withdrawal behavior should be observed in that group and not in the control groups. In Stage 2, slower recovery would also be predicted.

Pearce and Kaye (1985) report that the OR in Group $L^-$ decline at a significantly lower rate than that in the control groups as predicted by Pearce and Hall's model. It is not clear why the animals in Group $L^-$ did not acquire a withdrawal behavior. The authors do mention that their results contrast those of several studies reporting withdrawal and mention that this difference might be due to differences in density and magnitude of food presentations and the use of different species (rats as opposed to pigeons). Perhaps also the relatively few subjects used (N=8) in each group may also account for their findings. Nevertheless, Pearce and Kaye sustain that their results support the contention of central processing of the CS which eventually decreases with repeated pairings as reflected by a decrease in the strength of the OR. The findings in the series of experiments presented in this thesis contradict Pearce and Hall's assumption that the strength of the OR decreases with repeated exposure. Time spent on the platform consistently increased with repeated

US-CS pairings in our group exposed to backward conditioning. Consequently, Pearce and Hall's model does not offer any theoretical explanation for our results.

Let us now consider Wagner's (1981) SOP model (Standard Operating Procedures of memory) which presents an account of how memory processes may influence conditioning. Wagner stipulates that an association between a CS and a US will only be formed to the extent that they are rehearsed together. Exposure to a CS or to a US initially produces a representational activity, A1, which decays to a secondary representational activity, A2, which in turn decays to inactivity. According to Wagner's model, excitatory conditioning resuls from A1 processing of the CS concurrent with A1 processing of the US. Inhibitory conditioning results from A1 processing of the CS concurrent with A2 processing of the US.

The outcome of backward pairings is not obvious from Wagner's model. To account for conditioned inhibition in backward pairings, it must be assumed that an ISI of 10 sec (as used in the series of experiments presented in this thesis) was sufficient time for US representation to decay to a secondary representational activity (A2) at the time of CS presentation. An alternative account could be that a secondary representational activity (A2) of the CS rehearsed with an initial representation of the US (A1) can produce conditioned inhibition in the same fashion that an

A1 representation of the CS rehearsed with an A2 representation of the US is assumed by the model to yield conditioned inhibition.

In a series of experiments on distribution-of-trials effect, Erwing, Larew and Wagner (1985) discuss the effect of short ITI intervals and how inhibitory backward conditioning can be anticipated by Wagner's SOP model in such cases. Since details of the experiments were presented earlier (Experiment 2-Discussion), they will not be presented again. The authors suggest that short ITI (60 sec) produce conditioned inhibition because of A1 processing of the CS concurrently with A2 processing of the US from the previous trial. This provides support to the assumption made earlier that a 10 sec ISI in our backward procedure may have resulted in A2 processing of the US with A1 processing of the CS resulting in conditioned inhibition.

However, there are some problems with this interpretation of our results. In Experiment 2, exposure to one backward pairing per session clearly produced opposite behavioral tendencies to exposure to ten backward pairings per session assumed to be due to excitatory and inhibitory conditioning, respectively. Assuming, as stated earlier, that learning took place as a result of A2 processing of the US concurrent with A1 processing of the CS, then exposure to one backward trial per session would yield conditioned inhibition with repeated sessions.

If we consider our alternative assumption, that A1 processing of the US concurrent with A2 processing of the CS can result in conditioned inhibition, then Wagner's (1981) model clearly predicts conditioned excitation from one backward trial and conditioned inhibition from ten backward trials. Wagner's model can not be used to account for behavioral changes such as sign-tracking behaviors observed during conditioning. However, to accomodate our findings of excitation and inhibition in backward conditioning, the model can be extended by making the assumption that the order of presentation of the stimuli is of no consequence and therefore, as stated above, that A1 processing of the US with A2 processing of the CS produces conditioned inhibition. A comparatively simple assumption can not be incorporated into Rescorla and Wagner's (1974) model to account for our results.

In summary, in order to account for the present findings, a theory must predict excitatory conditioning from one backward conditioning trial and inhibitory conditioning from additional conditioning trials, and account for APPR$^-$ behavior. Although some of the findings can be reconciled with Dickinson's (1980) or Pearce and Hall's (1981) excitatory link model of conditioning, the first model provides no account of backward conditioning while the second makes predictions of sign-tracking behaviors which are opposite to those we observed. Rescorla and Wagner's (1972) or Wagner's (1980) inhibitory link model also fail to account for all our findings. While our results are consistent with Rescorla and Wagner's predictions concerning fear of the context, the model fails to predict that excitatory conditioning should result from one backward pairing and both models fail to predict APPR$^-$ behavior.

Perhaps with additional assumptions, these theories would be able to handle the present data. For example, it might be necessary to assume that both contingency and contiguity mechanisms are present in APPR$^-$ behavior: The CS would acquire inhibitory properties because it is negatively correlated with the US (Rescorla & Wagner, 1972) and APPR$^-$ behavior would develop because of the temporal contiguity between the CS and a subsequent no-shock period. Other assumptions may have to be provided to predict how learned associations can be translated into CS-directed behaviors such as APPR$^-$.

<u>Future experimentation in aversive sign-tracking</u>

An aversive sign-tracking analysis has been suggested to account for the results of the present studies and temporal contiguity between CS-offset and a subsequent no-shock period has been suggested as a necessary element to $APPR^-$ behavior. However, much experimental work is still needed to establish the generality of the sign-tracking phenomenon in aversive contexts and to provide support to the assumed associative mechanism underlying $APPR^-$ behavior in backward conditioning.

$APPR^-$ behavior was studied here primarily in the context of a backward conditioning procedure. Although such approach behavior was also observed in the context of explicitly unpaired and differential conditioning procedures, parametric studies should be carried out to evaluate the effects of variables such as stimulus-reinforcer correlation and temporal parameters (e.g., inter-stimulus intervals and inter-trial intervals) in these procedures. Since these variables have been shown to play a role in the acquisition of appetitive sign-tracking (see Hearst & Jenkins, 1974; Schwartz & Gamzu, 1977 for reviews), their role must also be investigated in aversive sign-tracking.

Other variables such as CS modality and localizability, and physical properties of the CS and the US have been identified as affecting the development of appetitive sign-tracking and were suggested by Hearst & Jenkins (1974) as variables that would likely be important in aversive sign-tracking as well. Moreover, selective association between certain types of CS and US has been demonstrated (Garcia & Koelling, 1966; Shettleworth, 1978; Shapiro, Jacobs & Lolordo, 1980), and perhaps the choice of particular combinations of CS and aversive US also affects the rate of acquisition and the topography of sign-tracking behaviors.

The need to further investigate the role played by such variables on $APPR^-$ behavior becomes evident in light of the results presented by Spetch, Terlecki, Pinel, Wilkie and Treit (1982). They used a backward conditioning procedure but reported $WDR^+$ behavior and excitatory conditioning. The US used was a shock to the rat's back and the CS was a retractable metal prod. Perhaps the CS-prod may have readily acquired excitatory properties because it was perceived as a predator or as an object causing pain, thus supportive of $WDR^+$ behavior and of a backward association with shock. The CS-platform used in the series of experiment presented in this thesis may have been responsible for learning to occur selectively in favor of an association between the CS and a period with no shock because it could easily be perceived as a "safe place". Consequently, the CS-platform might have been more supportive of a forward association with a safe period than a possible backward association with shock. Such conflicting reports of animals' performance in conditioning experiments suggest that the choice of particular combinations of CS and aversive US may markedly affect sign-tracking behavior. Future experimental work should try to determine the extent to which these factors affect aversive sign-tracking behavior.

It would also be imperative to replicate Experiment 4 to record behavioral observations with the modifications to the recording procedure suggested earlier and, most importantly, to verify the assumption made that suppression, in Group BK, might have been due to $APPR^-$ behavior.

Other studies should also further investigate the respective role played by contingency and contiguity in $APPR^-$ behavior. It was suggested that, in a backward conditioning procedure, temporal contiguity between CS and a shock-free period may be an essential element for the acquisition of $APPR^-$ behavior. This assumption, however, would require experimental evidence. Experimental work would consist in manipulating the degree of contingency between CS and US and of contiguity between the CS and the shock-free period to determine the effect of these manipulations on the acquisition of inhibition and $APPR^-$ behavior.

An experiment could attempt to manipulate the contiguity between the CS-platform and the shock-free period by first exposing two groups to forward conditioning of CS-buzzer and shock. Then, one group is exposed to backward conditioning of shock and CS-platform with random presentations of the buzzer while the second group is exposed to backward presentations of shock and CS-platform with CS-buzzer presentations during the intertrial intervals. Under such conditions, the negative contingency between US-shock and CS-platform is the same in the two groups but the temporal contiguity between the CS and a shock-free period is altered in the second group by buzzer presentations. If $APPR^-$ behavior is acquired in the first group because the CS reliably signals a "safe period", then presenting the buzzer might retard the acquisition of $APPR^-$ behavior in the second group.

Other experiments could attempt to manipulate the degree of contingency between US and CS without manipulations to the temporal relationship between the CS and the shock-free period. Such studies might provide some indication of the extent that conditioned inhibition plays a role in the acquisition of $APPR^-$ behavior.

Finally, it would be important to evaluate more directly the role of context conditioning in our Pavlovian aversive conditioning preparation of aversive sign-tracking. Since there are important procedural and empirical similarities between aversive and appetitive sign-tracking (Leclerc, 1985), one way to approach the study of context conditioning in aversive sign-tracking might be to attempt to parallel appetitive sign-tracking procedures which deal with the question of context control in conditioning (Kaplan & Hearst, 1985).

A general strategy used to evaluate contextual associative value consists in modifying the hypothesized associative value of the context while leaving intact the associative strength of the CS. The CS is then presented in the modified context and changes in behavior are assumed to be revealing of the nature (i.e., excitatory, inhibitory, or neutral) of the original contextual associative value (Balsam, 1985).

An example of this strategy could be incorporated in an experiment consisting of three phases. In Phase 1 (conditioning phase), $APPR^-$ behavior to the platform ($CS^-$) would be produced by backward pairings of shock-platform (Group $APPR^-$), and $WDR^+$ behavior to the platform ($CS^+$) would be produced by forward pairings of platform-shock (Group $WDR^+$). In Phase 2 (treatment phase), platforms would not be presented and half of the animals in each group would be exposed to the context alone (Group $APPR^-$/Extinction and Group $WDR^+$/Extinction) while the other half would stay in their home cage (Group $APPR^-$/Home Cage and Group $WDR^+$/Home Cage). In Phase 3 (CS alone phase), all subjects would be exposed to platform presentations in the absence of shock. It can be predicted from Rescorla and Wagner's (1972) model that Group $APPR^-$/Extinction should respond less than subjects in Group $APPR^-$/Home Cage.

If this prediction was confirmed, it would provide added support to the suggestion made earlier (in Experiment

4) that a background of excitation is necessary for the expression of conditioned inhibition. It would also provide some evidence that a background of excitation is also necessary for the development of $APPR^-$ behavior. The data would parallel those of Kaplan and Hearst (1985, Experiment 1) who concluded that, in appetitive sign-tracking, contextual excitation is necessary for the development of conditioned inhibition. In conclusion, studies of contextual control in aversive sign-tracking should help to identify more precisely the Pavlovian mechanism responsible for both $APPR^-$ and $WDR^+$ behavior.

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Appendix 1. Individual data (percent time on platform) for Group Diffcond for each baseline, training 1 and training 2 sessions in Experiment 1.

| | | Group Diffcond | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | |
| | Session | 1(2) | 2(3) | 3(8) | 4(17) | 5(6) | 6(7) | 7(14) | 8(2) |
| Baseline | 1 | 12.2 | 11.0 | 40.8 | 3.4 | 0 | 4.6 | 5.2 | 0 |
| | 2 | 3.7 | 3.7 | 43.7 | 4.3 | 2.2 | 9.8 | 1.0 | 0 |
| | 3 | 5.0 | 16.7 | 19.8 | 2.5 | 1.3 | 28.9 | 6.0 | 0 |
| | 4 | 15.7 | 24.0 | 10.0 | .9 | 0 | 58.7 | 13.4 | 16.7 |
| | 5 | 0 | 40.9 | 5.3 | 2.5 | 23.5 | 14.7 | 18.3 | 0 |
| Training 1 | 1 | 56.1 | 84.8 | 96.5 | 14.9 | 94.1 | 72.3 | 92.8 | 70.9 |
| | 2 | 68.7 | 99.3 | 99.0 | 45.7 | 76.1 | 44.9 | 97.4 | 92.2 |
| | 3 | 89.3 | 55.7 | 92.3 | 87.0 | 76.6 | 75.5 | 95.9 | 95.1 |
| | 4 | 98.8 | 86.1 | 98.9 | 99.0 | 89.6 | 100 | 86.8 | 90.3 |
| Training 2 | 1 | 100 | 90.6 | 97.5 | 98.6 | 89.9 | 92.1 | 100 | 88.9 |
| | 2 | 29.3 | 34.1 | 71.5 | 89.6 | 98.9 | 30.0 | 95.7 | 86.9 |
| | 3 | 0 | 8.5 | 38.0 | 99.2 | 82.6 | 99.1 | 42.8 | 57.2 |
| | 4 | 0 | 0 | 4.8 | 98.3 | 30.0 | 59.8 | 13.4 | 66.3 |
| | 5 | 0 | .7 | 38.6 | 10.7 | 59.7 | 60.0 | 14.3 | 66.8 |
| | 6 | 0 | 1.8 | 6.2 | 3.0 | 68.3 | 62.4 | 13.7 | 76.5 |

| Group Diffcond | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | | | | | | | | |
| 9(7) | 10(8) | 11(10) | 12(3) | 13(9) | 14(15) | 15(16) | 16(6) | X |
| 1.8 | 4.7 | 14.3 | 6.3 | 0 | 82.0 | 15.7 | 5.2 | 13.0 |
| 0 | 13.7 | 3.6 | 0 | 2.1 | 68.4 | 1.9 | 5.8 | 10.2 |
| 0 | 6.4 | 0 | 0 | 5.0 | 65.4 | 17.5 | 9.8 | 11.5 |
| 26.2 | 5.7 | 0 | 0 | 33.6 | 36.1 | 0 | 66.7 | 19.2 |
| 19.3 | 2.7 | 4.9 | 18.2 | 50.5 | 53.4 | 16.9 | 19.3 | 16.2 |
| | | | | | | | | |
| 14.5 | 69.1 | 68.9 | 82.8 | 70.4 | 56.8 | 50.0 | 70.0 | 66.6 |
| 45.2 | 92.1 | 99.4 | 97.7 | 99.0 | 100 | 84.5 | 80.0 | 82.6 |
| 50.3 | 94.8 | 94.2 | 89.3 | 94.5 | 89.2 | 91.6 | 90.0 | 85.1 |
| 74.8 | 81.5 | 95.2 | 95.3 | 95.6 | 94.0 | 71.9 | 100 | 91.1 |
| | | | | | | | | |
| 42.6 | 93.8 | 97.0 | 90.5 | 97.2 | 95.7 | 77.0 | 100 | 90.7 |
| 74.7 | 96.1 | 76.3 | 96.2 | 68.2 | 96.2 | 83.5 | 98.5 | 76.6 |
| 92.2 | 83.2 | 94.7 | 86.0 | 71.5 | 84.7 | 70.3 | 100 | 69.4 |
| 93.0 | 62.6 | 88.7 | 46.2 | 92.2 | 90.3 | 81.7 | 90.0 | 57.3 |
| 50.5 | 26.6 | 93.7 | 26.8 | 92.0 | 19.2 | 72.0 | 90.3 | 45.1 |
| 46.1 | 39.2 | 96.2 | 13.7 | 85.8 | 38.5 | 90.0 | 42.2 | 42.7 |

Appendix 2. Individual data (percent time on platform) for Group BKPLB for each baseline, training 1 and training 2 sessions in Experiment 1.

| | | Group BKPLB | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | |
| | Session | 1(9) | 2(6) | 3(7) | 4(12) | 5(13) | 6(10) | 7(11) | 8(12) |
| Baseline | 1 | 0 | 2.0 | 13.8 | 12.6 | 10.5 | .5 | 17.6 | 61.7 |
| | 2 | 0 | .4 | 6.2 | 2.0 | 16.7 | 1.0 | 32.0 | 13.4 |
| | 3 | 0 | 3.7 | 34.0 | 3.0 | 4.1 | 2.8 | 4.0 | 3.6 |
| | 4 | 9.6 | 8.6 | 18.1 | 8.0 | 2.2 | 3.3 | 20.9 | 0 |
| | 5 | 8.6 | 2.0 | 41.8 | 10.7 | 12.2 | 13.1 | 16.7 | 0 |
| Training 1 | 1 | 68.0 | 55.2 | 72.4 | 57.3 | 96.0 | 81.3 | 71.9 | 69.7 |
| | 2 | 97.8 | 92.5 | 91.6 | 95.7 | 99.6 | 99.5 | 93.8 | 98.8 |
| | 3 | 39.6 | 86.3 | 100 | 95.7 | 100 | 99.1 | 96.5 | 98.5 |
| | 4 | 89.8 | 99.3 | 99.7 | 100 | 100 | 99.8 | 92.0 | 99.7 |
| Training 2 | 1 | 100 | 100 | 100 | 100 | 99.5 | 99.7 | 98.6 | 100 |
| | 2 | 98.6 | 99.5 | 91.7 | 88.2 | 10.0 | 39.5 | 85.4 | 98.8 |
| | 3 | 40.0 | 29.8 | 87.2 | 57.8 | 0 | 10.0 | 49.6 | 99.1 |
| | 4 | 38.1 | 10.0 | 99.6 | 1.3 | 0 | 0 | 84.8 | 99.9 |
| | 5 | 39.6 | 10.0 | 78.3 | 19.8 | 2.5 | 0 | 66.6 | 44.9 |
| | 6 | 78.8 | 0 | 8.7 | 36.0 | 0 | 0 | 18.2 | 90.4 |

| Group BKPLB | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | | | | | | | | |
| 9(5) | 10(11) | 11(4) | 12(13) | 13(2) | 14(7) | 15(12) | 16(7) | X |
| 1.3 | 18.8 | .7 | 3.5 | 34.5 | 14.5 | 11.6 | 62.2 | 16.6 |
| 0 | 26.3 | 1.0 | 24.5 | 0 | 37.9 | 0 | 22.7 | 11.5 |
| 5.5 | 57.2 | 3.9 | 51.0 | 0 | 49.2 | 9.2 | 28.2 | 16.2 |
| 1.0 | 40.4 | 6.3 | 16.6 | 0 | 56.6 | 14.1 | 15.5 | 13.8 |
| 0 | 56.7 | 10.0 | 9.4 | 0 | 44.3 | 7.3 | 18.3 | 15.7 |
| 44.0 | 55.2 | 19.5 | 60.1 | 0 | 86.8 | 27.1 | 47.5 | 57.0 |
| 87.3 | 78.2 | 80.0 | 100 | 59.8 | 100 | 98.7 | 97.3 | 91.9 |
| 89.4 | 92.2 | 89.0 | 92.6 | 94.0 | 93.8 | 89.3 | 97.0 | 90.8 |
| 90.0 | 80.6 | 93.3 | 95.0 | 91.8 | 94.9 | 90.1 | 99.5 | 94.7 |
| 76.3 | 92.7 | 94.6 | 96.8 | 77.3 | 97.0 | 91.5 | 62.2 | 92.9 |
| 94.9 | 94.2 | 95.7 | 95.5 | 0 | 76.0 | 92.8 | 85.7 | 77.9 |
| 47.4 ? | 95.6 | 86.1 | 95.3 | 9.3 | 51.2 | 50.5 | 49.3 | 53.6 |
| 56.6 | 95.4 | 82.7 | 95.3 | 0 | 39.3 | 80.3 | 50.0 | 52.1 |
| 56.1 | 94.8 | 92.4 | 66.2 | 67.3 | 46.3 | 87.2 | 100 | 54.5 |
| 75.8 | 91.6 | 73.2 | 66.0 | 70.0 | 13.3 | 51.8 | 59.0 | 45.8 |

Appendix 3. Individual data (percent time on platform) for Group BKPL for each baseline, training 1 and training 2 sessions in Experiment 1.

| | | Group BKPL | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | |
| | Session | 1(5) | 2(10) | 3(11) | 4(9) | 5(2) | 6(15) | 7(16) | 8(18) |
| Baseline | 1 | 2.1 | 1.0 | 5.5 | 36.7 | 0 | 7.4 | 36.6 | 9.7 |
| | 2 | 9.3 | 0 | 0 | 10.6 | 0 | 2.2 | 3.0 | 2.0 |
| | 3 | 53.1 | 0 | 0 | 8.9 | 0 | 8.8 | 0 | 1.3 |
| | 4 | 54.3 | 0 | 7.5 | 3.5 | 0 | 9.5 | 0 | 36.5 |
| | 5 | 31.8 | 8.7 | 14.4 | 19.9 | 7.0 | 28.0 | 1.8 | 42.6 |
| Training 1 | 1 | 99.6 | 74.5 | 86.8 | 79.5 | 17.9 | 73.5 | 32.5 | 35.5 |
| | 2 | 89.8 | 98.5 | 98.8 | 99.5 | 100 | 90.3 | 98.2 | 46.5 |
| | 3 | 100 | 100 | 90.0 | 90.0 | 98.2 | 97.2 | 99.7 | 69.4 |
| | 4 | 99.9 | 98.8 | 89.8 | 99.8 | 99.0 | 83.1 | 100 | 69.4 |
| Training 2 | 1 | 88.4 | 89.9 | 89.6 | 99.5 | 99.7 | 94.4 | 99.6 | 90.0 |
| | 2 | 79.5 | 100 | 43.9 | 89.7 | 40.0 | 98.4 | 98.9 | 90.0 |
| | 3 | 39.5 | 99.0 | 11.9 | 69.7 | 19.0 | 97.9 | 94.7 | 100 |
| | 4 | 69.0 | 68.4 | 3.3 | 74.5 | 67.2 | 67.7 | 36.6 | 89.9 |
| | 5 | 78.9 | 94.4 | 0 | 99.9 | 69.8 | 44.9 | 13.7 | 89.8 |
| | 6 | 18.1 | 41.5 | 14.3 | 88.2 | 89.4 | 55.1 | 27.7 | 99.5 |

| Group BKPL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | | | | | | | | |
| 9(3) | 10(12) | 11(5) | 12(6) | 13(11) | 14(1) | 15(14) | 16(8) | X |
| 4.6 | 57.7 | 0 | 0 | 0 | 52.7 | 9.7 | 16.4 | 15.0 |
| 2.3 | 24.8 | 0 | 0 | 0 | 0 | 8.8 | 41.0 | 6.5 |
| 1.3 | 35.6 | 0 | .4 | 0 | 0 | 41.6 | 41.9 | 12.1 |
| 0 | 29.9 | 75.1 | 0 | 0 | 6.6 | 23.0 | 24.2 | 16.9 |
| 6.4 | 17.9 | 35.4 | 0 | 0 | 4.6 | 11.6 | 28.5 | 16.2 |
| | | | | | | | | |
| 53.0 | 69.1 | 98.5 | 0 | 14.8 | 72.8 | 89.2 | 88.3 | 67.1 |
| 76.5 | 96.8 | 95.3 | 26.3 | 52.8 | 89.5 | 96.5 | 94.5 | 84.4 |
| 91.7 | 96.5 | 96.7 | 55.2 | 76.2 | 95.2 | 96.7 | 96.5 | 90.6 |
| 94.7 | 89.4 | 96.2 | 75.8 | 84.2 | 95.7 | 96.7 | 94.8 | 89.7 |
| | | | | | | | | |
| 92.7 | 95.2 | 95.8 | 85.2 | 67.2 | 85.2 | 95.3 | 94.5 | 91.4 |
| 47.0 | 95.4 | 92.5 | 86.7 | 9.7 | 95.8 | 96.5 | 77.2 | 77.6 |
| 60.8 | 96.2 | 52.5 | 96.8 | 25.8 | 93.3 | 86.0 | 64.2 | 69.2 |
| 76.6 | 86.6 | 0 | 96.5 | 9.5 | 18.7 | 76.5 | 45.3 | 55.4 |
| 81.0 | 79.6 | 0 | 97.0 | 28.7 | 65.7 | 45.0 | 20.5 | 57.0 |
| 55.7 | 84.6 | 2.3 | 96.0 | 0 | 54.8 | 84.7 | 19.8 | 52.0 |

Appendix 4. Individual data (percent time on platform) for Group UNP for each baseline, training 1 and training 2 sessions in Experiment 1.

| | | Group UNP | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | |
| | Session | 1(1) | 2(2) | 3(3) | 4(4) | 5(5) | 6(6) | 7(7) | 8(8) |
| Baseline | 1 | 3.2 | 0 | 44.2 | 60.7 | 4.8 | 5.3 | 3.3 | 12.2 |
| | 2 | 2.2 | 0 | 21.7 | 32.9 | 0 | 0 | 2.8 | 30.2 |
| | 3 | 0 | 0 | 2.5 | 27.2 | 3.0 | 0 | 0 | 25.7 |
| | 4 | 9.7 | 0 | 8.0 | 15.3 | 1.8 | .7 | 10.2 | 11.5 |
| | 5 | 12.2 | 0 | 14.7 | 17.0 | 0 | 4.2 | 20.8 | 37.8 |
| Training 1 | 1 | 9.2 | 0 | 88.5 | 62.7 | 0 | 48.3 | 11.2 | 78.5 |
| | 2 | 54.2 | 0 | 74.0 | 74.7 | 0 | 54.7 | 46.2 | 64.2 |
| | 3 | 54.0 | 0 | 93.7 | 93.0 | 0 | 96.2 | 73.0 | 46.5 |
| | 4 | 36.5 | 0 | 93.3 | 84.2 | 0 | 93.5 | 82.2 | 16.7 |
| Training 2 | 1 | 88.5 | 0 | 78.0 | 91.8 | 0 | 93.2 | 93.0 | 0 |
| | 2 | 84.9 | 0 | 93.1 | 94.0 | 0 | 83.9 | 93.1 | 9.0 |
| | 3 | 94.4 | 0 | 89.6 | 93.7 | 0 | 94.6 | 91.5 | 9.2 |
| | 4 | 93.3 | 0 | 94.8 | 94.8 | 0 | 94.6 | 92.3 | 93.2 |
| | 5 | 91.4 | 0 | 92.9 | 93.6 | 0 | 94.1 | 94.4 | 36.3 |
| | 6 | 94.3 | 0 | 93.2 | 94.0 | 0 | 85.4 | 94.6 | 93.4 |

| Group UNP | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | | | | | | | | |
| 9(9) | 10(10) | 11(11) | 12(12) | 13(13) | 14(14) | 15(1) | 16(10) | X |
| 1.0 | 0 | 0 | 0 | 50.2 | 1.5 | 23.1 | 10.5 | 13.8 |
| 2.8 | 0 | 0 | 25.8 | 50.7 | 0 | 6.7 | 28.3 | 12.8 |
| 10.3 | 0 | 19.0 | 13.5 | 60.7 | 0 | 11.2 | 78.8 | 15.7 |
| 7.8 | 0 | 20.0 | 4.8 | 53.3 | 0 | 26.5 | 11.2 | 11.3 |
| 5.5 | 0 | 5.7 | 0 | 11.8 | 0 | 60.3 | 4.0 | 12.1 |
| | | | | | | | | |
| 35.7 | 17.2 | 7.7 | 7.5 | 34.0 | 79.0 | 36.7 | 10.0 | 32.9 |
| 83.3 | 75.2 | 53.2 | 15.8 | 39.2 | 94.0 | 90.0 | 0 | 51.2 |
| 90.3 | 84.0 | 79.7 | 41.5 | 75.3 | 94.3 | 20.3 | 99.3 | 65.1 |
| 94.0 | 65.8 | 84.0 | 6.8 | 84.3 | 94.5 | 38.2 | 100 | 60.9 |
| | | | | | | | | |
| 84.2 | 56.3 | 93.7 | 0 | 83.2 | 94.7 | 99.8 | 92.2 | 65.5 |
| 0 | 93.6 | 84.6 | 0 | 85.6 | 94.9 | 81.8 | 95.8 | 62.1 |
| 0 | 85.0 | 94.1 | 0 | 84.4 | 94.9 | 100 | 98.7 | 64.4 |
| 39.2 | 94.8 | 92.4 | 0 | 85.0 | 94.6 | 100 | 100 | 73.1 |
| 45.5 | 28.6 | 94.7 | 0 | 66.4 | 94.6 | 100 | 100 | 64.5 |
| 84.4 | 75.1 | 94.2 | 0 | 93.1 | 94.9 | 100 | 100 | 74.8 |

Appendix 5. Individual data (percent time on platform) for Group RAND for each baseline, training 1 and training 2 sessions in Experiment 1.

| | Group RAND | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | |
| | Session | 1(1) | 2(2) | 3(3) | 4(4) | 5(5) | 6(6) | 7(7) | 8(8) |
| Baseline | 1 | 56.3 | .5 | .2 | 54.5 | .6 | 1.3 | .3 | 15.8 |
| | 2 | 52.5 | 10.8 | 12.2 | 33.3 | 4.8 | 1.7 | 1.0 | 6.7 |
| | 3 | 33.2 | 23.3 | 29.8 | 21.0 | 11.8 | 14.2 | 54.2 | 4.8 |
| | 4 | 19.8 | 32.5 | 27.5 | 7.3 | 7.7 | 37.5 | 25.8 | 4.2 |
| | 5 | 25.5 | 21.8 | 21.0 | 25.0 | 5.7 | 26.7 | 16.0 | 6.8 |
| Training 1 | 1 | 83.7 | 68.7 | 27.7 | 20.3 | 5.2 | 82.5 | 68.5 | 27.0 |
| | 2 | 66.7 | 86.5 | 42.8 | 100 | .7 | 16.7 | 25.8 | 28.8 |
| | 3 | 58.8 | 99.2 | 80.0 | 70.0 | .2 | 69.8 | .7 | 98.5 |
| | 4 | 90.2 | 80.0 | 79.7 | 99.8 | 0 | 96.0 | 72.3 | 88.2 |
| Training 2 | 1 | 99.7 | 100 | 77.3 | 100 | 10.0 | 99.8 | 93.0 | 96.7 |
| | 2 | 99.5 | 100 | 60.7 | 90.0 | 0 | 100 | 29.7 | 76.8 |
| | 3 | 99.8 | 39.8 | 90.0 | 10.0 | 0 | 90.0 | 5.7 | 0 |
| | 4 | 100 | 10.0 | 56.0 | 10.0 | 0 | 96.3 | 3.7 | 10.0 |
| | 5 | 99.3 | 10.3 | 43.2 | 0 | 0 | 98.7 | 13.5 | 50.0 |
| | 6 | 49.8 | 30.2 | 45.8 | 0 | 0 | 99.8 | 9.8 | 39.5 |

| Group RAND | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subject | | | | | | | | |
| 9(9) | 10(10) | 11(11) | 12(12) | 13(5) | 14(2) | 15(3) | 16(4) | X |
| 7.7 | 3.7 | 2.5 | 16.7 | 0 | 28.3 | 47.5 | 4.7 | 15.0 |
| 4.5 | 1.2 | 5.2 | 3.0 | 0 | 85.8 | 36.7 | 5.3 | 16.5 |
| 7.0 | 3.3 | 7.7 | 58.7 | 13.0 | 96.7 | 10.8 | 40.5 | 26.9 |
| 6.8 | 3.7 | 17.2 | 19.5 | 14.2 | 72.8 | 42.3 | 60.3 | 24.9 |
| 24.0 | 2.3 | 20.7 | 21.2 | 17.2 | 79.8 | 47.8 | 65.5 | 26.7 |
| 89.3 | 69.8 | 4.8 | 78.7 | 75.2 | 75.0 | 75.7 | 59.7 | 57.0 |
| 80.5 | 56.8 | 24.7 | 99.0 | 90.0 | 92.8 | 99.2 | 46.5 | 59.8 |
| 100 | 99.7 | 76.3 | 66.7 | 100 | 79.8 | 99.5 | 55.3 | 72.2 |
| 89.8 | 100 | 100 | 83.5 | 100 | 98.0 | 98.8 | 69.7 | 84.1 |
| 100 | 59.7 | 100 | 78.7 | 100 | 100 | 100 | 78.2 | 87.1 |
| 0 | 0 | 0 | 30.5 | 100 | 99.8 | 78.3 | 69.7 | 58.4 |
| 0 | 0 | 0 | 1.2 | 70.0 | 99.0 | 2.8 | 100 | 38.0 |
| 0 | 0 | 0 | 28.5 | 74.0 | 100 | .7 | 12.5 | 31.4 |
| 0 | 0 | .2 | 38.2 | 49.2 | 100 | 1.7 | 77.3 | 36.4 |
| 0 | 0 | 92.0 | 10.0 | 100 | 100 | 2.3 | 39.7 | 38.7 |

Appendix 6. Summary of the statistical analyses made on baseline, training 1 and training 2 data in Experiment 1.

| | Baseline | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 4817.77 | 4 | 1204.44 | 1.21463 |
| S.WG | 74371.2 | 75 | 992.616 | |
| B | 2007.85 | 4 | 501.963 | 2.48086 |
| AB | 2352.9 | 16 | 147.056 | .726798 |
| BS.WG | 60700.3 | 300 | 202.334 | |

P(FA) = .311245
P(FB) = .0432853
P(FAB) = .766878

| | Training 1 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 45557.8 | 4 | 11389.4 | 7.70495 |
| S.WG | 11086.5 | 75 | 1478.2 | |
| B | 41822 | 3 | 13940.7 | 43.6548 |
| AB | 5905.25 | 12 | 492.104 | 1.54101 |
| BS.WG | 71851.3 | 225 | 319.339 | |

P(FA) = 1.01185E-04
P(FB) = 1.74135E-09
P(FAB) = .110595

| | Training 2 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 23574.3 | 4 | 5893.56 | 1.27707 |
| S.WG | 346119 | 75 | 4614.92 | |
| B | 75009.9 | 5 | 15002 | 30.4324 |
| AB | 36752.3 | 20 | 1837.61 | 3.7277 |
| BS.WG | 184860 | 375 | 492.961 | |

P(FA) = .285844
P(FB) = 4.36599E-10
P(FAB) = 5.7104E-06

Appendix 7. Individual data (percent time on platform) for Group BK1 for each baseline, training 1 and training 2 sessions in Experiment 2.

| | Session | Group BK1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | | 1(1) | 2(2) | 3(3) | 4(8) | 5(1) | 6(6) | 7(3) | 8(4) | X |
| Baseline | 1 | 6.7 | 3.3 | 6.7 | 23.3 | 0 | 10.0 | 40.0 | 8.3 | 12.3 |
| | 2 | 8.3 | 3.3 | 0 | 35.0 | 0 | 6.7 | 0 | 96.7 | 18.8 |
| | 3 | 0 | 0 | 3.3 | 100 | 0 | 0 | 98.3 | 83.3 | 35.6 |
| | 4 | 0 | 0 | 0 | 96.7 | 0 | 6.7 | 100 | 28.3 | 29.0 |
| | 5 | 0 | 1.7 | 3.3 | 78.3 | 0 | 3.3 | 68.3 | 80.0 | 29.4 |
| Training 1 | 1 | 0 | 1.7 | 0 | 3.3 | 0 | 0 | 35.0 | 1.7 | 5.2 |
| | 2 | 0 | 0 | 68.3 | 0 | 1.7 | 36.7 | 53.3 | 98.3 | 32.3 |
| | 3 | 0 | 0 | 20.0 | 1.7 | 0 | 0 | 100 | 0 | 15.2 |
| | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 58.3 | 0 | 7.3 |
| | 5 | 0 | 1.7 | 8.3 | 76.7 | 0 | 0 | 26.7 | 0 | 14.2 |
| | 6 | 0 | 100 | 100 | 0 | 18.3 | 0 | 100 | 93.3 | 51.5 |
| | 7 | 5.0 | 0 | 100 | 0 | 11.0 | 0 | 60.0 | 32.0 | 26.0 |
| Training 2 | 1 | 0 | 0 | 88.3 | 0 | 3.3 | 0 | 100 | 0 | 24.0 |
| | 2 | 0 | 5.0 | 96.7 | 0 | 0 | 0 | 48.3 | 0 | 18.8 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 12.5 |
| | 4 | 0 | 0 | 1.7 | 0 | 0 | 0 | 1.6 | 0 | .4 |
| | 5 | 0 | 0 | 98.3 | 0 | 0 | 0 | 0 | 0 | 12.3 |
| | 6 | 0 | 0 | 38.3 | 0 | 0 | 0 | 0 | 0 | 4.8 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Appendix 8. Individual data (time spent on platform) for Group RD1 for each baseline, training 1 and training 2 sessions in Experiment 2.

| | Session | Group RD1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | | 1(5) | 2(6) | 3(7) | 4(4) | 5(5) | 6(2) | 7(7) | 8(8) | X |
| Baseline | 1 | 0 | 0 | 0 | 60.0 | 0 | 21.7 | 23.3 | 46.7 | 19.0 |
| | 2 | 0 | 0 | 0 | 93.3 | 0 | 23.7 | 8.3 | 80.0 | 25.7 |
| | 3 | 0 | 0 | 6.7 | 98.7 | 0 | 91.7 | 10.0 | 13.3 | 27.6 |
| | 4 | 0 | 3.3 | 0 | 71.7 | 0 | 93.3 | 8.3 | 48.3 | 28.1 |
| | 5 | 0 | 3.3 | 0 | 85.0 | 0 | 70.0 | 5.0 | 100 | 32.9 |
| Training 1 | 1 | 3.3 | 3.3 | 5.0 | 75.0 | 0 | 100 | 21.7 | 8.3 | 26.5 |
| | 2 | 0 | 0 | 0 | 90.0 | 0 | 38.3 | 86.7 | 50.0 | 34.0 |
| | 3 | 31.7 | 0 | 0 | 85.0 | 70.0 | 56.7 | 100 | 85.0 | 49.6 |
| | 4 | 0 | 0 | 0 | 93.3 | 0 | 98.3 | 93.3 | 90.0 | 51.5 |
| | 5 | 0 | 0 | 0 | 98.3 | 0 | 100 | 100 | 70.0 | 46.0 |
| | 6 | 0 | 0 | 0 | 100 | 0 | 0 | 100 | 100 | 37.5 |
| | 7 | 5.2 | 0 | 0 | 100 | 0 | 0 | 60.0 | 57.0 | 27.1 |
| Training 2 | 1 | 0 | 0 | 0 | 16.7 | 0 | 0 | 100 | 100 | 27.1 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 25.0 |
| | 3 | 0 | 0 | 0 | 0 | 0 | 5.0 | 100 | 100 | 25.6 |
| | 4 | 0 | 0 | 0 | 0 | 0 | 55.0 | 15.0 | 100 | 21.3 |
| | 5 | 0 | 0 | 0 | 0 | 0 | 3.3 | 100 | 100 | 25.4 |
| | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 25.0 |
| | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78.3 | 9.8 |

Appendix 9. Individual data (percent time on platform) for Group BK5 for each baseline, training 1 and training 2 sessions in Experiment 2.

| | Session | Group BK5 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | | 1(9) | 2(10) | 3(11) | 4(12) | 5(9) | 6(10) | 7(11) | 8(12) | X |
| Baseline | 1 | 0 | 16.0 | 1.3 | 21.3 | 3.3 | 28.0 | 11.3 | 11.3 | 11.6 |
| | 2 | 1.7 | 51.0 | 1.0 | 3.0 | 70.7 | 37.0 | 2.0 | 20.0 | 23.3 |
| | 3 | 1.0 | 30.3 | 3.3 | 5.7 | 68.3 | 12.3 | 12.0 | 28.3 | 20.2 |
| | 4 | .3 | 12.7 | 2.7 | 5.0 | 54.3 | 29.7 | 5.7 | 39.0 | 18.7 |
| | 5 | 1.7 | 12.7 | 2.3 | 6.7 | 40.7 | 3.7 | 35.3 | 24.3 | 15.9 |
| Training 1 | 1 | 0 | 13.7 | 2.0 | 75.3 | 100 | 22.1 | 0 | 38.3 | 32.5 |
| | 2 | 53.0 | 45.0 | 93.0 | 75.0 | 100 | 31.0 | 39.7 | 80.0 | 60.7 |
| | 3 | 100 | 79.3 | 75.3 | 98.7 | 100 | 0 | 77.3 | 79.3 | 76.2 |
| | 4 | 33.3 | 100 | 99.4 | 100 | 100 | 0 | 17.3 | 100 | 68.8 |
| | 5 | 0 | 100 | 80.0 | 60.0 | 100 | 0 | 100 | 100 | 67.5 |
| | 6 | 33.0 | 80.0 | 94.7 | 80.0 | 100 | 0 | 86.0 | 100 | 71.7 |
| | 7 | 54.7 | 40.0 | 100 | 60.0 | 100 | 0 | 99.7 | 99.7 | 69.3 |
| Training 2 | 1 | 40.0 | 20.0 | 98.7 | 100 | 100 | 0 | 80.0 | 99.7 | 67.3 |
| | 2 | 37.3 | 60.0 | 60.0 | 80.0 | 94.0 | 0 | 100 | 100 | 66.4 |
| | 3 | 0 | 47.7 | 80.0 | 100 | 97.0 | 0 | 80.0 | 100 | 63.1 |
| | 4 | 0 | 39.3 | 60.7 | 100 | 20.0 | 0 | 60.0 | 78.7 | 44.8 |
| | 5 | 0 | 0 | 28.0 | 100 | 0 | 100 | 40.0 | 60.0 | 41.0 |
| | 6 | 19.7 | 0 | 0 | 93.0 | 0 | 97.0 | 0 | 19.7 | 28.7 |
| | 7 | 0 | 96.3 | 0 | 80.0 | 0 | 99.0 | 18.3 | 15.0 | 38.6 |

Appendix 10. Individual data (percent time on platform) for Group RD5 for each baseline, training 1 and training 2 sessions in Experiment 2.

| | Group RD5 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Subject | | | | | | | | | |
| | Session | 1(13) | 2(14) | 3(15) | 4(16) | 5(13) | 6(14) | 7(15) | 8(16) | X |
| Baseline | 1 | 3.3 | 2.7 | 0 | 11.3 | 10.3 | 5.7 | 10.0 | 26.3 | 8.7 |
| | 2 | 0 | 2.3 | .7 | 13.3 | 64.7 | 1.0 | 0 | 34.3 | 14.5 |
| | 3 | 1.3 | 7.0 | 10.0 | 25.0 | 80.3 | 1.0 | 19.0 | 10.0 | 19.2 |
| | 4 | 10.0 | 9.7 | 3.3 | 19.7 | 52.3 | 5.3 | 56.7 | 32.0 | 23.6 |
| | 5 | 5.3 | 46.0 | 5.0 | 30.3 | 35.3 | 28.0 | 32.7 | 18.0 | 25.1 |
| Training 1 | 1 | .7 | 41.3 | 54.3 | 20.3 | 98.7 | 9.0 | 42.0 | 6.0 | 34.0 |
| | 2 | .7 | 80.0 | 58.0 | 1.0 | 100 | 60.0 | 17.3 | 20.0 | 42.1 |
| | 3 | .3 | 0 | 10.0 | 0 | 40.0 | 66.7 | 19.3 | 0 | 17.0 |
| | 4 | 1.3 | 55.7 | 99.3 | 0 | 75.0 | 59.0 | 20.0 | 0 | 38.8 |
| | 5 | 1.7 | 40.0 | 100 | 1.0 | 71.7 | 80.0 | 0 | 0 | 36.8 |
| | 6 | 0 | 80.0 | 60.0 | 1.3 | 19.3 | 80.0 | 0 | 17.3 | 32.2 |
| | 7 | 2.3 | 60.0 | 78.7 | 1.7 | 29.7 | 91.7 | 0 | 0 | 33.0 |
| Training 2 | 1 | 0 | 40.0 | 100 | 0 | 18.0 | 95.7 | 13.0 | 0 | 33.3 |
| | 2 | 2.0 | 20.0 | 0 | 11.6 | 20.0 | 59.7 | 0 | 0 | 15.9 |
| | 3 | 2.0 | 24.0 | .7 | 5.3 | 49.3 | 99.7 | 14.0 | 0 | 24.4 |
| | 4 | 2.3 | 36.0 | 11.3 | 4.3 | 20.0 | 80.0 | 0 | 0 | 19.2 |
| | 5 | 13.3 | 97.0 | 1.2 | 9.0 | 37.3 | 80.7 | .7 | 0 | 29.9 |
| | 6 | 16.0 | 11.0 | 10.3 | 11.3 | 25.7 | 20.0 | .7 | 0 | 11.9 |
| | 7 | 12.3 | 5.7 | 1.3 | .5 | 6.3 | 80.0 | 0 | 0 | 13.3 |

Appendix 11. Individual data (percent time on platform) for Group BK10 for each baseline, training 1 and training 2 sessions in Experiment 2.

| | | Group BK10 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | Session | 1(1) | 2(2) | 3(3) | 4(4) | 5(5) | 6(6) | 7(7) | 8(8) | X |
| Baseline | 1 | 1.3 | 2.3 | 32.5 | 12.3 | 0 | .5 | 6.5 | 0 | 6.9 |
| | 2 | .7 | 10.8 | 31.7 | 1.9 | 0 | 14.8 | 2.3 | 0 | 7.8 |
| | 3 | .5 | 8.3 | 8.8 | 1.7 | .8 | 7.3 | 2.0 | .3 | 3.7 |
| | 4 | 0 | 1.7 | 1.3 | 0 | 4.8 | 14.8 | 1.5 | 2.8 | 3.4 |
| | 5 | 0 | 2.2 | 6.7 | 1.8 | 0 | 27.2 | 0 | 2.3 | 5.0 |
| Training 1 | 1 | 65.0 | 37.7 | 86.8 | 76.5 | 73.7 | 89.8 | 87.8 | 58.2 | 71.9 |
| | 2 | 80.0 | 95.8 | 99.2 | 93.3 | 96.8 | 77.8 | 82.0 | 100 | 90.6 |
| | 3 | 100 | 99.3 | 90.0 | 100 | 97.5 | 94.8 | 97.0 | 96.3 | 96.9 |
| | 4 | 100 | 100 | 100 | 100 | 99.0 | 79.3 | 100 | 87.2 | 95.7 |
| | 5 | 100 | 90.5 | 100 | 97.2 | 98.7 | 100 | 100 | 100 | 98.3 |
| | 6 | 100 | 95.8 | 97.8 | 92.3 | 97.0 | 98.2 | 100 | 100 | 97.6 |
| | 7 | 100 | 100 | 100 | 98.3 | 100 | 100 | 100 | 98.0 | 99.5 |
| Training 2 | 1 | 100 | 96.2 | 97.8 | 95.2 | 94.0 | 100 | 100 | 100 | 97.9 |
| | 2 | 99.3 | 100 | 100 | 98.7 | 100 | 100 | 99.8 | 98.3 | 99.5 |
| | 3 | 100 | 78.7 | 100 | 97.7 | 92.7 | 66.2 | 78.7 | 89.0 | 87.9 |
| | 4 | 59.8 | 41.3 | 89.8 | 100 | 96.7 | 100 | 97.3 | 35.0 | 77.5 |
| | 5 | 96.2 | 15.3 | 19.8 | 100 | 99.5 | 100 | 99.7 | .7 | 66.4 |
| | 6 | 15.2 | 60.5 | 0 | 100 | 34.0 | 100 | 57.3 | 0 | 44.6 |
| | 7 | 72.0 | 33.8 | 60.0 | 88.8 | 29.0 | 100 | 46.3 | .5 | 53.8 |

Appendix 12. Individual data (percent time on platform) for Group RD10 for each baseline, training 1 and training 2 sessions in Experiment 2.

| | | Group RD10 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | Session | 1(1) | 2(2) | 3(3) | 4(4) | 5(5) | 6(6) | 7(7) | 8(8) | X |
| Baseline | 1 | 0 | 1.7 | 17.7 | 1.0 | 1.0 | .5 | 0 | 3.5 | 3.2 |
| | 2 | .5 | 4.2 | .7 | 10.2 | .5 | 4.8 | 0 | 11.8 | 4.1 |
| | 3 | .8 | 14.2 | 1.7 | 0 | 41.0 | 6.8 | 0 | 12.7 | 9.7 |
| | 4 | 17.5 | 3.2 | .5 | 7.3 | 14.8 | 60.7 | .5 | 22.0 | 15.8 |
| | 5 | 84.7 | 1.0 | 2.5 | 22.3 | 5.7 | 23.2 | 0 | 27.2 | 20.8 |
| Training 1 | 1 | 12.2 | 35.7 | 1.0 | .8 | 10.7 | 60.8 | 3.2 | 79.7 | 25.5 |
| | 2 | .7 | 83.2 | 0 | 4.2 | 67.7 | 99.8 | 90.0 | 94.0 | 55.0 |
| | 3 | 1.2 | 99.3 | 0 | 0 | 90.7 | 81.2 | 0 | 59.0 | 41.4 |
| | 4 | 0 | 99.2 | 0 | 0 | 100 | 90.0 | 3.3 | 69.5 | 45.3 |
| | 5 | 29.3 | 39.5 | .3 | 0 | 100 | 100 | 0 | 80.0 | 43.6 |
| | 6 | 0 | 95.7 | .3 | 8.0 | 100 | 80.0 | 7.5 | 80.0 | 46.4 |
| | 7 | 0 | 100 | 0 | 0 | 100 | 100 | 28.8 | 79.5 | 51.0 |
| Training 2 | 1 | 0 | 90.0 | 2.2 | 0 | 100 | 100 | 10.0 | 100 | 50.3 |
| | 2 | 0 | 90.0 | 2.2 | 0 | 90.5 | 0 | 10.0 | 41.3 | 29.3 |
| | 3 | .8 | 90.0 | 0 | 4.7 | 29.8 | 10.3 | 2.0 | 44.5 | 22.8 |
| | 4 | 3.2 | 90.0 | 0 | 1.0 | 3.2 | 0 | 3.5 | 14.5 | 14.4 |
| | 5 | 0 | 90.0 | 0 | .7 | 15.7 | 7.0 | 1.5 | 0 | 14.4 |
| | 6 | 0 | 89.5 | 0 | 0 | 0 | .3 | 0 | 4.7 | 11.8 |
| | 7 | .7 | 99.2 | 0 | 1.3 | 0 | 28.2 | 0 | 0 | 16.2 |

Appendix 13. Summary of the statistical analyses made for Group BK1 and Group RD1 on baseline, training 1 and training 2 data in Experiment 2.

| | Baseline | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 53.488 | 1 | 53.488 | .0100997 |
| S.WG | 74144.3 | 14 | 5296.02 | |
| B | 2976.55 | 4 | 744.138 | 1.63789 |
| AB | 626.41 | 4 | 156.603 | .34469 |
| BS.WG | 25442.4 | 56 | 454.328 | |

P(FA) = .918161
P(FB) = .176556
P(FAB) = .847364

| | Training 1 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 8295.48 | 1 | 8295.48 | 1.20342 |
| S.WG | 96505.8 | 14 | 6893.27 | |
| B | 6997.06 | 6 | 1166.18 | 1.7601 |
| AB | 10894.1 | 6 | 1815.68 | 2.74038 |
| BS.WG | 55655.5 | 84 | 662.565 | |

P(FA) = .291321
P(FB) = .116651
P(FAB) = .0174742

| | Training 2 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 4273.09 | 1 | 4273.09 | .642588 |
| S.WG | 93097.3 | 14 | 6649.81 | |
| B | 4667.39 | 6 | 777.898 | 1.78837 |
| AB | 1054.84 | 6 | 175.807 | .404175 |
| BS.WG | 36538.1 | 84 | 434.977 | |

P(FA) = .55851
P(FB) = .110654
P(FAB) = .874672

Appendix 14. Summary of the statistical analyses made for Group BK5 and Group RD5 on baseline, training 1 and training 2 data in Experiment 2.

| | Baseline | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 1.871 | 1 | 1.871 | 1.66197E-03 |
| S.WG | 15761.6 | 14 | 1125.83 | |
| B | 1307.39 | 4 | 326.848 | 1.57766 |
| AB | 774.551 | 4 | 193.638 | .934667 |
| BS.WG | 11601.7 | 56 | 207.173 | |

P(FA) = .966992
P(FB) = .191932
P(FAB) = .547809

| | Training 1 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 25555.4 | 1 | 25555.4 | 4.10674 |
| S.WG | 87119.3 | 14 | 6222.81 | |
| B | 4808.41 | 6 | 801.401 | 1.45192 |
| AB | 8536.69 | 6 | 1422.78 | 2.5777 |
| BS.WG | 46364.5 | 84 | 551.958 | |

P(FA) = .0596504
P(FB) = .204052
P(FAB) = .0240101

| | Training 2 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 23661.1 | 1 | 23661.1 | 6.02029 |
| S.WG | 55023.1 | 14 | 3930.22 | |
| B | 10273.8 | 6 | 1712.29 | 2.01739 |
| AB | 4606.08 | 6 | 767.68 | .904465 |
| BS.WG | 71296.4 | 84 | 848.767 | |

P(FA) = .0264865
P(FB) = .0716358
P(FAB) = .503096

Appendix 15. Summary of the statistical analyses made for Group BK10 and Group RD10 on baseline, training 1 and training 2 data in Experiment 2.

| | Baseline | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 205.119 | 1 | 205.119 | 2.51257 |
| S.WG | 1142.92 | 14 | 81.6374 | |
| B | 238.563 | 4 | 59.6406 | .982425 |
| AB | 467.205 | 4 | 116.801 | 1.924 |
| BS.WG | 3399.62 | 56 | 60.7076 | |

P(FA) = .132273
P(FB) = .5742
P(FAB) = .118174

| | Training 1 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 24114.2 | 1 | 24114.2 | 11.7503 |
| S.WG | 28731.2 | 14 | 2052.23 | |
| B | 2757.27 | 6 | 459.544 | 5.39831 |
| AB | 380.719 | 6 | 63.4531 | .74539 |
| BS.WG | 7150.7 | 84 | 85.1274 | |

P(FA) = 4.26193E-03
P(FB) = 2.09824E-04
P(FAB) = .616538

| | Training 2 | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 27944 | 1 | 27944 | 17.6757 |
| S.WG | 22133 | 14 | 1580.93 | |
| B | 9316.91 | 6 | 1552.82 | 8.34157 |
| AB | 1754.17 | 6 | 292.362 | 1.57054 |
| BS.WG | 15637 | 84 | 186.154 | |

P(FA) = 1.15628E-03
P(FB) = 8.84899E-06
P(FAB) = .165162

Appendix 16. Individual data (percent time on platform) for Group BK10, Group BK5 and Group BK1 for each of the first seven trials of training 1 in Experiment 2.

| Group | Rat | Percentage of time spent on platform 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| | 1 | 0 | 0 | 10 | 70 | 100 | 100 | 78.3 |
| | 2 | 0 | 13.3 | 0 | 0 | 88.3 | 100 | 0 |
| | 3 | 16.7 | 51.7 | 100 | 100 | 100 | 100 | 100 |
| | 4 | 0 | 0 | 70 | 100 | 100 | 95 | 100 |
| BK10 | 5 | 10 | 0 | 68.3 | 100 | 100 | 100 | 100 |
| | 6 | 0 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 7 | 18.3 | 60 | 100 | 100 | 100 | 100 | 100 |
| | 8 | 0 | 10 | 0 | 0 | 85 | 100 | 100 |
| | X | 4.4 | 29.4 | 56.0 | 71.3 | 96.7 | 99.4 | 84.8 |
| | 9 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 10 | 0 | 0 | 0 | 66.7 | 88.3 | 0 | 0 |
| | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BK5 | 12 | 0 | 95 | 0 | 0 | 96.7 | 0 | 100 |
| | 5(9) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 6(10) | 60 | 1.7 | 0 | 6.7 | 0 | 0 | 0 |
| | 7(11) | 1.7 | 0 | 0 | 0 | 8.3 | 81.7 | 100 |
| | 8(12) | 3.3 | 78.3 | 100 | 100 | 95 | 88.3 | 75 |
| | X | 20.6 | 34.4 | 25.0 | 34.2 | 48.5 | 33.8 | 46.9 |
| | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 1.7 | 0 | 0 | 0 | 1.7 | 100 | 0 |
| | 3 | 0 | 68.3 | 20.0 | 0 | 8.3 | 100 | 100 |
| | 4 | 3.3 | 0 | 1.7 | 0 | 76.7 | 0 | 0 |
| BK1 | 5 | .0 | 1.7 | 0 | 0 | 0 | 18.3 | 11.0 |
| | 6 | 0 | 36.7 | 0 | 0 | 0 | 0 | 0 |
| | 7 | 35.0 | 53.3 | 100 | 58.3 | 26.7 | 100 | 60.0 |
| | 8 | 1.7 | 98.3 | 0 | 0 | 0 | 93.3 | 32.0 |
| | X | 5.2 | 32.3 | 15.2 | 7.3 | 14.2 | 51.5 | 25.4 |

Appendix 17. Summary of the statyistical analyses made for Group BK10, Group BK5 and Group BK1 on the first seven trials of training 1 in Experiment 2.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 50958.6 | 2 | 25479.3 | 4.86526 |
| S.WG | 10997.7 | 21 | 5236.99 | |
| B | 42990.7 | 6 | 7165.11 | 9.02914 |
| AB | 34540.7 | 12 | 2878.39 | 3.62721 |
| BS.WG | 99987.8 | 126 | 793.554 | |

P(FA) = .0179968

P(FB) = 2.85806E-06

P(FAB) = 2.31261E-04

Appendix 18. Individual data (percent time on platform) for Group BK5 and Group BK10 for the first thirty trials of training 1 in Experiment 2.

| | | Subject | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group | Session | 1(9) | 2(10) | 3(11) | 4(12) | 5(9) | 6(10) | 7(11) | 8(12) | X |
| | 1 & 2 | 26.5 | 29.4 | 47.5 | 75.2 | 100 | 26.6 | 19.9 | 59.2 | 48.0 |
| BK5 | 3 & 4 | 66.7 | 89.7 | 87.4 | 99.4 | 100 | 0 | 47.3 | 89.7 | 72.5 |
| | 5 & 6 | 16.5 | 90.0 | 87.4 | 70.0 | 100 | 0 | 93.0 | 100 | 69.6 |
| | 1 | 65.0 | 37.7 | 86.8 | 76.5 | 73.7 | 89.8 | 87.8 | 58.2 | 71.9 |
| BK10 | 2 | 80.0 | 95.8 | 99.2 | 93.3 | 96.8 | 77.8 | 82.0 | 100 | 90.6 |
| | 3 | 100 | 99.3 | 90.0 | 100 | 92.5 | 94.8 | 97.0 | 96.3 | 96.9 |

Appendix 19. Summary of the statistical analyses made for Group BK5 and Group BK10 for the first thirty trials of training 1 in Experiment 2.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 6391.75 | 1 | 6391.75 | 4.84094 |
| S.WG | 18484.9 | 14 | 1320.35 | |
| B | 5382 | 2 | 2691 | 8.33574 |
| AB | 171.969 | 2 | 85.9844 | 2.66348 |
| BS.WG | 9039.16 | 28 | 322.827 | |

P(FA) = .0429972

P(FB) = 1.76444E-03

P(FAB) = .771317

Appendix 20. Individual data (percent time on platform) for Group BKav for each baseline, training 1 and extinction sessions in Experiment 3.

| | Session | Group BKav | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | | 1(1) | 2(10) | 3(3) | 4(12) | 5(13) | 6(14) | 7(15) | 8(4) | X |
| Baseline | 1 | 2.0 | 0 | 0 | 39.0 | 1.0 | 7.5 | 0 | 26.0 | 9.4 |
| | 2 | 8.5 | 0 | 1.0 | 26.5 | 0 | 6.5 | 0 | 28.5 | 8.9 |
| | 3 | 2.5 | 1.5 | 6.0 | 27.0 | 1.0 | 7.5 | 0 | 22.0 | 8.4 |
| | 4 | 4.0 | 2.5 | 9.0 | 36.0 | 3.0 | 29.5 | 4.0 | 43.0 | 16.4 |
| | 5 | 2.0 | 0 | 15.5 | 26.5 | 2.0 | 9.5 | 4.0 | 48.5 | 13.5 |
| | 6 | 2.0 | 7.0 | 21.0 | 21.5 | 5.0 | 9.0 | 7.5 | 40.5 | 14.2 |
| Training | 1 | 96.8 | 41.0 | 95.7 | 83.5 | 67.9 | 46.1 | 2.1 | 60.6 | 61.7 |
| | 2 | 90.2 | 95.9 | 98.5 | 100 | 100 | 61.8 | 7.5 | 84.4 | 79.8 |
| | 3 | 95.3 | 100 | 97.9 | 89.6 | 99.4 | 77.4 | 44.6 | 99.4 | 88.0 |
| | 4 | 89.9 | 100 | 100 | 98.9 | 94.2 | 87.4 | 66.3 | 78.4 | 89.4 |
| | 5 | 82.2 | 100 | 100 | 94.8 | 95.8 | 79.4 | 61.9 | 89.9 | 88.0 |
| | 6 | 71.7 | 99.0 | 98.4 | 97.4 | 93.8 | 65.0 | 47.5 | 88.7 | 82.7 |
| | 7 | 95.1 | 100 | 100 | 96.4 | 100 | 71.3 | 25.9 | 98.2 | 85.9 |
| Extinction | 1 | 88.5 | 100 | 95.3 | 96.4 | 82.7 | 70.3 | 29.2 | 65.4 | 82.2 |
| | 2 | 99.5 | 100 | 84.2 | 98.4 | 94.2 | 39.5 | 7.4 | 64.7 | 78.5 |
| | 3 | 65.6 | 85.9 | 59.4 | 97.4 | 87.4 | 29.8 | 14.7 | 61.8 | 73.5 |
| | 4 | 48.2 | 84.3 | 63.9 | 87.4 | 85.3 | 25.1 | 22.5 | 75.4 | 62.8 |
| | 5 | 29.2 | 78.4 | 67.8 | 93.6 | 31.1 | 54.1 | 6.6 | 64.3 | 61.5 |
| | 6 | 65.8 | 70.7 | 82.1 | 95.7 | 80.3 | 95.3 | 17.6 | 78.8 | 53.1 |
| | 7 | 32.5 | 23.7 | 80.4 | 79.9 | 38.5 | 91.8 | 24.6 | 74.9 | 73.3 |

Appendix 21. Individual data (percent time on platform) for Group BKshlg for each baseline, training 1 and extinction sessions in Experiment 3.

| | Session | Group BKshlg | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Subject | | | | | | | | |
| | | 1(9) | 2(2) | 3(11) | 4(16) | 5(5) | 6(6) | 7(7) | 8(8) | X |
| Baseline | 1 | .5 | 0 | 0 | 2.5 | 0 | 1.5 | 0 | 49.5 | 6.8 |
| | 2 | 1.0 | 0 | 0 | 0 | .5 | 8.0 | 6.0 | 27.0 | 5.3 |
| | 3 | 16.0 | 10.0 | 1.5 | 0 | 11.0 | 7.0 | 8.5 | 28.5 | 10.3 |
| | 4 | 36.5 | 1.0 | 0 | 0 | 35.5 | 44.5 | 2.5 | 31.0 | 18.9 |
| | 5 | 41.5 | 0 | 0 | 4.5 | 20.0 | 25.0 | 8.5 | 42.5 | 17.8 |
| | 6 | 26.5 | 2.5 | 1.5 | 36.0 | 15.5 | 28.0 | 3.5 | 13.0 | 15.8 |
| Training | 1 | 87.6 | 0 | 11.9 | 43.3 | 86.4 | 77.0 | 84.3 | 69.6 | 57.5 |
| | 2 | 91.2 | 0 | 42.7 | 71.9 | 75.7 | 90.0 | 100 | 92.1 | 70.5 |
| | 3 | 78.9 | 0 | 68.6 | 98.9 | 86.8 | 100 | 17.6 | 68.1 | 64.9 |
| | 4 | 83.4 | 0 | 19.7 | 58.0 | 88.9 | 100 | 3.2 | 79.5 | 54.1 |
| | 5 | 91.1 | 0 | 0 | 100 | 53.2 | 100 | 0 | 62.6 | 50.9 |
| | 6 | 82.3 | 0 | 0 | 80.2 | 22.2 | 84.7 | 0 | 39.2 | 38.6 |
| | 7 | 98.9 | 5.9 | 0 | 98.8 | 2.1 | 100 | 0 | 30.9 | 41.0 |
| Extinction | 1 | 94.4 | 2.6 | 20.9 | 87.8 | 20.5 | 97.4 | 0 | 27.4 | 43.9 |
| | 2 | 100 | 14.1 | 17.1 | 85.9 | 11.5 | 90.1 | 29.8 | 26.7 | 46.9 |
| | 3 | 93.7 | 3.1 | 38.7 | 90.6 | 33.5 | 71.2 | 27.2 | 58.6 | 52.1 |
| | 4 | 78.4 | 50.0 | 30.5 | 88.4 | 65.4 | 51.9 | 7.0 | 74.6 | 55.8 |
| | 5 | 81.3 | 46.2 | 57.7 | 78.6 | 40.1 | 23.9 | 13.2 | 56.9 | 49.7 |
| | 6 | 72.2 | 52.9 | 59.9 | 86.6 | 22.7 | 70.2 | 3.5 | 66.7 | 54.3 |
| | 7 | 60.6 | 61.7 | 73.1 | 70.5 | 25.0 | 34.0 | 10.1 | 55.9 | 48.9 |

Appendix 22. Summary of the statistical analyses made for Group BKav and Group BKshlg on baseline, training 1 and extinction data in Experiment 3.

| | Baseline | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 7.033 | 1 | 7.033 | 8.08328E-03 |
| S.WG | 12181.3 | 14 | 870.093 | |
| B | 1558.27 | 5 | 311.655 | 3.86864 |
| AB | 171.249 | 5 | 34.2498 | .425151 |
| BS.WG | 5639.15 | 70 | 80.5592 | |

P(FA) = .927012
P(FB) = 4.04489E-03
P(FAB) = .830773

| | Training | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 22401.8 | 1 | 22401.8 | 4.15 |
| S.WG | 75577 | 14 | 5398.36 | |
| B | 4517.25 | 6 | 752.75 | 2.22246 |
| AB | 6500 | 6 | 1083.33 | 3.18357 |
| BS.WG | 28584.3 | 84 | 340.289 | |

P(FA) = .05848
P(FB) = .04909
P(FAB) = 7.47112E-03

| | Extinction | | | |
|---|---|---|---|---|
| Source | SS | DF | MS | F |
| A | 6522.34 | 1 | 6522.34 | 1.65047 |
| S.WG | 55325.4 | 14 | 3951.82 | |
| B | 1989.59 | 6 | 331.599 | .896161 |
| AB | 3350.037 | 6 | 558.339 | 1.50894 |
| BS.WG | 31081.8 | 84 | 370.022 | |

P(FA) = .217937
P(FB) = .502773
P(FAB) = .18445

Appendix 23. Individual data (suppression ratio) for Group BK, Group FD and Group RD for each baseline, test 1 after completion of training 1, and after 1, 2, 3, and 4 days of training 2 sessions in Experiment 4.

| Group | Rat | Baseline Day 1 | Baseline Day 2 | Baseline Day 3 | Training 1 After Completion | Training 2 After Day 1 | Training 2 After Day 2 | Training 2 After Day 3 | Training 2 After Day 4 |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | .38 | .29 | .43 | .40 | .21 | .26 | .05 | .15 |
| | 2 | .37 | .49 | .46 | .39 | .47 | .38 | .35 | .02 |
| | 3 | .44 | .39 | .48 | 40 | .43 | .33 | .31 | .40 |
| | 8 | .40 | .53 | .50 | .42 | .44 | .36 | .10 | .02 |
| BK | 5 | .13 | .42 | .30 | .42 | .18 | .30 | .26 | .11 |
| | 18 | .49 | .29 | .37 | .48 | .31 | .53 | .01 | .40 |
| | 15 | .34 | .43 | .46 | .38 | .13 | .36 | .27 | .21 |
| | 16 | .44 | .43 | .51 | .42 | .41 | .36 | .10 | .09 |
| | X | .39 | .42 | .45 | .42 | .35 | .35 | .20 | .22 |
| | 21 | .35 | .50 | .37 | 0 | .18 | .09 | .30 | .27 |
| | 6 | .20 | .31 | .46 | .02 | .25 | 0 | .13 | 0 |
| | 7 | .05 | .20 | .25 | .18 | 0 | 0 | .03 | 0 |
| | 4 | .38 | .49 | .46 | 0 | .01 | .04 | .11 | .31 |
| FD | 13 | .32 | .48 | .41 | .01 | .23 | .01 | .01 | .17 |
| | 22 | .37 | .38 | .49 | .11 | .01 | .34 | .07 | .11 |
| | 23 | .49 | .45 | .51 | 0 | 0 | .19 | .14 | .17 |
| | 24 | .26 | .39 | .47 | .10 | .34 | .37 | .20 | .44 |
| | X | .30 | .40 | .43 | .06 | .16 | .15 | .14 | .22 |
| | 9 | .39 | .29 | .48 | .49 | .50 | .31 | .46 | .46 |
| | 10 | .25 | .42 | .49 | .04 | .34 | .08 | .05 | .01 |
| | 11 | .40 | .42 | .37 | .30 | 0 | 0 | .02 | .23 |
| | 12 | .48 | .44 | .47 | .43 | .39 | .43 | .42 | .31 |
| RD | 17 | .44 | .43 | .43 | .36 | .16 | .40 | .24 | .40 |
| | 14 | .30 | .40 | .49 | .40 | .35 | .36 | .27 | 0 |
| | 19 | .43 | .51 | .46 | .45 | .38 | .37 | .41 | .37 |
| | 20 | .37 | .42 | .45 | .45 | .39 | .23 | .12 | .36 |
| | X | .38 | .42 | .46 | .39 | .35 | .31 | .30 | .31 |

Appendix 24. Summary of the statistical analyses made for Group BK, Group FD and Group RD on suppression ratio data in baseline, training 1 and training 2 in Experiment 4.

| SOURCE | SS | DF | MS | F |
| --- | --- | --- | --- | --- |
| A | .659938 | 2 | .329969 | 8.6896 |
| S.WG | .79743 | 21 | .0379729 | |
| B | .976299 | 5 | .19526 | 16.7404 |
| AB | .470813 | 10 | .0470813 | 4.03645 |
| BS.WG | 1.22472 | 105 | .011664 | |

P(FA) = 2.09134E-03

P(FB) = 1.23748E-07

P(FAB) = 2.23455E-04

Appendix 25. Individual data (latency periods) for Group BK, Group FD and Group RD for test 1 after completion of training 1 in Experiment 4.

| Group | Rat | Latency Periods (in seconds) First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|---|
| | 1 | 440.5 | 24.0 | 30.0 | 76.0 | 20.0 |
| | 2 | 756.0 | 66.5 | 20.5 | 21.5 | 22.0 |
| | 3 | 1006.0 | 104.5 | 20.0 | 20.0 | 25.5 |
| | 8 | 200.5 | 358.5 | 20.0 | 20.0 | 20.0 |
| BK | 5 | 341.5 | 37.0 | 46.0 | 28.0 | 66.5 |
| | 18 | 250.5 | 36.0 | 20.0 | 60.5 | 20.0 |
| | 15 | 471.0 | 36.5 | 20.0 | 26.5 | 20.0 |
| | 16 | 128.0 | 223.0 | 20.0 | 20.0 | 104.0 |
| | X | 449.3 | 110.8 | 24.6 | 34.1 | 37.3 |
| | 21 | 331.0 | 152.5 | 216.5 | 150.5 | 122.0 |
| | 6 | 316.5 | 111.0 | 140.0 | 150.0 | 98.5 |
| | 7 | 111.0 | 62.5 | 62.5 | 43.5 | 54.0 |
| | 4 | 432.5 | 324.5 | 90.5 | 122.5 | 164.5 |
| FD | 13 | 363.5 | 222.5 | 214.5 | 129.0 | 177.5 |
| | 22 | 605.5 | 108.5 | 102.5 | 44.5 | 64.5 |
| | 23 | 165.0 | 222.5 | 318.0 | 162.5 | 201.0 |
| | 24 | 182.0 | 233.5 | 127.5 | 53.0 | 138.5 |
| | X | 313.4 | 179.7 | 159.0 | 107.0 | 127.6 |
| | 9 | 62.0 | 205.0 | 28.5 | 20.0 | 20.0 |
| | 10 | 440.0 | 49.0 | 155.5 | 33.0 | 65.0 |
| | 11 | 460.5 | 57.5 | 27.0 | 54.0 | 47.0 |
| | 12 | 171.0 | 20.0 | 20.0 | 92.5 | 20.0 |
| RD | 17 | 44.0 | 41.0 | 30.5 | 26.0 | 20.0 |
| | 14 | 48.0 | 26.0 | 20.5 | 20.0 | 53.5 |
| | 19 | 99.0 | 60.0 | 120.0 | 130.0 | 20.0 |
| | 20 | 63.0 | 75.5 | 70.0 | 30.0 | 72.0 |
| | X | 173.4 | 66.8 | 59.0 | 50.7 | 39.7 |

Appendix 26. Individual data (latency periods) for Group BK, Group FD and Group RD for test 1 after 1 day of training 2 in Experiment 4.

| Group | Rat | Latency Periods (in seconds) First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|---|
| | 1 | 89.5 | 42.0 | 35.0 | 74.0 | 20.5 |
| | 2 | 204.5 | 66.0 | 20.0 | 75.0 | 61.5 |
| | 3 | 56.0 | 40.5 | 42.0 | 25.5 | 51.5 |
| | 8 | 389.0 | 20.0 | 74.0 | 171.5 | 203.5 |
| BK | 5 | 113.5 | 93.5 | 20.0 | 44.5 | 43.5 |
| | 18 | 154.0 | 176.5 | 25.5 | 114.5 | 20.0 |
| | 15 | 189.5 | 111.5 | 23.5 | 20.0 | 30.0 |
| | 16 | 1084.0 | 25.0 | 20.0 | 169.0 | 20.5 |
| | X | 285.0 | 71.9 | 32.5 | 86.8 | 56.4 |
| | 21 | 51.0 | 67.5 | 31.0 | 187.5 | 65.0 |
| | 6 | 18.5 | 47.0 | 38.5 | 39.0 | 39.0 |
| | 7 | 11.0 | 130.0 | 318.0 | 500.0 | 255.0 |
| | 4 | 13.5 | 126.0 | 133.0 | 122.5 | 306.0 |
| FD | 13 | 68.0 | 101.0 | 32.0 | 63.5 | 48.5 |
| | 22 | 341.5 | 106.5 | 159.0 | 88.5 | 86.5 |
| | 23 | 349.5 | 190.0 | 326.5 | 201.5 | 211.0 |
| | 24 | 140.5 | 169.5 | 58.0 | 24.5 | 20.0 |
| | X | 124.2 | 117.2 | 137.0 | 153.4 | 128.9 |
| | 9 | 30.5 | 47.0 | 20.0 | 48.0 | 115.5 |
| | 10 | 504.5 | 80.5 | 26.5 | 51.0 | 20.0 |
| | 11 | 843.5 | 194.5 | 429.5 | 70.0 | 327.5 |
| | 12 | 437.5 | 20.0 | 110.0 | 20.0 | 104.0 |
| RD | 17 | 91.0 | 25.0 | 71.5 | 63.5 | 31.0 |
| | 14 | 614.0 | 35.0 | 63.5 | 48.0 | 20.0 |
| | 19 | 74.5 | 38.5 | 29.5 | 20.5 | 49.5 |
| | 20 | 65.0 | 20.5 | 20.0 | 20.0 | 20.0 |
| | X | 332.6 | 57.6 | 96.3 | 42.6 | 85.9 |

Appendix 27. Individual data (latency periods) for Group BK, Group FD and Group RD for test 1 after 2 days of training 2 in Experiment 4.

| Group | Rat | Latency Periods (in seconds) First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|---|
| | 1 | 65.5 | 151.5 | 144.0 | 84.5 | 46.5 |
| | 2 | 305.0 | 43.0 | 28.0 | 20.0 | 38.0 |
| | 3 | 313.5 | 35.5 | 81.5 | 47.5 | 49.0 |
| | 8 | 329.0 | 29.5 | 54.5 | 79.0 | 78.0 |
| BK | 5 | 30.0 | 38.0 | 39.5 | 57.5 | 47.0 |
| | 18 | 96.5 | 20.0 | 20.0 | 20.0 | 20.0 |
| | 15 | 70.0 | 31.0 | 59.5 | 31.5 | 20.5 |
| | 16 | 139.5 | 42.5 | 174.5 | 157.0 | 142.0 |
| | X | 168.6 | 48.9 | 75.2 | 62.1 | 56.1 |
| | 21 | 299.0 | 105.0 | 51.0 | 50.5 | 57.5 |
| | 6 | 266.0 | 132.5 | 124.0 | 52.0 | 58.0 |
| | 7 | 175.5 | 224.5 | 88.0 | 66.0 | 186.0 |
| | 4 | 209.5 | 115.5 | 120.5 | 58.5 | 50.5 |
| FD | 13 | 236.0 | 142.5 | 105.0 | 102.0 | 62.0 |
| | 22 | 145.5 | 53.5 | 45.5 | 20.5 | 67.0 |
| | 23 | 156.0 | 50.5 | 53.5 | 93.0 | 31.0 |
| | 24 | 83.5 | 131.5 | 33.5 | 20.0 | 61.5 |
| | X | 196.4 | 119.4 | 77.6 | 57.8 | 71.7 |
| | 9 | 35.5 | 77.5 | 34.5 | 35.5 | 54.0 |
| | 10 | 276.0 | 305.0 | 566.5 | 399.5 | 182.5 |
| | 11 | 438.5 | 205.5 | 220.5 | 151.5 | 357.0 |
| | 12 | 166.5 | 20.0 | 20.0 | 30.0 | 20.0 |
| RD | 17 | 55.0 | 25.5 | 64.0 | 30.0 | 25.0 |
| | 14 | 100.5 | 35.5 | 20.0 | 30.5 | 20.0 |
| | 19 | 42.5 | 22.0 | 20.5 | 20.0 | 20.0 |
| | 20 | 71.5 | 26.5 | 68.0 | 31.5 | 118.0 |
| | X | 148.3 | 89.7 | 126.8 | 91.1 | 99.6 |

Appendix 28. Individual data (latency periods) for Group BK, Group FD and Group RD for test 1 after 3 days of training 2 in Experiment 4.

| Group | Rat | Latency Periods (in seconds) | | | | |
|---|---|---|---|---|---|---|
| | | First | Second | Third | Fourth | Fifth |
| | 1 | 90.0 | 115.5 | 129.0 | 73.0 | 77.0 |
| | 2 | 111.5 | 100.0 | 56.0 | 20.0 | 35.5 |
| | 3 | 159.0 | 33.0 | 30.5 | 25.0 | 20.5 |
| | 8 | 249.5 | 82.0 | 184.5 | 257.0 | 261.0 |
| BK | 5 | 25.5 | 50.0 | 43.5 | 47.0 | 32.0 |
| | 18 | 447.5 | 91.5 | 28.5 | 51.5 | 233.5 |
| | 15 | 50.0 | 20.0 | 23.5 | 20.0 | 40.0 |
| | 16 | 214.5 | 86.0 | 111.0 | 71.0 | 60.5 |
| | X | 168.4 | 72.3 | 75.8 | 70.6 | 95.0 |
| | 21 | 34.0 | 148.0 | 27.5 | 30.0 | 33.0 |
| | 6 | 103.5 | 53.5 | 54.5 | 61.0 | 31.0 |
| | 7 | 44.5 | 194.0 | 82.5 | 145.0 | 399.0 |
| | 4 | 118.5 | 79.5 | 32.5 | 43.0 | 31.5 |
| FD | 13 | 97.5 | 100.5 | 89.0 | 33.5 | 58.0 |
| | 22 | 116.5 | 204.5 | 168.0 | 90.0 | 101.0 |
| | 23 | 216.0 | 74.5 | 35.5 | 69.5 | 55.5 |
| | 24 | 148.0 | 40.5 | 50.5 | 29.0 | 20.0 |
| | X | 109.8 | 111.9 | 67.5 | 62.6 | 91.1 |
| | 9 | 27.0 | 29.5 | 23.5 | 36.0 | 20.0 |
| | 10 | 316.5 | 365.5 | 153.0 | 140.0 | 116.5 |
| | 11 | 316.5 | 492.5 | 74.0 | 425.5 | 59.0 |
| | 12 | 126.5 | 29.0 | 46.5 | 34.5 | 73.0 |
| RD | 17 | 34.0 | 43.5 | 43.0 | 37.5 | 62.0 |
| | 14 | 74.5 | 42.0 | 29.5 | 58.0 | 125.5 |
| | 19 | 55.0 | 30.5 | 38.5 | 25.5 | 30.0 |
| | 20 | 117.0 | 41.5 | 145.5 | 55.0 | 52.0 |
| | X | 133.4 | 134.3 | 69.2 | 101.5 | 67.3 |

Appendix 29. Individual data (latency periods) for Group BK, Group FD and Group RD for test 1 after 4 days of training 2 in Experiment 4.

| Group | Rat | Latency Periods (in seconds) | | | | |
|---|---|---|---|---|---|---|
| | | First | Second | Third | Fourth | Fifth |
| | 1 | 81.0 | 100.5 | 102.5 | 83.5 | 42.5 |
| | 2 | 200.5 | 70.5 | 34.0 | 35.0 | 40.0 |
| | 3 | 160.0 | 45.0 | 50.5 | 36.5 | 30.0 |
| | 8 | 278.5 | 45.0 | 100.5 | 151.0 | 191.5 |
| BK | 5 | 78.5 | 23.0 | 64.5 | 21.5 | 53.0 |
| | 18 | 56.0 | 45.0 | 38.0 | 26.0 | 65.5 |
| | 15 | 92.0 | 27.0 | 27.0 | 28.5 | 33.5 |
| | 16 | 80.0 | 79.5 | 50.5 | 27.5 | 31.0 |
| | X | 128.3 | 54.4 | 58.4 | 51.2 | 60.9 |
| | 21 | 51.5 | 100.5 | 30.5 | 95.5 | 49.0 |
| | 6 | 120.0 | 71.0 | 75.5 | 43.0 | 28.0 |
| | 7 | 52.0 | 136.0 | 155.5 | 126.0 | 201.5 |
| | 4 | 97.5 | 83.5 | 66.0 | 67.5 | 48.5 |
| FD | 13 | 39.0 | 55.0 | 36.0 | 32.0 | 45.0 |
| | 22 | 408.5 | 84.0 | 28.0 | 31.5 | 34.5 |
| | 23 | 109.5 | 76.0 | 59.0 | 32.5 | 33.5 |
| | 24 | 57.5 | 38.5 | 20.5 | 22.5 | 71.0 |
| | X | 116.9 | 80.6 | 58.9 | 56.3 | 63.9 |
| | 9 | 32.0 | 41.0 | 27.5 | 27.5 | 29.0 |
| | 10 | 298.5 | 180.0 | 191.5 | 211.0 | 177.5 |
| | 11 | 309.0 | 200.5 | 103.0 | 118.5 | 89.0 |
| | 12 | 85.0 | 104.5 | 28.5 | 75.0 | 76.5 |
| RD | 17 | 22.0 | 35.5 | 33.5 | 27.5 | 47.0 |
| | 14 | 49.5 | 37.0 | 115.0 | 252.0 | 207.5 |
| | 19 | 49.0 | 20.0 | 29.0 | 38.5 | 78.0 |
| | 20 | 70.5 | 34.0 | 20.0 | 83.5 | 122.0 |
| | X | 114.4 | 81.6 | 68.5 | 104.2 | 103.3 |

Appendix 30. Summary of the statistical analyses made for Group BK, Group FD and Group RD on latency period data in test 1 after completion of training 1 in Experiment 4.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 197947 | 2 | 98973.4 | 8.34236 |
| S.WG | 249143 | 21 | 11864 | |
| B | 1.05246E+06 | 4 | 263115 | 20.4822 |
| AB | 301933 | 8 | 37741.6 | 2.93799 |
| BS.WG | 1.07907E+06 | 84 | 12846 | |

P(FA) = 2.46741E-03

P(FB) = 1.59179E-07

P(FAB) = 6.27498E-03

Appendix 31. Summary of the statistical analyses made for Group BK, Group FD and Group RD on latency period data in test 1 after 1 day of training 2 in Experiment 4.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 13496.4 | 2 | 6749.19 | .161595 |
| S.WG | 876958 | 21 | 41759.9 | |
| B | 483428 | 4 | 120857 | 7.12713 |
| AB | 308159 | 8 | 38519.8 | 2.27158 |
| BS.WG | 1.42441E+06 | 84 | 16957.3 | |

P(FA) = .852285

P(FB) = 1.51848E-04

P(FAB) = .029559

Appendix 32. Summary of the statistical analyses made for Group BK, Group FD and Group RD on latency period data in test 1 after 2 days of training 2 in Experiment 4.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 18639 | 2 | 9319.5 | .311767 |
| S.WG | 627742 | 21 | 29892.5 | |
| B | 162589 | 4 | 40647.2 | 10.4835 |
| AB | 37618.3 | 8 | 4702.28 | 1.21279 |
| BS.WG | 325689 | 84 | 3877.25 | |

P(FA) = .739438

P(FB) = 1.15482E-05

P(FAB) = .301031

Appendix 33. Summary of the statistical analyses made for Group BK, Group FD and Group RD on latency period data in test 1 after 3 days of training 2 in Experiment 4.

| SOURCE | SS | DF | MS | F |
| --- | --- | --- | --- | --- |
| A | 3202.5 | 2 | 1601.25 | .0665998 |
| S.WG | 504901 | 21 | 24042.9 | |
| B | 69145.5 | 4 | 17286.4 | 3.22132 |
| AB | 37166.3 | 8 | 4645.78 | .865742 |
| BS.WG | 450764 | 84 | 5366.24 | |

P(FA) = .935429

P(FB) = .0163017

P(FAB) = .549393

Appendix 34. Summary of the statistical analyses made for Group BK, Group FD and Group RD on latency period data in test 1 after 4 days of training 2 in Experiment 4.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 12669.5 | 2 | 6334.75 | .545879 |
| S.WG | 243698 | 21 | 11604.7 | |
| B | 50011.4 | 4 | 12502.9 | 4.39668 |
| AB | 15154.8 | 8 | 1894.34 | .666153 |
| BS.WG | 238871 | 84 | 2843.71 | |

P(FA) = .592246

P(FB) = 3.15796E-03

P(FAB) = .721303

Appendix 35. Individual data (time spent on platform) for Group BK, Group FD and Group RD for each baseline, test 2 after completion of training 1, and after 1, 2, 3, and 4 days of training 2 sessions in Experiment 4.

| Group | Rat | Baseline Day 1 | Baseline Day 2 | Baseline Day 3 | Training 1 After Completion | Training 2 After Day 1 | Training 2 After Day 2 | Training 2 After Day 3 | Training 2 After Day 4 |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | .7 | 7.7 | 12.7 | 16.0 | 30.0 | 7.0 | 60.7 | 70.0 |
| | 2 | 3.7 | 12.7 | 8.2 | 6.3 | 5.7 | 9.5 | 51.3 | 31.7 |
| | 3 | 14.0 | 85.0 | 54.0 | 58.7 | 85.0 | 48.0 | 85.0 | 89.3 |
| | 8 | 5.0 | 0 | 11.3 | 1.0 | 9.3 | 17.7 | 4.7 | 51.7 |
| BK | 5 | 11.3 | 15.0 | 5.7 | 8.3 | 20.0 | 7.0 | 5.0 | 13.7 |
| | 18 | 6.0 | 3.0 | 4.5 | 75.0 | 96.3 | 84.3 | 76.3 | 91.0 |
| | 15 | 3.3 | 20.7 | 55.0 | 14.7 | 72.6 | 88.3 | 90.7 | 98.7 |
| | 16 | 2.7 | 19.0 | 10.0 | 22.0 | 76.3 | 52.0 | 80.3 | 83.0 |
| | X | 5.8 | 20.4 | 20.2 | 25.3 | 49.4 | 39.2 | 56.8 | 66.1 |
| | 21 | 4.7 | 4.0 | 2.7 | 1.0 | 4.7 | 1.3 | 2.3 | 5.3 |
| | 6 | 3.0 | 4.0 | 3.5 | 1.0 | 3.0 | 2.5 | 63.7 | 58.0 |
| | 7 | 9.3 | 4.3 | 2.3 | 3.3 | 4.7 | 27.3 | 66.3 | 45.7 |
| | 4 | 71.0 | 62.7 | 89.0 | 85.3 | 93.3 | 62.7 | 95.3 | 92.7 |
| FD | 13 | 1.7 | 5.0 | 62.3 | 21.3 | 35.7 | 36.7 | 22.3 | 58.0 |
| | 22 | 6.3 | .3 | 3.3 | 0 | 48.3 | 25.7 | 46.3 | 85.0 |
| | 23 | 3.7 | 2.3 | .6 | 0 | 11.0 | 31.3 | 52.3 | 71.7 |
| | 24 | 2.3 | 27.0 | 45.3 | .7 | 72.7 | 50.7 | 74.7 | 56.0 |
| | X | 12.8 | 13.7 | 26.1 | 14.1 | 34.2 | 29.8 | 52.9 | 59.1 |
| | 9 | 11.7 | 14.3 | 2.3 | 11.3 | 8.0 | 4.8 | 22.3 | 11.3 |
| | 10 | 11.7 | 35.7 | 23.7 | 98.7 | 89.0 | 100 | 92.0 | 85.7 |
| | 11 | 0 | 2.7 | 5.3 | 0 | 0 | 0 | 0 | 0 |
| | 12 | 6.3 | 32.3 | 41.3 | 67.0 | 36.0 | 14.3 | 81.3 | 97.7 |
| RD | 17 | 0 | 3.0 | 1.3 | 20.3 | 64.7 | 22.3 | 55.3 | 44.7 |
| | 14 | 29.3 | 87.3 | 58.3 | 90.0 | 74.7 | 43.0 | 75.7 | 38.0 |
| | 19 | 0 | 0 | 6.7 | 8.7 | 9.0 | 14.7 | 17.7 | 53.0 |
| | 20 | 2.3 | 10.3 | 13.3 | 63.3 | 93.0 | 48.7 | 85.3 | 84.7 |
| | X | 7.7 | 23.2 | 19.0 | 45.0 | 46.8 | 31.0 | 53.7 | 51.9 |

Appendix 36. Summary of the statistical analyses made for Group BK, Group FD and Group RD on time spent on platform data in baseline, test 2 after completion of training 1 and test 2 sessions during training 2 in Experiment 4.

| SOURCE | SS | DF | MS | F |
|---|---|---|---|---|
| A | 1214.97 | 2 | 607.484 | .14007 |
| S.WG | 91077.4 | 21 | 4337.02 | |
| B | 26436.3 | 5 | 5287.27 | 15.247 |
| AB | 5280.34 | 10 | 528.034 | 1.52271 |
| BS.WG | 36411.3 | 105 | 346.774 | |

P(FA) = .870094

P(FB) = 2.29019E-07

P(FAB) = .141142

Appendix 37. Individual data (positions) for Group BK, Group FD and Group RD for training 1 and for test 2 after completion of training 1 in Experiment 4.

| | | Position | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Training 1 | | | Test 2 | | | |
| Group | Rat | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| | 1 | 13 | 6 | 21 | 1 | 8 | 0 | 1 |
| | 2 | 15 | 9 | 16 | 0 | 6 | 2 | 2 |
| | 3 | 12 | 14 | 14 | 5 | 3 | 2 | 0 |
| | 8 | 13 | 15 | 12 | 0 | 4 | 4 | 2 |
| BK | 5 | 7 | 22 | 11 | 0 | 4 | 3 | 3 |
| | 18 | 11 | 6 | 23 | 6 | 0 | 0 | 4 |
| | 15 | 26 | 12 | 2 | 0 | 7 | 2 | 1 |
| | 16 | 16 | 22 | 2 | 2 | 2 | 4 | 2 |
| | X | 3.5 | 3.3 | 3.2 | 1.8 | 4.3 | 2.1 | 1.9 |
| | 21 | 22 | 7 | 11 | 0 | 8 | 1 | 1 |
| | 6 | 3 | 16 | 21 | 0 | 3 | 3 | 4 |
| | 7 | 18 | 18 | 4 | 0 | 5 | 5 | 0 |
| | 4 | 12 | 11 | 17 | 10 | 0 | 0 | 0 |
| FD | 13 | 2 | 9 | 29 | 4 | 1 | 4 | 1 |
| | 22 | 2 | 5 | 33 | 0 | 0 | 7 | 3 |
| | 23 | 8 | 17 | 15 | 0 | 3 | 3 | 4 |
| | 24 | 13 | 14 | 13 | 0 | 5 | 3 | 2 |
| | X | 2.5 | 3.0 | 4.5 | 1.8 | 3.1 | 3.3 | 1.9 |
| | 9 | 15 | 10 | 15 | 1 | 6 | 0 | 3 |
| | 10 | 14 | 6 | 20 | 10 | 0 | 0 | 0 |
| | 11 | 6 | 7 | 27 | 0 | 0 | 0 | 10 |
| | 12 | 5 | 21 | 14 | 5 | 3 | 0 | 2 |
| RD | 17 | 14 | 15 | 11 | 0 | 9 | 1 | 0 |
| | 14 | 20 | 7 | 13 | 8 | 1 | 0 | 1 |
| | 19 | 13 | 10 | 17 | 0 | 8 | 0 | 2 |
| | 20 | 13 | 15 | 12 | 6 | 1 | 1 | 2 |
| | X | [illegible] | [illegible] | | | | | |

Appendix 38. Individual data (positions) for Group BK, Group FD and Group RD for training 2 and for test 2 after 1, 2, 3, and 4 days of training 2 in Experiment 4.

| | | Position | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Training 2 | | | Test 2 | | | |
| Group | Rat | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| | 1 | 9 | 8 | 23 | 17 | 18 | 1 | 4 |
| | 2 | 6 | 14 | 20 | 10 | 15 | 3 | 12 |
| | 3 | 11 | 16 | 13 | 29 | 5 | 2 | 4 |
| | 8 | 9 | 22 | 9 | 10 | 18 | 10 | 2 |
| BK | 5 | 3 | 11 | 26 | 7 | 14 | 8 | 11 |
| | 18 | 8 | 9 | 23 | 36 | 4 | 0 | 0 |
| | 15 | 10 | 15 | 15 | 35 | 5 | 0 | 0 |
| | 16 | 14 | 18 | 8 | 27 | 7 | 2 | 4 |
| | X | 2.2 | 3.5 | 4.3 | 5.3 | 2.7 | .8 | 1.2 |
| | 21 | 11 | 11 | 18 | 0 | 17 | 13 | 10 |
| | 6 | 2 | 27 | 11 | 13 | 12 | 7 | 8 |
| | 7 | 12 | 21 | 7 | 14 | 10 | 4 | 12 |
| | 4 | 18 | 22 | 0 | 33 | 6 | 1 | 0 |
| FD | 13 | 6 | 29 | 5 | 15 | 10 | 5 | 10 |
| | 22 | 3 | 8 | 29 | 18 | 14 | 6 | 2 |
| | 23 | 12 | 14 | 14 | 18 | 14 | 6 | 2 |
| | 24 | 18 | 18 | 4 | 22 | 15 | 2 | 1 |
| | X | 2.6 | 4.7 | 2.8 | 4.2 | 3.1 | 1.4 | 1.4 |
| | 9 | 5 | 21 | 14 | 13 | 24 | 4 | 7 |
| | 10 | 3 | 21 | 16 | 25 | 2 | 1 | 2 |
| | 11 | 12 | 8 | 20 | 0 | 0 | 13 | 27 |
| | 12 | 6 | 23 | 11 | 19 | 4 | 10 | 7 |
| RD | 17 | 6 | 10 | 24 | 25 | 7 | 2 | 6 |
| | 14 | 9 | 22 | 9 | 27 | 8 | 3 | 2 |
| | 19 | 7 | 22 | 11 | 3 | 25 | 7 | 5 |
| | 20 | 8 | 14 | 18 | 35 | 2 | 0 | 3 |

Appendix 39. Transformed unweighted scores (Dual Scaling) for Group BK, Group FD and Group RD on position data for training 1 and test 2 after completion of training 1 in Experiment 4.

| Group | Rat | Training 1 Rows | | Training 1 Columns | Test 2 Rows | | Test 2 Columns |
|---|---|---|---|---|---|---|---|
| | 1 | -0.6130 | 1 | 0.9990 | -0.5237 | 1 | 1.7537 |
| | 2 | 0.0229 | 2 | 0.5738 | -0.7562 | 2 | -0.6945 |
| | 3 | 0.1736 | 3 | -1.2370 | 0.7050 | 3 | -0.5762 |
| BK | 8 | 0.4334 | | | -0.7260 | 4 | -0.3072 |
| | 5 | 0.3858 | | | -0.6918 | | |
| | 18 | -0.9001 | | | 1.1843 | | |
| | 15 | 1.9509 | | | 0.8056 | | |
| | 16 | 1.6779 | | | 0.1021 | | |
| | 21 | 0.7954 | | | -0.8206 | | |
| | 6 | -0.8860 | | | -0.6424 | | |
| | 7 | 1.5000 | | | -0.8097 | | |
| FD | 4 | -0.1752 | | | 2.2348 | | |
| | 13 | -1.8434 | | | 0.4726 | | |
| | 22 | -2.3085 | | | -0.6314 | | |
| | 23 | -0.0519 | | | -0.6424 | | |
| | 24 | 0.3171 | | | -0.7411 | | |
| | 9 | 0.1392 | | | -0.4250 | | |
| | 10 | -0.4694 | | | 2.2348 | | |
| | 11 | -1.5017 | | | -0.3915 | | |
| RD | 12 | 0.0176 | | | 0.7736 | | |
| | 17 | 0.5769 | | | -0.8700 | | |
| | 14 | 0.5082 | | | 1.6602 | | |
| | 19 | -0.1479 | | | -0.7864 | | |
| | 20 | 0.4334 | | | 1.1006 | | |

Appendix 40. Transformed unweighted scores (Dual Scaling) for Group BK, Group FD and Group RD on position data for training 2 and test 2 after 1, 2, 3, and 4 days of training 2 in Experiment 4.

| | | Training 2 | | | Test 2 | | |
|---|---|---|---|---|---|---|---|
| Group | Rat | Rows | Columns | | Rows | Columns | |
| | 1 | -1.1863 | 1 | 0.6886 | 0.0882 | 1 | 1.0041 |
| | 2 | -0.7489 | 2 | 0.7870 | -0.7630 | 2 | 0.4579 |
| | 3 | 0.1938 | 3 | -1.3252 | 0.8258 | 3 | -1.2708 |
| BK | 8 | 0.7640 | | | -0.6035 | 4 | -1.3888 |
| | 5 | -1.5652 | | | -1.0945 | | |
| | 18 | -1.1798 | | | 1.5129 | | |
| | 15 | -0.0783 | | | 1.4484 | | |
| | 16 | 0.8709 | | | 0.6969 | | |
| | 21 | -0.5027 | | | -1.6838 | | |
| | 6 | 0.5308 | | | -0.5488 | | |
| | 7 | 1.0232 | | | -0.5410 | | |
| FD | 4 | 1.9593 | | | 1.2837 | | |
| | 13 | 1.3407 | | | -0.4303 | | |
| | 22 | -1.9831 | | | 0.0555 | | |
| | 23 | 0.0480 | | | 0.0555 | | |
| | 24 | 1.4021 | | | 0.4978 | | |
| | 9 | 0.0935 | | | -0.4681 | | |
| | 10 | -0.1722 | | | 1.1838 | | |
| | 11 | -0.7878 | | | -2.3815 | | |
| RD | 12 | 0.5049 | | | -0.2285 | | |
| | 17 | -1.3061 | | | 0.4859 | | |
| | 14 | 0.7640 | | | 0.7432 | | |
| | 19 | 0.4984 | | | -1.0703 | | |
| | 20 | -0.4832 | | | 1.3253 | | |

Appendix 41. Summary of the statistical analyses made for Group BK, Group FD and Group RD on position data for training 1, test 2 after completion of training 1, training 2 and test 2 after 1, 2, 3, and 4 days of training 2 in Experiment 4.

Training 1

| Source | SS | DF | MS | F |
|---|---|---|---|---|
| Between | 2.13385 | 2 | 1.06692 | 1.02469 |
| Within | 21.8656 | 21 | 1.04122 | |
| Total | 23.9995 | 23 | | |

Probability of F = .377784

After completion of Training 1

| Source | SS | DF | MS | F |
|---|---|---|---|---|
| Between | 2.03845 | 2 | 1.01923 | .974589 |
| Within | 21.9618 | 21 | 1.0458 | |
| Total | 24.0003 | 23 | | |

Probability of F = .604161

Training 2

| Source | SS | DF | MS | F |
|---|---|---|---|---|
| Between | 2.99407 | 2 | 1.49704 | 1.49663 |
| Within | 21.0058 | 21 | 1.00027 | |
| Total | 23.9998 | 23 | | |

Probability of F = .245942

After each day of Training 2

| Source | SS | DF | MS | F |
|---|---|---|---|---|
| Between | .786826 | 2 | .393413 | .3521 |
| Within | 23.464 | 21 | 1.11733 | |
| Total | 24.2508 | | | |

Probability of F = .711833