DOSE-RELATED EFFECTS OF ETHANOL ON AVOIDANCE-AVOIDANCE CONFLICT BEHAVIOR IN THE RAT

by

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A THESIS

Presented to the Department of Medical Psychology
and the Graduate Council of the
University of Oregon Health Sciences Center
in partial fulfillment of
the requirements for the degree of

Master of Science
September 1977

APPROVED:

[redacted]

(Professor in Charge of Thesis)

[redacted]

(Chairman, Graduate Council)

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INTRODUCTION

As a socially approved drug, ethanol is widely used in this country. For some people ethanol consumption may be excessive, resulting in impaired functioning within the society, or in physical dependence. Attempts to understand such excessive drinking have involved several different approaches, including not only the study of physiological and biochemical mechanisms, but also consideration of genetic, psychological, and sociological factors. One popular hypothesis has been that tension reduction plays an important role as a psychological variable contributing to overconsumption of ethanol. According to this proposal, ethanol reduces fear, tension, or anxiety, thereby reinforcing the drinking behavior (Conger, 1951, 1956; Dollard & Miller, 1950). More specifically, this hypothesis can be broken down into two assumptions: first, that ethanol does indeed mitigate aversive emotional states such as fear, tension, or anxiety, and second, that this alleviation of an unpleasant state reinforces the behavior immediately preceding it.

One purpose of the present investigation was an evaluation of the first of these assumptions. Though popular and supported by anecdotal evidence, this tension-reduction hypothesis has recently been called into question. Current reviews of the scientific studies bearing on this hypothesis have concluded that, with a few notable exceptions, the evidence is largely equivocal (Cappell, 1975; Cappell & Herman, 1972; Higgins, 1975; Mello, 1970). For a number of reasons this conclusion is understandable. Studies of the effects of ethanol on behavior are not without methodological and interpretive weaknesses,

most of which have been outlined in the aforementioned reviews. Perhaps the more notable of these weaknesses have been the following. (a) Often it is not possible to distinguish behavioral changes due to altered emotional states from changes due to non-specific motor effects. Motor impairment resulting from depression of central nervous system functioning is a well documented effect of ethanol (Ritchie, 1975). For this reason, changes in behavior that may be attributed to motor impairment provide little support for a tension-reduction position. For example, though a tension-reduction view predicts ethanol-produced impairment in one-way avoidance performance, this prediction is confounded with a motor impairment outcome. (b) Studies have often lacked adequate controls for the effects of stimulus change between training and testing conditions. It has been pointed out (Miller, 1957; Grossman & Miller, 1961), that drug-produced sensory distortions may result in behavioral changes that mimic tension-reduction predictions. Miller and Kraeling (1952) and Murray and Miller (1952) have shown for example, that merely changing apparatus cues between training and testing trials can produce performance changes that might, under other circumstances, be attributed to a drug-produced emotional change. For this reason, a balanced design in which subjects are both trained and tested under drug and no-drug conditions is necessary to control for such an effect. (c) Data allowing determination of dose-response relationships are often lacking. There is a variety of evidence to suggest that the behavioral effects of ethanol may vary considerably as a function of dose. Anecdotally, consumption of moderate amounts of

ethanol has been reported to produce loud or boisterous behavior followed, with increasing consumption, by stupor or coma. Additionally, in experimental work with rats, increasing doses of ethanol appear to produce first increases, then decreases in exploratory and open-field activity (Buckalew & Cartwright, 1968; Eriksson & Wallgren, (1967). Thus, the use of only one dose level may produce results of limited generality. (d) Reference to drug-produced change in emotions is necessarily based on observations and interpretations of changes in behavior, and such interpretations depend on clear specification of the theoretical relations between drug action and behavioral outcomes. One approach to the interpretation of motivational or emotional effects of drugs is to relate antecedent conditions to behavioral outcomes via theoretical intervening variables (see Brown & Farber, 1959; Miller, 1957). As a specific example, administration of ethanol (antecedent) may be said to produce an increase in bar-pressing rate (outcome) by decreasing an inhibitory conditioned fear (intervening variable). An important requirement for such an analysis is a theoretical framework relating the intervening variable to both antecedent events and observed behavior. An additional problem of some concern is that these theoretical relationships may be specific to the behavioral task, drug dose, or stimulus contingencies involved.

Studies of the effect of ethanol on experimental conflict behavior have generally supported the tension-reduction hypothesis, thus providing one of the exceptions alluded to earlier. Beginning with the work of Masserman and Yum (1946) and Conger (1951,1956) conflict paradigms have been used to study the effects of ethanol

and other drugs on behavior, and in testing the tension-reduction hypothesis. These early investigators created approach-avoidance conflicts by shocking hungry animals in goal areas where they had previously been rewarded with food. The finding that administration of ethanol resulted in closer approach to such bivalent goals has been interpreted as evidence that the drug reduced the conditioned fear supporting the tendency to avoid the goal area.

Additional approach-avoidance conflict studies, that have included controls for stimulus change and other factors, have yielded similar results, lending further support to the tension-reduction hypothesis. Using a balanced design, in which rats were both trained and tested under drug and no-drug conditions, Grossman & Miller (1961) were able to control for the possible effects of drug-produced stimulus changes. In their experiment, hungry rats were first given food-approach training, followed by avoidance trials, during which different alley lengths, from start box to goal box, were consistantly associated with different levels of shock, administered when the rat touched the food cup. These investigators found that, in approach-avoidance conflict tests, rats tested under the influence of ethanol (1.2 g/kg) ran faster and farther toward the food cup than did control animals. Importantly, these results were obtained for animals trained after receiving injections of either ethanol or saline, and thus could not be attributed to stimulus change between training and testing conditions. Using a similar apparatus and methodology, Barry and Miller (1962) obtained essentially similar results. Unlike the Grossman and Miller study, however, their design

did not allow for evaluation of the effects of possible drug-produced stimulus changes.

In a series of related experiments, Freed (1967, 1968a, 1968b) studied the effect of ethanol on approach-avoidance conflict behavior under a variety of conditions. In the first of these experiments, Freed (1967) initially trained hungry rats to approach and eat from a food cup in the goal end of a 15-ft alley. This approach training was followed by trials during which the rats were shocked at the food cup until they no longer approached or ate from it. In subsequent conflict trials, rats injected with ethanol (.5 g/kg, 1.0 g/kg, or 1.5 g/kg) approached and touched the food cup more than did control animals. Unfortunately, the design of this experiment also was "unbalanced" in that all animals were trained under no-drug conditions, with half subsequently tested under the influence of ethanol. In a subsequent study, Freed (1968a) used schedule-induced polydipsia (Falk, 1961) to induce rats to drink ethanol solutions prior to approach-avoidance conflict trials. The lack of a balanced design, and the small number of animals per group (2 or 3) preclude any useful interpretations of the data. In yet another similarly designed experiment (Freed, 1968b), rats injected with ethanol (1.0 g/kg) prior to approach-avoidance conflict tests exhibited closer approach to a food cup where they had been previously shocked than did saline control animals.

More recently, Cook and Davidson (1973) used a multiple-schedule operant paradigm to assess the effect of ethanol and other drugs on bar-press responding that was both rewarded and punished. These

investigators trained rats to bar-press under two different schedules of reinforcement: (a) a VI-30 schedule during which bar-presses were, on the average, reinforced every 30 sec, and (b) an FR-10 schedule during which every 10th bar-press was followed by the simultaneous presentation of a food pellet and foot-shock. The non-punished, VI-30 schedule was signalled by a steady light, while the punished, FR-10 schedule was signalled by a flashing light. After sufficient training, a shift from the non-punished to punished schedule typically resulted in a suppression of responding. Cook and Davidson reported that administration of chlordiazepoxide, meprobamate, amobarbital, and ethanol (1.0 and 2.0 g/kg) produced increases in responding during the punished (FR-10) schedule at dose levels that did not alter non-punished (VI-30) responding. One advantage of such a multiple schedule is that responding during the non-punished schedule provides a comparable performance measure by which effects such as motor impairment or stimulus change may be assessed. It was noted, for example, that at the 2.0 g/kg dose level, ethanol produced an <u>increase</u> in responding on the punishment schedule while producing a decrease in non-punished responding that was attributed to ataxia. To evaluate the possibility that drug-produced analgesia contributed to the increases in punished responding, Cook and Davidson also administered morphine. They found that in general, this analgesic agent did not alleviate the suppression of punished responding, and thus concluded that analgesia was not a major factor contributing to such an effect. Thus in various tasks in which responding has been both punished and rewarded, ethanol produced

changes in behavior consistent with tension-reduction interpretations.

In addition to the methodological and interpretive weaknesses discussed previously, there are complicating factors inherent in the approach-avoidance design which merit discussion. Behavior in such conflict situations is presumably controlled by the interaction of opposing tendencies to approach and to avoid the same area. For this reason, closer approach to such a bivalent region could be produced not only by a weakened tendency to avoid, but also by an increase in the tendency to approach, as for example, by an ethanol-produced increase in appetite. Thus, it is necessary to measure separately the effect of ethanol on both the approach and the avoidance tendencies as Conger (1951) did. Using a special restraint device, he was able to quantify approach and avoidance tendencies by measuring the strength of pull exerted by rats in separate approach and avoidance tasks. Conger found that while administration of ethanol reduced the strength of pull exerted by the rats during avoidance trials, it had no effect on the strength of pull towards the goal during food-approach trials. Barry and Miller (1965) on the other hand, reported that ethanol decreased running speeds similarly in food-approach, shock-avoidance, and shock-escape tasks. In subsequent investigations this problem has not always been addressed.

When establishing an approach-avoidance conflict, it is difficult to train animals to approach areas where they have been previously punished. For this reason, animals usually receive food-approach training first, followed by shock-punishment trials to establish an avoidance tendency. It has been pointed out (Barry & Miller, 1962),

that such sequential training may make it difficult to distinguish later between a drug that reduces fear and one which merely affects a more recently learned habit.

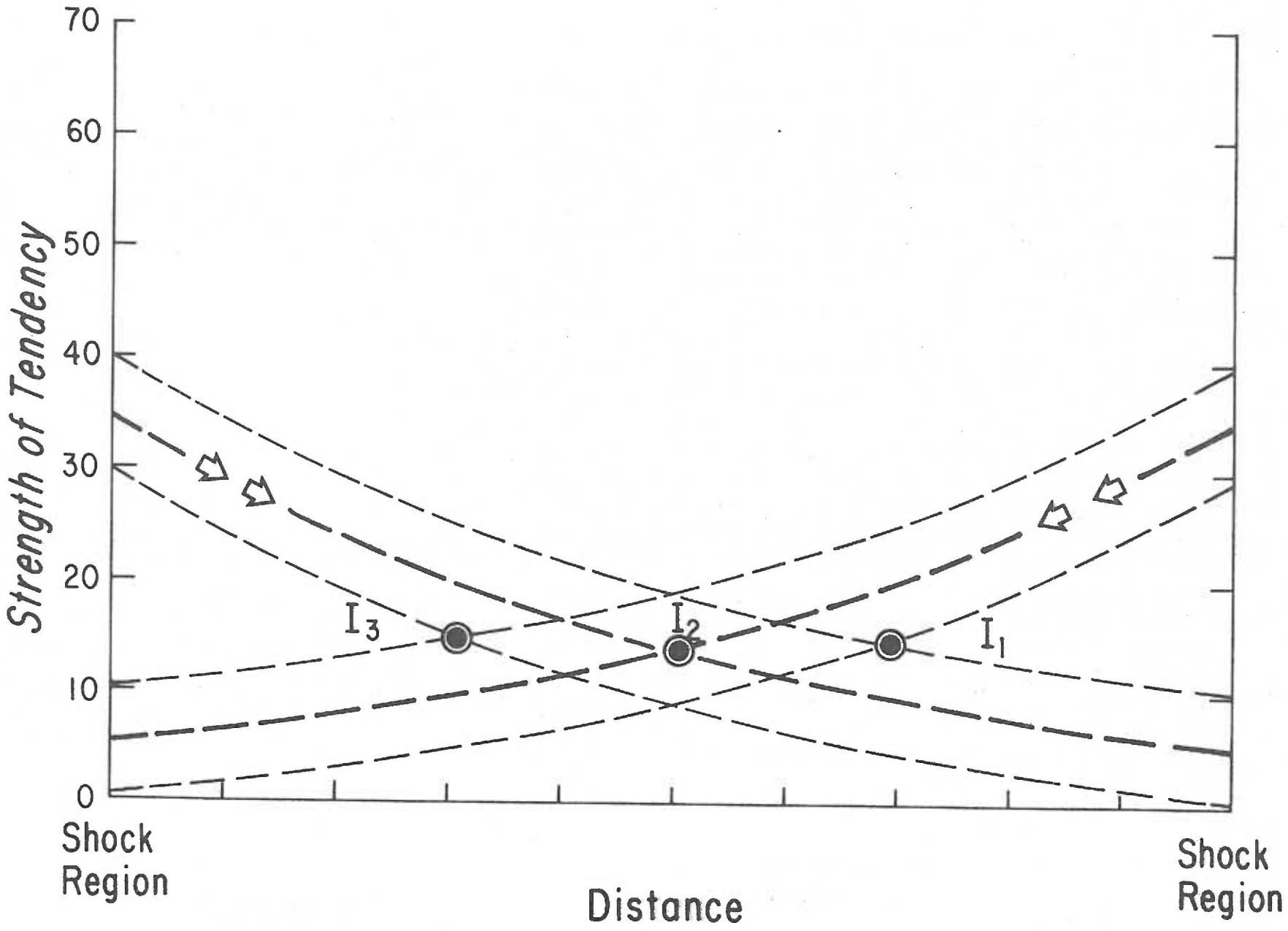
As an alternative to the approach-avoidance paradigm, an avoidance-avoidance conflict situation can be created by first training animals to escape from shock at whichever end of a straight alley is made distinctive with a signal, and then placing them in the alley with signals turned on at both ends (Klebanoff, 1939). In addition to broadening the range of conflict and ethanol studies, this paradigm offers some advantages over the approach-avoidance design. Opposing tendencies to avoid both end regions can be built up simultaneously simply by alternating shock-escape trials between the ends of the alley during training. Additionally, since the tendency to avoid either end of the alley is not dependent upon any hunger-motivated approach tendency, closer approach to an end region clearly represents a change in tendencies to avoid.

In a recent theoretical analysis, Brown and Crowell (1974) outlined changes in conflict behavior that might be expected to result from ethanol-produced changes in conditioned fear. Based on the assumption that ethanol would attenuate fear-motivated avoidance tendencies, a number of specific predictions concerning the effects of ethanol on locomotor behavior in an avoidance-avoidance conflict situation were advanced. According to this extension of Miller's (1944, 1959) conflict theory, the administration of shock at both ends of a straight alley produces two equal but opposing tendencies to avoid the punishment regions. Though initially established by

shock-escape training, each tendency should be maintained by conditioned fear during shock-free test trials and should be maximally strong at the place of punishment, diminishing as a function of the distance from the punishment region. The heavy dashed lines in Figure 1 represent the hypothetical gradients in the strengths of the avoidance tendencies assumed to result from such shock-escape training.

It was further assumed that in a conflict situation, when both avoidance tendencies are simultaneously aroused, the strength of the tendency to move in either direction would be a function of the algebraic difference between the opposing tendencies at any point in the alley. Accordingly, if an animal were placed into this environment at either side of the intersection of the gradients (Point I_2), it would tend to move toward that place. Notice also that the difference between the two gradients and hence the tendency to move toward this intersection increases as a function of the distance between the animal's position and this point. Presumably a stronger avoidance tendency would be reflected behaviorally in strength of pull, running speed, or starting speed. An additional assumption made by Brown and Crowell was that such gradients fluctuate widely and independently from moment to moment due to uncontrollable changes in the external and internal stimulus complex. The lighter dashed lines in Figure 1 represent hypothetical upper and lower limits of such fluctuations, and the resulting back and forth shift of the intersection of the gradients is represented at the extremes by Points I_1 and I_3. As the animal will always tend to move toward the intersection of the gradients

Figure 1. Opposing avoidance gradients, hypothesized to result from the administration of punishment at each of two spatially separated regions. The lighter, dashed lines represent the hypothetical upper and lower limits of moment-to-moment fluctuations in the strengths of the avoidance tendencies, and the resulting extreme displacements of the intersection of the gradients (Points I_1 and I_3) delineate the expected range of oscillation.


70
60
50
40
30
20
10
0
Strength of Tendency
I_3
I_2
I_1
Shock Region
Distance
Shock Region

its range of movement back and forth in the alley should be a reflection of the distance between these hypothetical extremes.

This theoretical framework provides a means for analyzing conflict behavior and testing the hypothesis that ethanol reduces fear. On the assumption that avoidance behavior is maintained by conditioned fear, Brown and Crowell concluded that if one of the effects of ethanol is to attenuate fear, the heights and slopes of both avoidance gradients would be reduced. This led to the prediction of several observable changes in locomotor conflict behavior. With lowered gradients and flattened slopes, the range of moment-to-moment variations in the position of the intersection of the gradients would be increased. Hence, the extreme positions (I_1 and I_3) of the intersection should be displaced farther from the alley center. This should result in a wider range of oscillation around the center point of the alley, and concomitantly, closer approaches to both of the punishment regions. One would also expect longer starting latencies and slower running speeds throughout the alley, for at all points, the difference between the opposing gradients would be reduced. This theoretical analysis provides not only a framework for the interpretation of drug effects on conditioned fear, but may also make it possible to differentiate between non-specific motor impairment and behavioral changes due to a decrease in conditioned fear. In the present case, while one might appeal to motor incoordination to explain slower starting and running speeds, the predicted increase in range of oscillation and closer approach to the ends of the alley cannot be easily explained in a similar manner. In brief,

three testable predictions stem from the Brown-Crowell analysis of the effects of ethanol on locomotor behavior in an avoidance-avoidance conflict situation. In shock-free tests, ethanol should produce (a) an increase in oscillation range, accompanied by closer approach to the punishment regions (b) longer starting latencies, and (c) decreased running speeds.

In a recent evaluation of the Brown and Crowell analysis and its predictions, Mansfield, Eaton, Cunningham, and Brown (1977) created an avoidance-avoidance conflict by first training rats to escape from shock in whichever end of a straight alley was made distinctive with a flashing light and an intermittent tone. On subsequent shock-free conflict trials, during which detailed records of locomotor behavior were obtained, the rats were placed in the alley with tones and lights turned on at both ends. The animals were trained and tested according to a 2 X 2 factorial design, half being trained after drinking a sugar-water solution containing 4.75% ethanol v/v, and half after drinking a plain sugar-water solution. For the testing phase each training group was further sub-divided. Half of each group was tested after drinking ethanol, and half after drinking sugar-water. The mean self-administered dose was 2.2 g/kg during the training phase, and 2.4 g/kg during the testing phase. Six different measures of locomotor behavior were reported: (a) Shock Region Approach--the closest approach to either end of the alley after the initial run away from the starting area; (b) Total Oscillation--the cumulative movement during the test trial; (c) Starting Speed--the reciprocal of the latency to move 30 cm from the initial starting location;

(d) Length of Initial Run--the distance from the start to where the rat first paused or turned around; (e) Number of Reversals of Direction; and (f) Running Speeds--through the four middle segments of the alley. The factorial design employed allowed for evaluation of the effects of ethanol on shock-escape training; the effects of being trained under the influence of ethanol on subsequent conflict test behavior; and the effects of ethanol administered just prior to avoidance-avoidance conflict testing.

During training, ethanol-trained rats ran more slowly when escaping shock than did the sugar-water-trained animals. In addition, during conflict tests, rats that had been previously trained under the influence of ethanol started and ran more slowly, had lower total oscillation scores, and approached the shock regions less closely than did control animals that had received sugar-water during the training phase. These findings led Mansfield, et al. to two possible interpretations of the effects of ethanol during training on later conflict test behavior. First, the results during the testing phase could have reflected a carry-over of a learned "slow running" habit (cf. Logan, 1956) produced by analgesia, motor impairment, reduced fear, or a combination of these factors. Second, it was postulated that an analgesia-produced reduction of the effective shock level during training might have resulted in a reduced level of conditioned fear which carried over to the testing phase. Animals that were under the influence of ethanol during conflict test trials approached the shock-regions more closely, had longer initial runs, higher total oscillation scores, and ran faster in the middle segments of the

alley than did control animals. There were no significant differences in starting speeds between animals tested after drinking ethanol and those tested after drinking sugar-water.

The findings of closer shock-region approach (reflecting a wider oscillation range) and the longer initial runs are compatible with the assumption that an ethanol-produced reduction in fear resulted in a lowering of both avoidance gradients, and hence are in agreement with the fear-reduction interpretations of earlier results (Barry & Miller, 1962; Conger, 1951, 1956; Freed, 1967, 1968a, 1968b; Grossman & Miller, 1961; Masserman & Yum, 1946). However, it is apparent that the lack of a difference in starting speeds, and especially the faster running of the ethanol-tested rats, obtained by Mansfield, et al. are findings not clearly supportive of the fear-reduction predictions. Within the Brown-Crowell framework, faster running speeds indicate a greater difference between opposing avoidance gradients throughout the middle alley segments. Such an increase could be due to a lowered avoidance gradient for the punishment region being approached at the time, or to a heightened avoidance gradient for the punishment region being left behind, or to some combination of these effects (refer to Figure 1). The first of these possibilities was proposed by Mansfield, et al. as the "asymmetry hypothesis" and will be discussed later in more detail.

There are alternative proposals, not directly addressed by the Brown-Crowell analysis, to explain why moderate doses of ethanol, a central nervous system depressant, produced indications of an increase in locomotor activity in five out of the six measures in this

testing situation. Perhaps the most straightforward hypothesis would be that ethanol produces a motor excitation effect. Although this appears to be unlikely for a number of reasons, it has been noted that low doses of ethanol may produce increased exploratory activity (Buckalew & Cartwright, 1968) and that ethanol may temporarily enhance spinal reflexes (Ritchie, 1975). Consistent with the tension-reduction hypothesis is another suggestion that the increased performance may be due to a reduction of a fear-motivated tendency to freeze. Such freezing responses have been invoked in the explanation of a variety of behaviors (cf. Bolles, 1975), including behavior in conflict situations (Barry, Wagner, & Miller, 1962).

The experiment reported here was designed as an extension of the earlier Mansfield, et al. study, and as a further evaluation of the Brown-Crowell conflict analysis. Avoidance tendencies were first established by training rats to escape shock by running in one direction in a white alley, and in the opposite direction in a black alley. Conflict tests, with no shock present, were conducted in an alley painted black along one wall and white along the opposite wall, an environment in which competing tendencies to avoid both ends of the alley were presumably aroused. In the 3 X 3 factorial design employed, three groups of rats were trained after drinking 0%, 3%, or 6% ethanol solutions. In the subsequent conflict testing phase, each training group was further divided into groups that were tested after drinking either 0%, 3%, or 6% ethanol solutions. Continuous monitoring of each rat's position throughout the test trials allowed a detailed analysis of the effects of ethanol on avoidance-avoidance conflict

behavior, as reflected in measures of oscillation range, total movement, starting speeds, running speeds, and number of reversals of direction of movement. In addition, daily recording of weight and fluid intake for individual animals made possible determination of dose-effect relationships.

METHODS

Subjects

The subjects were 72 female albino rats from the Holtzman Company, Madison, Wisconsin. They were 90 to 110 days old at the beginning of the experiment, and weighed between 190 and 240 g. Throughout the experiment they were maintained in individual cages in a colony room with a 12-h light-dark cycle.

Apparatus

All training and testing were conducted in an apparatus consisting of three alleys mounted side-by-side, all 18.5 cm deep, but of differing widths and interior colors. One alley was black and was 7.5 cm wide, the second was white and 10 cm wide, and the third had one black and one white wall, and was 8.7 cm wide. The three alleys could be moved laterally so that any one could be positioned over a grid floor constructed of 2.4-mm diameter stainless steel bars mounted at 2.8-cm intervals. The alleys were covered by hinged Plexiglas lids. Translucent ground-glass panels were inset into both ends of each of the three alleys so as to form 7.5-cm high windows. The right-end windows of the white and the black alleys were made distinctive by marking each with a 1.8-cm wide, black stripe. The centrally positioned stripe was vertically oriented in the black alley and horizontally oriented in the white alley. Sixty-Hz AC was supplied to the grid as needed, from a variable auto-transformer through a series resistance of 10 KΩ. Interchangeable panels were positioned 5.5 cm below the grid floor so that during each training or testing trial the color of the floor could be made to correspond to

that of the particular alley in use at the time. The panel used with the black and white center alley was half black and half white, divided lengthwise. Each end of the grid floor rested on the tip of a slightly flexible aluminum arm. Strain gauges attached to the upper and lower sides of each arm were wired in a Wheatstone-bridge configuration such that the output voltage was a linear function of the rat's position in the alley, making possible position measurement with an accuracy of $\pm$ 4 cm over the 184-cm range. During each trial, the output of the bridge circuit was sampled at .20-sec intervals by a digital voltmeter (Hewlett-Packard, Model 3440A) used as an analog-to-digital converter. The output of the voltmeter was interfaced electronically with a PDP/8F minicomputer which monitored the input, controlled the sampling rate, and punched the data onto paper tape. Thus, throughout every trial the rat's position was accurately recorded five times per second.

A trap-door-floored start box was used to introduce the rats into the alley. Internally, the box was 19.5 cm long, 7.3 cm wide, and 11 cm deep. It was covered by a translucent top, and the trap-door floor was fashioned from two stainless steel plates, hinged to open outwards like aircraft bomb bay doors. With the start box on top of the alley, its floor was 22 cm above the grid floor. A 60-W, white, incandescent bulb in a reflector was located 107 cm above the alley, and 10 cm in from the right end of the alley. This lamp, directed down toward the alley, provided the only illumination during habituation, training, and testing, and made the right end of the alley distinctive.

Procedure

Following a 5-day quarantine period in the Animal Care Department, the rats were distributed to individual cages and maintained on ad lib food and water for several days. Once the experimental schedule was entered, Purina Lab Chow was available at all times, but the rats were allowed access to fluid for only one 15-min period each day. This period began approximately 1 h before the end of the light cycle. All testing, training, and habituation trials took place within a 40-min period which began 30 min following the drinking period. The order in which the rats were run each day was varied randomly. The experiment was run in two replications of 36 rats each.

For the training phase, the animals were divided into three groups, scheduled to be trained after drinking either (a) a plain sugar-water solution (0% ethanol), (b) a sugar-water solution containing 3% ethanol, or (c) a sugar-water solution containing 6% ethanol. Solutions were made up each day in the following manner. The 0% solution consisted of 96 g of granulated cane sugar mixed with room temperature tap water to a volume of 1200 ml. The 3% solution contained 96 g of sugar, 38 ml of 95% ethanol, and room-temperature tap water to 1200 ml, yielding a concentration of ethanol of 3.01% v/v. The 6% solution consisted of an identical amount of sugar, 76 ml of 95% ethanol, and water to 1200 ml, yielding a concentration of ethanol of 6.02% v/v.

Table 1 outlines the treatment and fluid schedules for the three groups during the training phase of the experiment. This phase

consisted of a 9-day period of handling, habituation, and fluid ingestion, followed by a 15-day period during which the rats were trained every third day. Though the treatment schedule was identical for all training groups, they began the schedule sequentially over a period of 3 days, so that after the initial handling days, all animals drank the same fluid on each calendar day and differed only with respect to the treatment they received following the drinking period.

The treatment schedule for the group trained after drinking the 6% ethanol solution (Train-6%) is shown in the second column in Table 1, and is described in detail here after. As this group began its experimental sequence, water bottles were removed from the cages at 8:00 am on the first day. At about 4:00 pm on the same day, (2 h before the end of the light cycle) the rats were handled for 2 min and were weighed. Immediately thereafter, drinking tubes containing plain tap water were inserted into the cages for 20 min. On subsequent days, all drinking periods were 15 min long. On Days 2 and 3, the animals were handled for 1 min (and also weighed during this time), then allowed to drink plain water for 15 min. On Day 4 a repeating, 3-day fluid sequence (6%-3%-0%) was initiated, such that the animals received habituation and training trials after drinking their scheduled fluids. Day 7 was an habituation day, on which the rats were allowed to explore the white and black alleys for 1 min each. The two days following the habituation day and the two days following each training day were designated "fluid only" days, on which the rats were weighed and allowed to drink for 15 min, but were

Table 1. Treatment and fluid schedule for the training phase. The letter W indicates that the rats received plain tap water during their drinking period, whereas 0%, 3%, and 6% refer respectively to sugar-water solutions containing 0%, 3%, or 6% ethanol.

Day	Train-6%	Train-3%	Train-0%
1	W Handling		
2	W Handling	W Handling	
3	W Handling	W Handling	W Handling
4	6% Handling	W Handling	W Handling
5	3% Handling	3% Handling	W Handling
6	0% Handling	0% Handling	0% Handling
7	6% Habituation	6% Handling	6% Handling
8	3% Fluid Only	3% Habituation	3% Handling
9	0% Fluid Only	0% Fluid Only	0% Habituation
10	6% Training	6% Fluid Only	6% Fluid Only
11	3% Fluid Only	3% Training	3% Fluid Only
12	0% Fluid Only	0% Fluid Only	0% Training
13		6% Fluid Only	6% Fluid Only
14			3% Fluid Only
	Four more 3-day cycles like Days 10-12.	Four more 3-day cycles like Days 11-13.	Four more 3-day cycles like Days 12-14.

otherwise not handled. Fluids consumed on these "fluid only" days were the two fluids the animals did not drink on habituation and training days, thus assuring that all animals would have equal experience with all fluids used during the experiment. On the 10th day, after the drinking period, each rat received two shock-escape trials, one in the black and one in the white alley. Escape training was counterbalanced. Half the rats in each group were trained to escape shock by running toward the illuminated end in the white alley, and away from the illuminated end in the black alley; the others were trained to escape in the opposite direction in the two alleys. At the beginning of each escape trial, the rat was placed in the trap-door start box, positioned over one end of the alley. As soon as the rat faced the opposite end, the trap doors were opened and the recording system was turned on. Fifteen seconds after being dropped into the alley, the animal was removed and returned to its carrying box. The shock was on for the entire 15-sec trial so it was possible for the rat to wander back onto the electrified portion of the grid. The conditions in effect on Days 10, 11, and 12, were repeated four more times, resulting in five days of exposure to 6% ethanol followed by shock-escape training, and 10 days of interposed exposures to 3% and 0% ethanol solutions. Over the five training days, each rat received ten escape trials, five in the black, and five in the white alley. On the first training day a shock of 60 V (as measured at the grid) was applied to the 30-cm portion of the grid at the end where the rat was dropped. On subsequent training days, the shock was 67, 67, 72, and 72 V, respectively. Training

trials were distributed with an intertrial interval of approximately 15 min. As indicated by the last two columns of Table 1, the treatment schedules for the Train-3% and Train-0% groups were identical to that described for the Train-6% animals, save that the former groups received habituation and training following ingestion of 3% and 0% ethanol solutions, respectively.

For the testing phase, each of the three training groups was randomly divided into thirds, which were assigned to be tested after drinking either 0%, 3%, or 6% ethanol solutions. This assignment yielded the nine groups of the 3 X 3 factorial design, diagrammed in Figure 2. The fluid and treatment schedules in effect during this phase are outlined in Table 2. Note that because of their sequential entry into the training phase, the three training groups also began the testing phase sequentially over a period of three days. Test trials involved dropping the rat into the black-white alley with the start box positioned at one of four locations: at either end of the alley, or 34 cm from either end. Test trials were 15 sec long, with the shock source disconnected. The lamp illuminated one end of the alley as it had during the training trials. The animals were started when they faced the far end of the alley as they had been during training.

After assignment to subgroups for testing, the rats remained on the same schedule of one treatment day followed by two fluid only days, but the fluid schedule was shifted so that the conflict tests would be conducted following consumption of the assigned ethanol solutions. This resulted in a change in the pattern of the fluid

Figure 2. The 3 X 3 factorial design. Three groups of rats received shock-escape training shortly after drinking either a 0%, 3%, or 6% ethanol solution. For conflict tests, each training group was divided into thirds, to be tested after drinking either 0%, 3%, or 6% ethanol solutions.

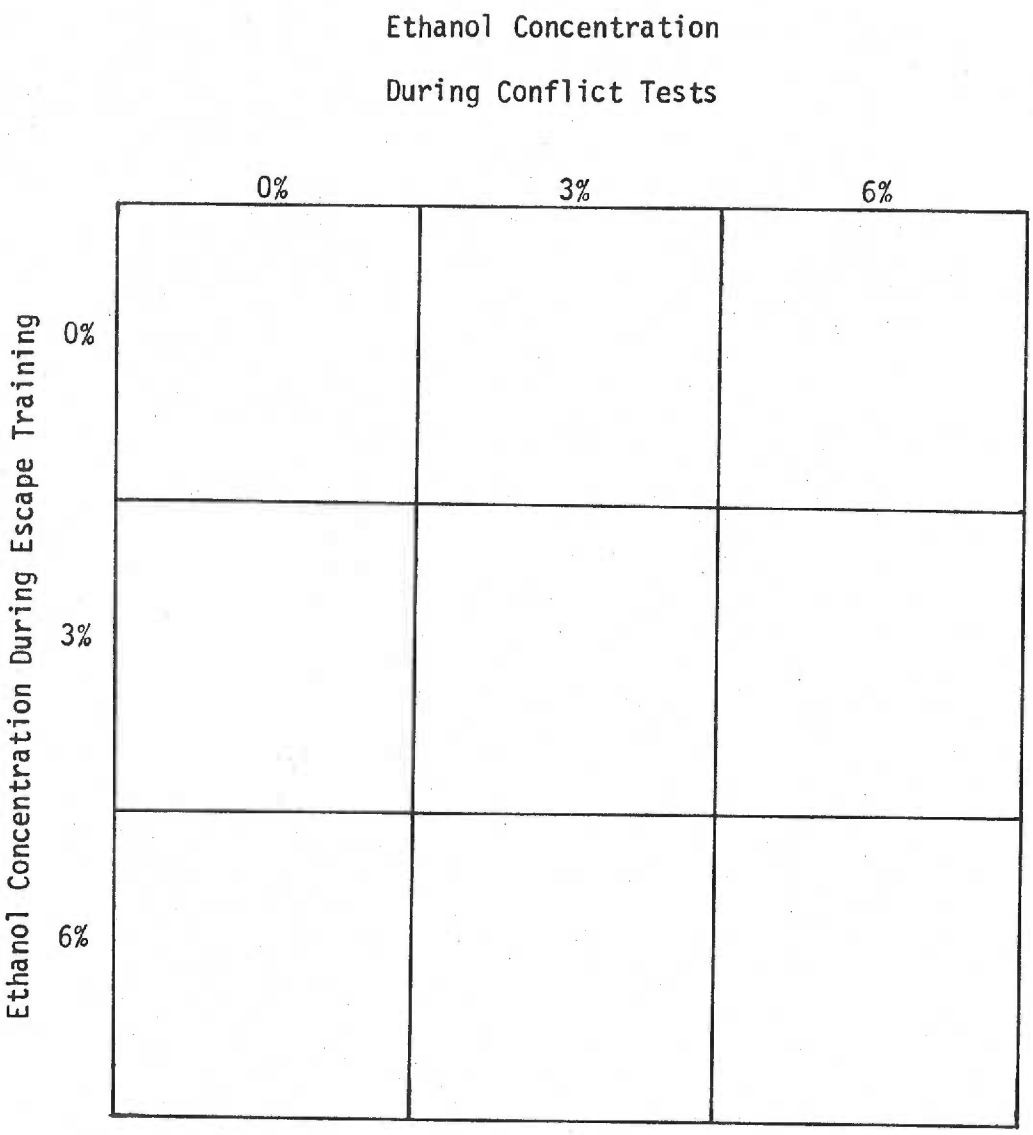

Ethanol Concentration
During Conflict Tests
0%
3%
6%
Ethanol Concentration During Escape Training
0%
3%
6%

Table 2. Treatment and fluid schedule for the testing phase. The two percentages heading each column indicate the ethanol concentration used during training (first figure), and testing (second figure). Fluid Only days are indicated by a dash (-).

Day	Test Fluid	6%-0%	3%-6%	0%-3%	Test Fluid	6%-3%	3%-0%	0%-6%	Test Fluid	6%-6%	3%-3%	0%-0%
25	0%	test	-	-	3%	test	-	-	6%	test	-	-
26	6%	-	test	-	0%	-	test	-	3%	-	test	-
27	3%	-	-	test	6%	-	-	test	0%	-	-	test
28	0%	test	-	-	3%	-	-	test	6%	-	-	test
29	6%		test	-	0%		test	-	3%		test	-
30	3%			test	6%			test	0%			test

schedule for all groups of the factorial design which were tested after drinking solutions which differed from the training solution. For example, the rats both trained and tested after drinking a 6% ethanol solution remained on the same repeating fluid sequence (6%-3%-0%) throughout the study. The rats trained after drinking a 6% solution but tested after drinking a 3% solution, were shifted from a 6%-3%-0% sequence for training, to a 3%-0%-6% fluid sequence for the testing phase.

A daily record was kept of each animal's weight and fluid consumption, from which the daily ethanol doses were calculated. Early in the experiment it was noted that a few of the rats were developing respiratory infections. For prophylactic and treatment purposes, all rats received three, intra-muscular injections of 5 mg of oxytetracycline[1], one on the habituation day and one on each of the two days following. These injections were given approximately 5 h before the drinking period each day.

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[1]Rachelle Aquachel Intramuscular Oxytetracycline Hydrochloride with 2% Lidocaine, 50 mg/ml.

RESULTS

As described earlier, at the end of the training phase each of the three groups was divided into groups to be tested after drinking a 0%, 3%, or 6% ethanol solution. This manipulation yielded the nine groups depicted in Figure 2. In the discussions to follow, a label such as "Train-6%" will be used to designate all animals trained after drinking a 6% ethanol solution, regardless of the concentration of ethanol in solutions consumed prior to conflict tests. In a similar manner, groups labeled "Test-6%" include the three groups tested after drinking a 6% ethanol solution, regardless of the ethanol concentration during training.

Body Weight, Fluid Consumption, and Ethanol Dose

Body Weight. Body weights during the habituation and training phases of the experiment are plotted in Figure 3. From this figure it is apparent that the rats lost weight during the initial days of the water deprivation schedule, then slowly gained weight throughout the remainder of the experiment. It is also apparent that the animals of the second replication weighed less than those in the first. The most reasonable basis for this weight difference is that, due to scheduling problems, the rats in the second replication were approximately two weeks younger than those in the first. These observations were confirmed with an analysis of variance, which yielded a significant main effect of days [$F(11, 726) = 160.98$, $p < .001$], and of replications [$F(1, 66) = 48.98$. $p < .001$]. There was no significant effect of ethanol concentration during training, indicating that there were no weight differences among groups trained after drinking

Figure 3. Body weights during habituation and training.

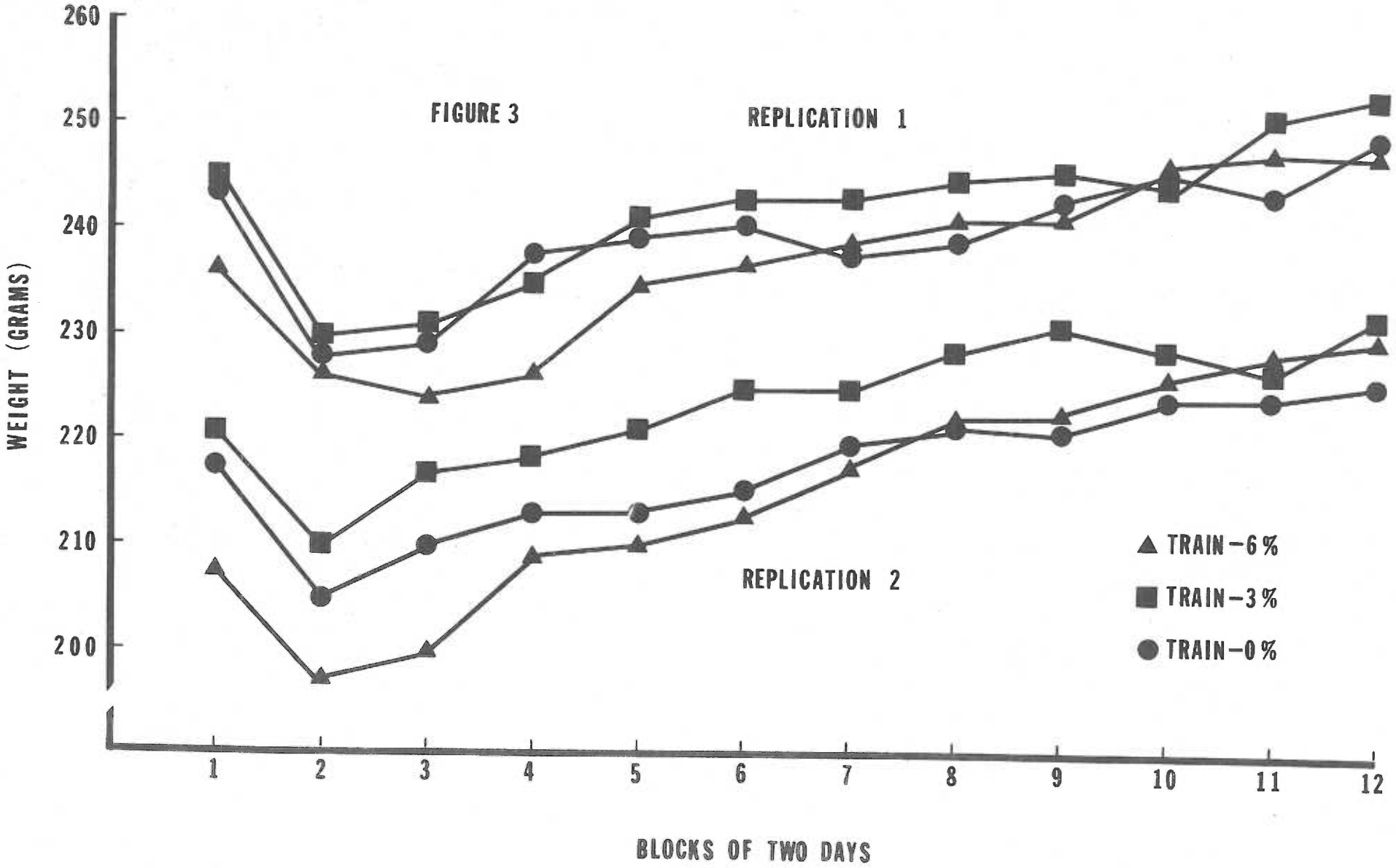


FIGURE 3
REPLICATION 1
REPLICATION 2
WEIGHT (GRAMS)
260
250
240
230
220
210
200
TRAIN-6%
TRAIN-3%
TRAIN-0%
1
2
3
4
5
6
7
8
9
10
11
12
BLOCKS OF TWO DAYS

different concentrations of ethanol. That weight differences between replications differed during the 24-day period was indicated by a significant replications by days interaction [$F(11, 726) = 4.04$, $p < .01$]. Additionally a significant training-concentration by days interaction indicated that changes in weight over days differed among training groups. Examination of the data revealed that animals assigned to the Train-6% groups tended to lose more weight initially and to gain more subsequently than did rats in the other training groups.

Weights on test days for the nine groups of the factorial design are plotted in Figure 4. Though weights changed significantly from Test Day 1 to Test Day 2 [$F(1, 63) = 17.36$, $p < .001$], there were no significant weight differences among training or testing groups, and no significant interactions.

Fluid Consumption. During the training phase, although all animals drank the same ethanol solution each calendar day, the three training groups were trained on different days, as described in Table 1. For example, on days when all rats drank a 3% ethanol solution, only those rats in the Train-3% group were given shock-escape trials following the drinking period. In order to evaluate the effect of ethanol concentration on fluid intake during training, the training phase was divided into five, 3-day periods during which the sequence of ethanol concentrations was 6%-3%-0%. Fluid consumption during training is plotted in Figure 5, where one can see that fluid intake tended to increase during each period as the ethanol concentration changed from 6% to 3% to 0%. For each replication a three-way analysis of variance was completed using training period, training concentration,

Figure 4. Weights on test days for the nine groups of the factorial design.

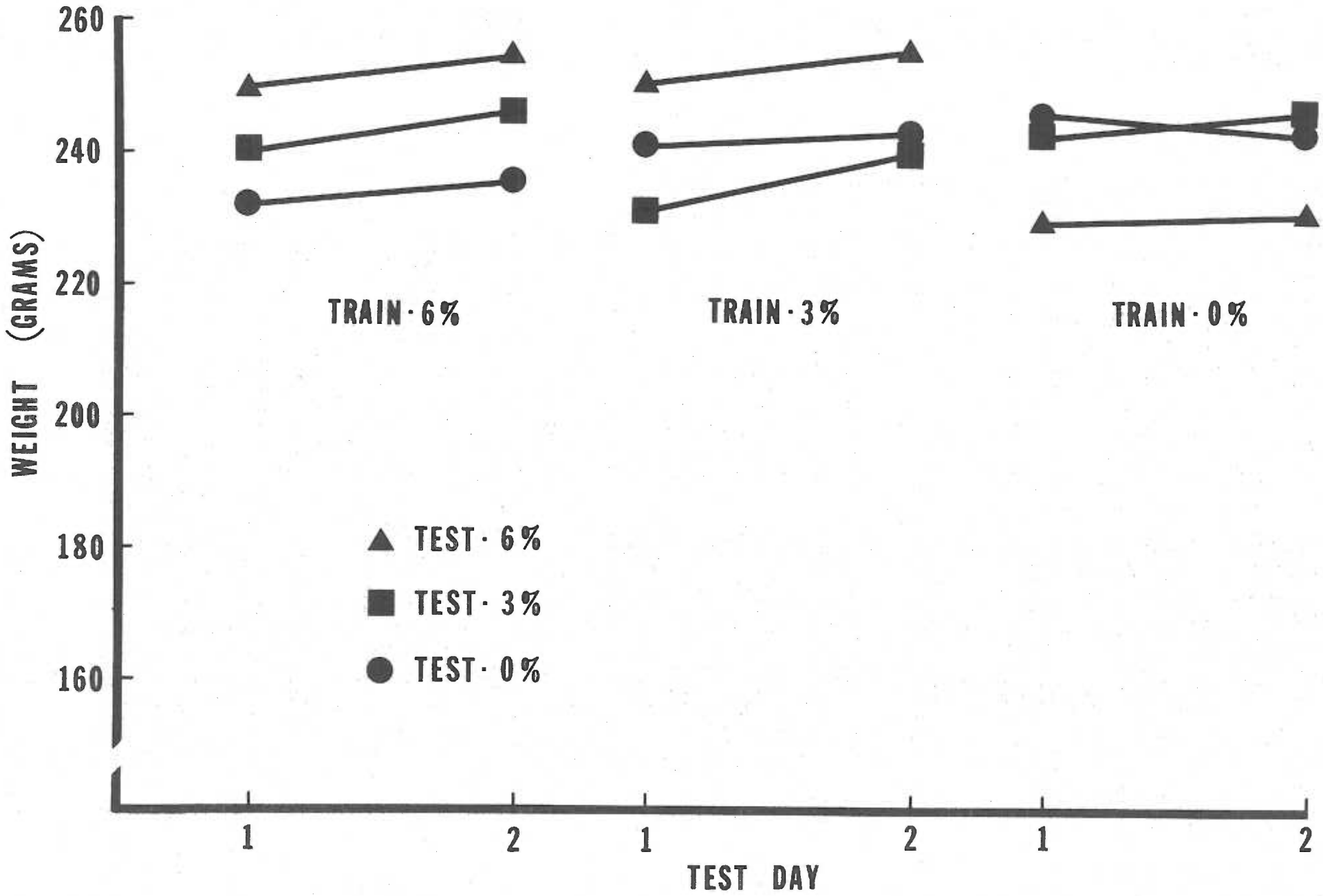
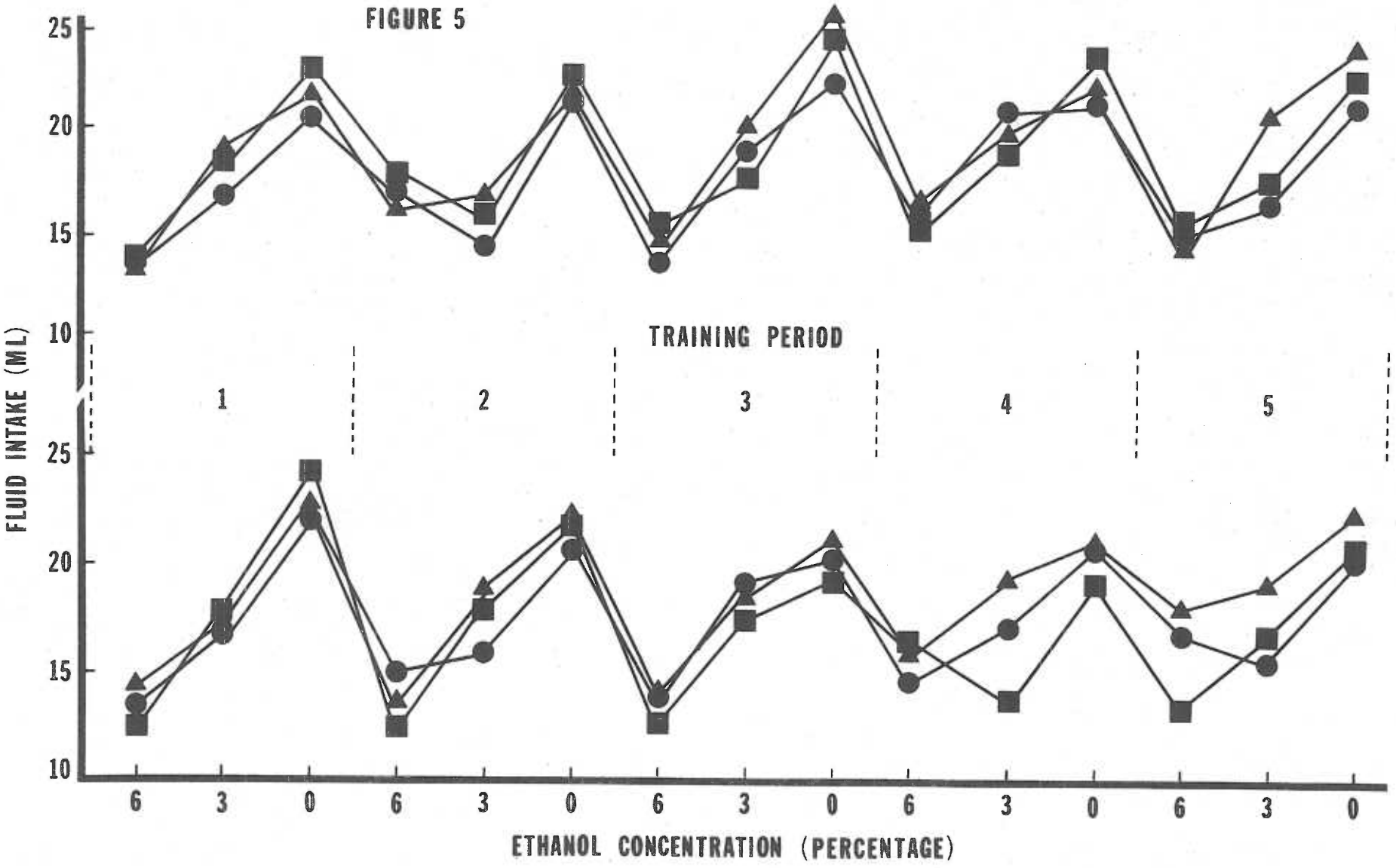

260
240
220
200
180
160
WEIGHT (GRAMS)
TRAIN · 6%
TRAIN · 3%
TRAIN · 0%
▲ TEST · 6%
■ TEST · 3%
● TEST · 0%
1
2
1
2
1
2
TEST DAY

Figure 5. Fluid intake during five, 3-day training periods. Mean daily fluid intake is shown for the three training groups (triangles = Train-6%, squares = Train-3%, circles = Train-0%). Fluid intake is plotted on the ordinate, while the concentration of ethanol in the sugar-water solution available during the 15-min drinking period is indicated across the abscissa. Data for Replication 1 are plotted in the upper panel, data for Replication 2 in the lower panel.

FIGURE 5


25
20
15
10
FLUID INTAKE (ML)
TRAINING PERIOD
1
2
3
4
5
25
20
15
10
6 3 0 6 3 0 6 3 0 6 3 0 6 3 0
ETHANOL CONCENTRATION (PERCENTAGE)

and ethanol concentration (in the offered drinking fluid) as factors. Differences in consumption of the three ethanol concentrations were highly significant for the data of both Replication 1 [$F(2, 99) = 87.17$, $p < .001$] and Replication 2 [$F(2, 99) = 122.96$, $p < .001$], with Newman-Keuls tests revealing that, in both replications fluid intake increased significantly as ethanol concentration decreased from 6% to 3% to 0%. Though there was no significant main effect of training concentration upon fluid intake in Replication 1 (plotted in the upper panel of Figure 5), there was a significant training periods effect [$F(4, 396) = 2.70$, $p < .05$], reflecting a small but significant increase in the amount of fluid consumed in later training periods. Additionally, for the first replication there was a significant interaction involving the factors of training period and ethanol concentration [$F(8, 396) = 4.95$, $p < .01$], indicating that the changes in fluid consumption during the training phase were different for the three ethanol concentrations. In the second replication (see lower panel of Figure 5), there was a significant main effect of training concentration [$F(2, 99) = 4.60$, $p < .05$]. A Newman-Keuls test showed that Train-3% rats, drinking an average of 17.0 ml per day, consumed significantly less than the Train-6% rats, which drank an average of 18.5 ml per day. The Train-0% animals drank an average of 17.8 ml per day and did not differ significantly from the other two training groups. Additionally, there was a significant interaction involving the factors of training concentration, ethanol concentration in the offered solution, and training period [$F(16, 396) = 1.80$, $p < .05$].

In order to examine fluid consumption during the testing phase, a separate analysis of variance was first completed for each replication, with testing concentration, training concentration, and test day as factors. During testing, there were no significant fluid intake differences between animals trained after drinking different concentrations of ethanol, and fluid consumption did not change over the two test days. There was, however, a significant main effect of testing concentration for both Replication 1 [$F(2, 27) = 42.04$, $p < .001$], and Replication 2 [$F(2, 27) = 13.65$, $p < .001$], and a significant training concentration by test-day interaction, [$F(2, 27) = 5.76$, $p < .01$]. Graphic interpretation of this interaction revealed that while both Train-6% and Train-3% groups tended to increase fluid consumption from Test Day 1 to Test Day 2, there was a decrease in consumption for the Train-0% animals. To assess possible replication differences, a subsequent analysis of variance, using the same data was completed, utilizing replication, testing ethanol concentration, and test day as factors. This analysis again revealed a significant effect of testing concentration [$F(2, 66) = 46.60$, $p < .001$], and a Newman-Keuls test further indicated that on both test days, Test-0% rats drank more than Test-3% rats, which in turn drank more than Test-6% rats. There was no significant main effect of replications.

In summary, the most important aspect of drinking behavior during training was the regular pattern of increasing consumption as ethanol concentration was cycled from 6% to 3% to 0%. Though there were no differences in fluid intake among training groups in the first replication, in the second, rats trained after drinking the 3% ethanol

solution tended to drink less than the Train-6% animals, while the Train-0% animals did not differ from the other groups. On test days there was again an inverse relation between the concentration of ethanol in the solution and the amount consumed, so that before testing, Test-0% rats drank more than Test-3% rats, which in turn drank more than Test-6% rats.

Ethanol Dose. Mean ethanol doses self-administered by the different training groups are shown for Replication 1 (solid figures) and Replication 2 (open figures) in Figure 6. Mean doses over the five training days are also listed in Table 3, along with average doses during the testing phase. It is evident from this table that the oral administration method used resulted in fairly uniform mean dose levels throughout the training and testing phases. For both replications combined, the mean training doses for the Train-6%, Train-3% and Train-0% groups were 3.0 g/kg, 1.7 g/kg, and 0.0 g/kg, in that order. Frequency distributions of mean test doses are shown in Figure 7, for groups tested after drinking 3% or 6% ethanol solutions. From this figure, both the dose range within each testing group, and the overlap between groups may be discerned. The dose for the Test-0% groups (not plotted) was always 0.0 g/kg. An analysis of variance utilizing replication, test concentration, and test day as factors indicated no significant dose differences between replications or between the two test days. As expected though, there was a highly significant difference in dose level between the 3% and 6% test groups [$F(1, 44) = 51.05$, $p < .001$], with Test-3% and Test-6% animals averaging 1.9 g/kg, and 2.8 g/kg, respectively over the two test days.

Figure 6. Mean ethanol doses on the five training days. Data for Replication 1 are plotted with solid figures, while data for Replication 2 are plotted with open figures.

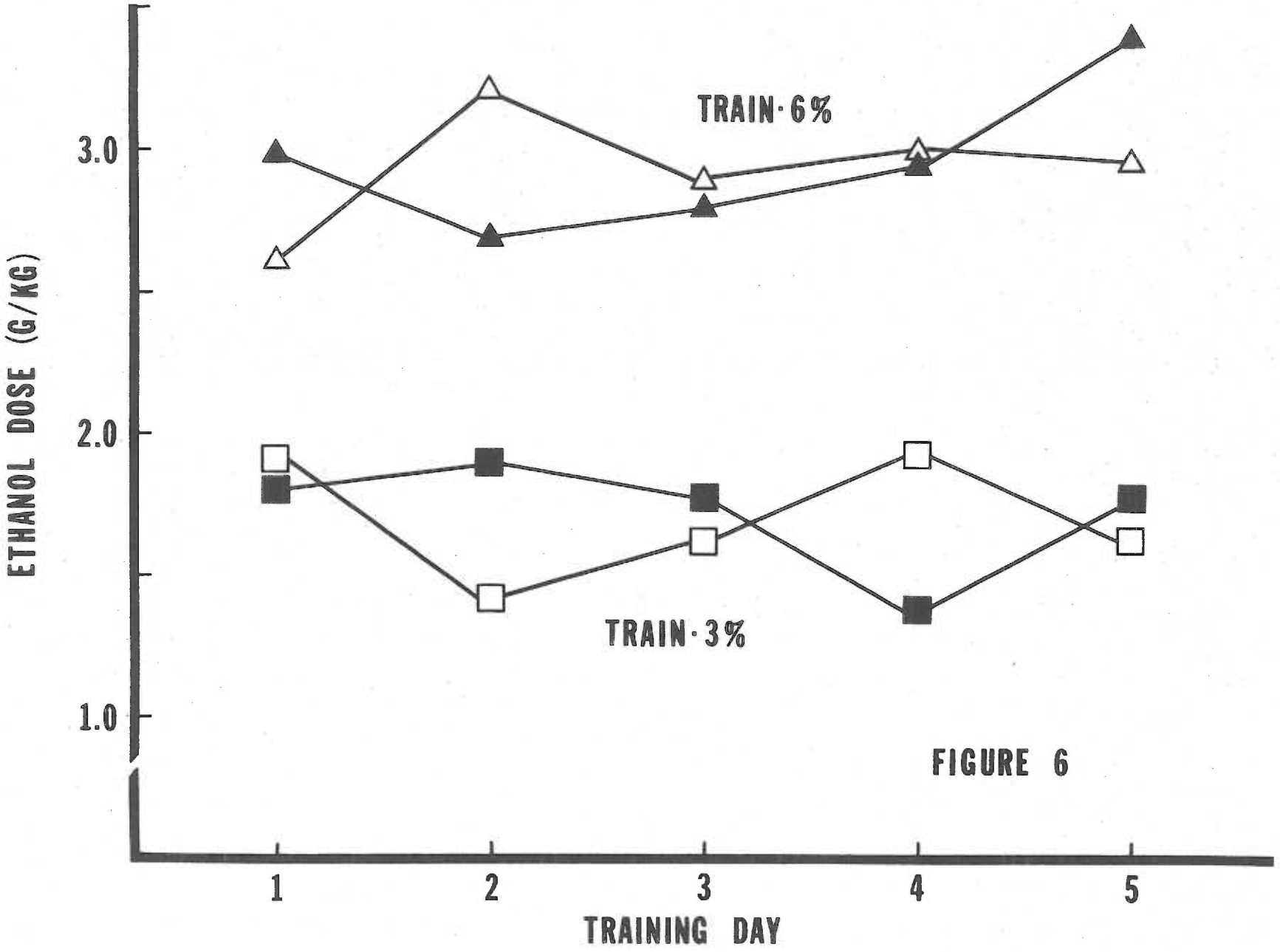


FIGURE 6

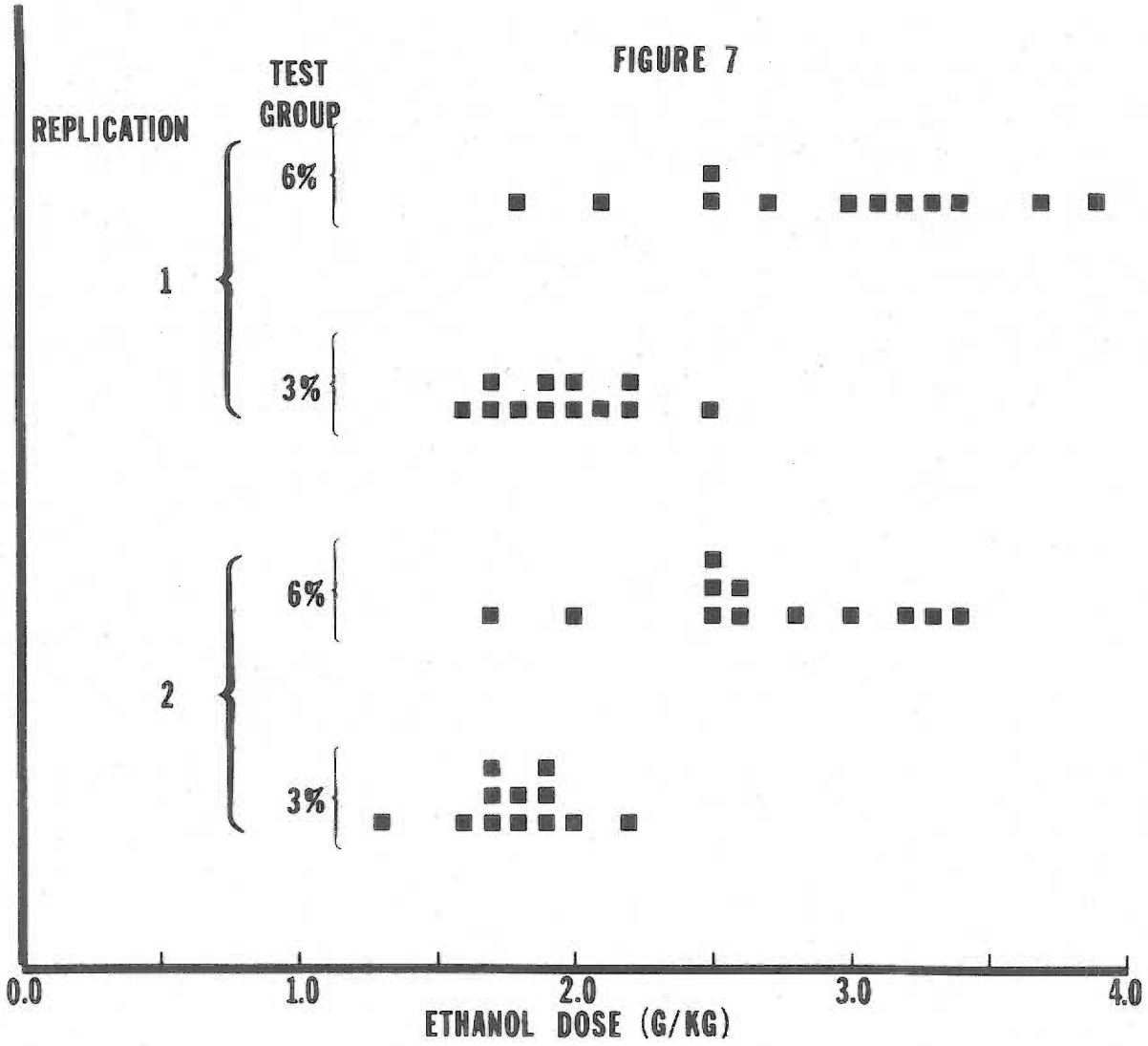
Table 3. Average Ethanol Doses By Groups For Training and Testing Phases. All doses are expressed in grams/kilogram.

		Training Day					
	Training Concentration	1	2	3	4	5	$\bar{X}$
Replication 1	6%	2.6	3.2	2.9	3.1	3.0	3.0
	3%	1.8	1.4	1.6	2.0	1.7	1.7
	0%	0.0	0.0	0.0	0.0	0.0	0.0
Replication 2	6%	3.0	2.7	2.8	3.0	3.4	3.0
	3%	1.7	1.9	1.8	1.4	1.8	1.7
	0%	0.0	0.0	0.0	0.0	0.0	0.0
Both Replications Combined	6%	2.8	3.0	2.8	3.0	3.2	3.0
	3%	1.8	1.7	1.7	1.7	1.8	1.7
	0%	0.0	0.0	0.0	0.0	0.0	0.0

		Testing Day		
	Testing Concentration	1	2	$\bar{X}$
Replication 1	6%	2.9	2.4	2.7
	3%	1.8	1.7	1.8
	0%	0.0	0.0	0.0
Replication 2	6%	2.8	3.0	2.9
	3%	2.0	1.9	2.0
	0%	0.0	0.0	0.0
Both Replications Combined	6%	2.9	2.7	2.8
	3%	1.9	1.8	1.9
	0%	0.0	0.0	0.0

Figure 7. A frequency distribution of the mean ethanol doses self-administered just prior to conflict tests by Test-6% and Test-3% animals. For each animal in a test group, a mean dose for Test Days 1 and 2 is plotted.

FIGURE 7


REPLICATION
TEST GROUP
6%
3%
1
6%
3%
2
0.0
1.0
2.0
3.0
4.0
ETHANOL DOSE (G/KG)

Locomotor Performance Measures

Escape Speeds During Training Trials. Escape speeds were calculated by measuring the time interval between the moment the rat dropped onto the grid at the beginning of a trial and the time when it moved past a point in the alley 30 cm from the start. The 30-cm distance was then divided by this time to yield a speed in cm/sec. The mean speeds with which the three training groups traversed the first 30 cm of the alley during the shock-escape training phase are plotted for Replication 1 (dashed lines with open symbols) and Replication 2 (solid lines with solid symbols) in Figure 8. Due to equipment failure, data for Replication 1 are incomplete. From the data plotted for the second replication, it is apparent that the higher the ethanol concentration during training, the slower the starting speeds. A tendency for escape speeds to increase over the training period is also apparent, with a large part of the increase occuring early in the training phase. These observations were supported statistically. Analysis of the data for the second replication revealed a significant main effect of ethanol concentration during training [$F(2, 33) = 10.58$, $p < .01$], and a Newman-Keuls test indicated a significant decrease in escape speeds as the concentration increased from 0% to 3% to 6%. Additionally, a significant main effect of training days [$F(4, 132) = 8.14$, $p < .01$] indicated that escape speeds varied with training period. Data from Training Days 3 and 5 were available for all groups in both replications, and were examined with an analysis of variance utilizing replication, training concentration, and training day as factors. This analysis

Figure 8. Escape speeds during training trials. The mean speeds with which the three training groups traversed the first 30 cm of the alley are plotted for Replication 1 (dashed lines and open figures), and Replication 2 (solid lines and solid figures). The data for Replication 1 are incomplete.

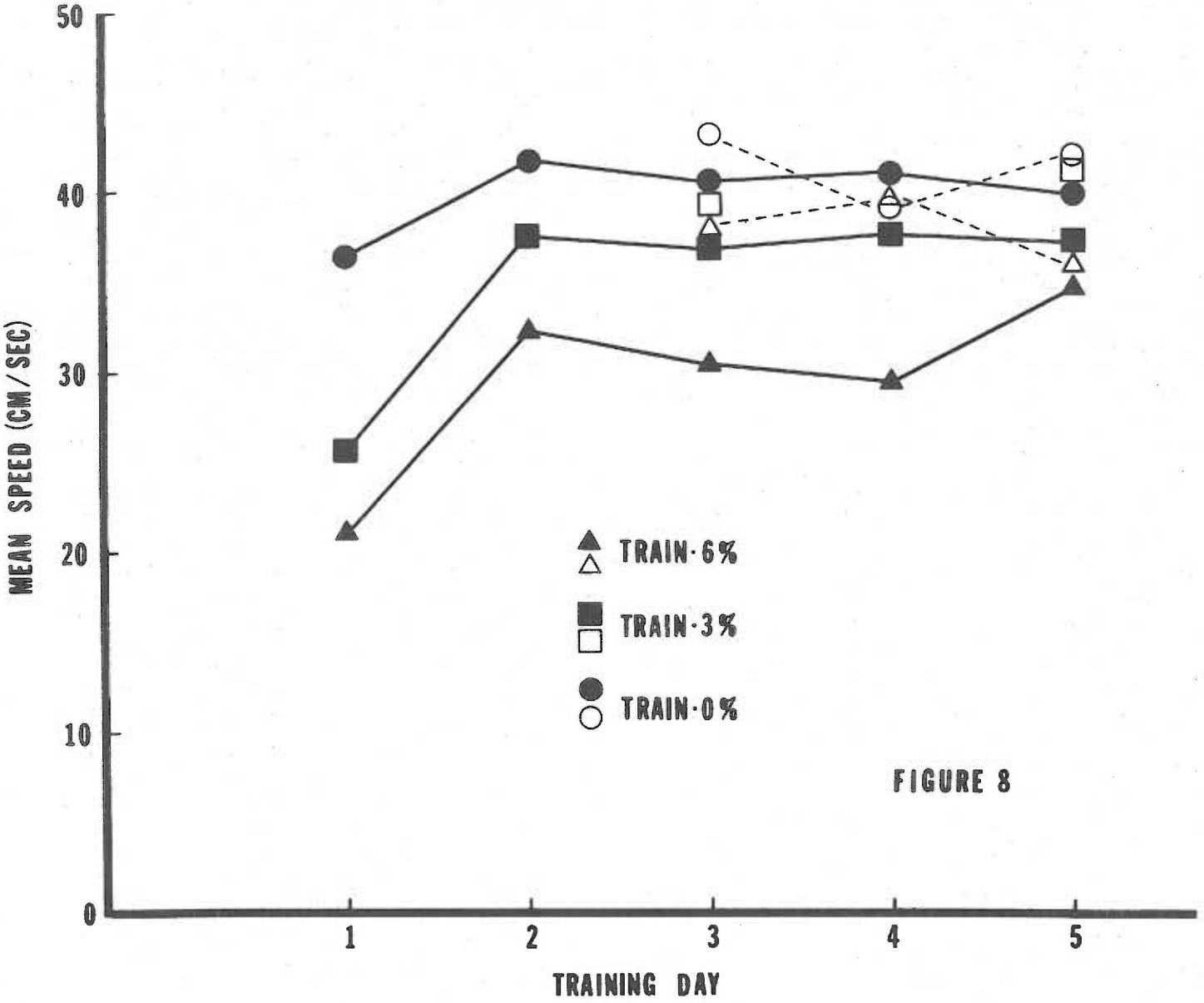

50
40
30
20
10
0
MEAN SPEED (CM/SEC)
1
2
3
4
5
TRAINING DAY
TRAIN-6%
TRAIN-3%
TRAIN-0%

FIGURE 8

indicated no differences between escape speeds as a function of either replication or training day. There was again a significant main effect of training concentration [$F(2, 66) = 4.48$, $p < .05$], and a Newman-Keuls test showed that only the Train-0% and Train-6% groups differed significantly in escape speeds. A similar analysis of escape speeds on the final training day indicated no significant differences between replications or among training groups, and no significant interactions.

Starting Speeds During Conflict Tests. Ethanol concentration during training and ethanol concentration during testing were used as factors in all analyses of conflict test data. The three levels of each factor, 0%, 3%, and 6% ethanol concentrations, corresponded to the 3 X 3 factorial design employed in the experiment. It should be noted that during the second replication, on Test Day 2, for Train-6% animals, the data for the last 10 trials were lost due to equipment failure. This resulted in the loss, for 10 animals, of the data for one out of the four conflict test trials. In subsequent analyses of starting speeds, running speeds, total movement, oscillation range, and reversals, a mean score based on performance in the other three conflict test trials was entered in place of the missing data.

It will be recalled that during each conflict test trial, rats were dropped into the alley at one of four locations: the two ends of the alley (end starts) and two points located 35 cm toward the center from either end (near-end starts). During conflict tests, starting speeds were determined by measuring how long it took each rat to move 30 cm toward the alley center from its starting position.

The 30-cm distance was divided by the time measurement to yield a speed score in cm/sec. Separate analyses of variance were carried out for each replication to determine whether the factors of starting position and test day influenced starting speeds. For neither replication were there significant main effects of either training concentration or test day, indicating that the animals trained after drinking different concentrations of ethanol did not differ in starting speeds during conflict tests, and that there were no changes in starting speeds over the two test days. However, animals dropped into the alley at the end start positions had significantly faster starting speeds than those dropped near the center, for Replication 1 [$F(1, 54) = 6.70$, $p < .05$], and Replication 2 [$F(1, 54) = 4.39$, $p < .05$]. In neither of the two replications were there significant interactions involving factors of training concentration, testing concentration, starting position, or test day. There was no significant effect of testing concentration in Replication 1. In Replication 2 however, testing concentration significantly influenced starting speeds [$F(2, 54) = 9.16$, $p < .01$], with a Newman-Keuls test indicating that Test-0% rats, with an average starting speed of 23.5 cm/sec were significantly slower than the Test-6% and Test-3% rats, with respective starting speeds of 33.1 and 38.5 cm/sec. Test-6% animals did not differ significantly from Test-3% animals.

Running Speeds During Conflict Tests. Running speeds during the conflict tests, were tabulated for each of six, central, 24-cm segments of the alley. The 20-cm regions at the ends of the alley were excluded from this measurement to minimize contamination with

starting and stopping accelerations. Only test trials from the end starting positions were used, with data from the two trials being averaged for statistical analysis. If a rat failed to enter any segment, a speed of 0.0 cm/sec was assigned for that segment on that trial. If a rat entered a segment but did not run completely through it, a speed score for the actual distance traversed was assigned.

Running speeds in the six alley segments are shown in Figure 9, for the three differently trained groups (collapsed across testing conditions), and in Figure 10 for the three differently tested groups (collapsed across training conditions). It can be seen from these figures that, generally speaking, while the effect of ethanol during training was to decrease running speeds during subsequent conflict tests (Figure 9), the effect of ethanol during conflict tests was to increase running speeds (Figure 10). In addition, running speeds tended to decrease uniformly as a function of distance from the starting point, indicative of a gradient in the tendency to avoid the starting area. An overall analysis of variance, yielding significant main effects of ethanol concentration during training [$F(2, 63) = 3.26$, $p < .05$], ethanol concentration during testing [$F(2, 63) = 6.39$, $p < .005$, and alley segment [$F(5, 135) = 59.37$, $p < .001$] confirmed these observations. Newman-Keuls tests showed that although rats trained after drinking a 0% ethanol solution ran significantly faster during conflict tests than those trained after drinking 6% solutions ($p < .05$), the Train-3% rats did not differ from either of the other groups. Rats tested after drinking a 0% solution ran significantly slower than both Test-3% and Test-6%

Figure 9. Running speeds during conflict tests, in the six, central alley segments. Mean speeds for the three differently trained groups (collapsed across testing conditions), are shown.

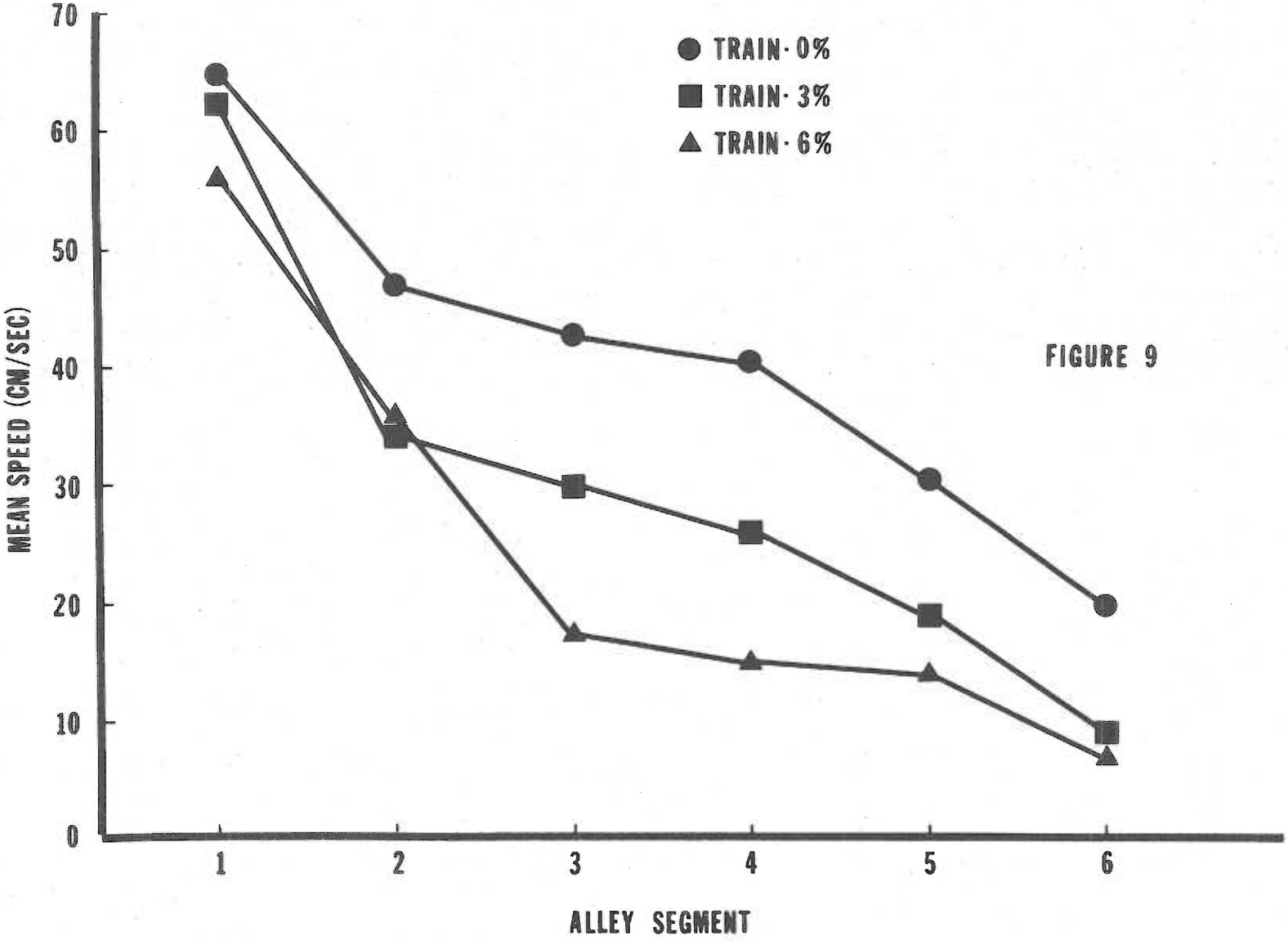

TRAIN-0%
TRAIN-3%
TRAIN-6%
MEAN SPEED (CM/SEC)
70
60
50
40
30
20
10
0
1
2
3
4
5
6
ALLEY SEGMENT

FIGURE 9

Figure 10. Running speeds during conflict tests, in the six, central alley segments. Mean speeds for the three differently tested groups (collapsed across training conditions), are shown.

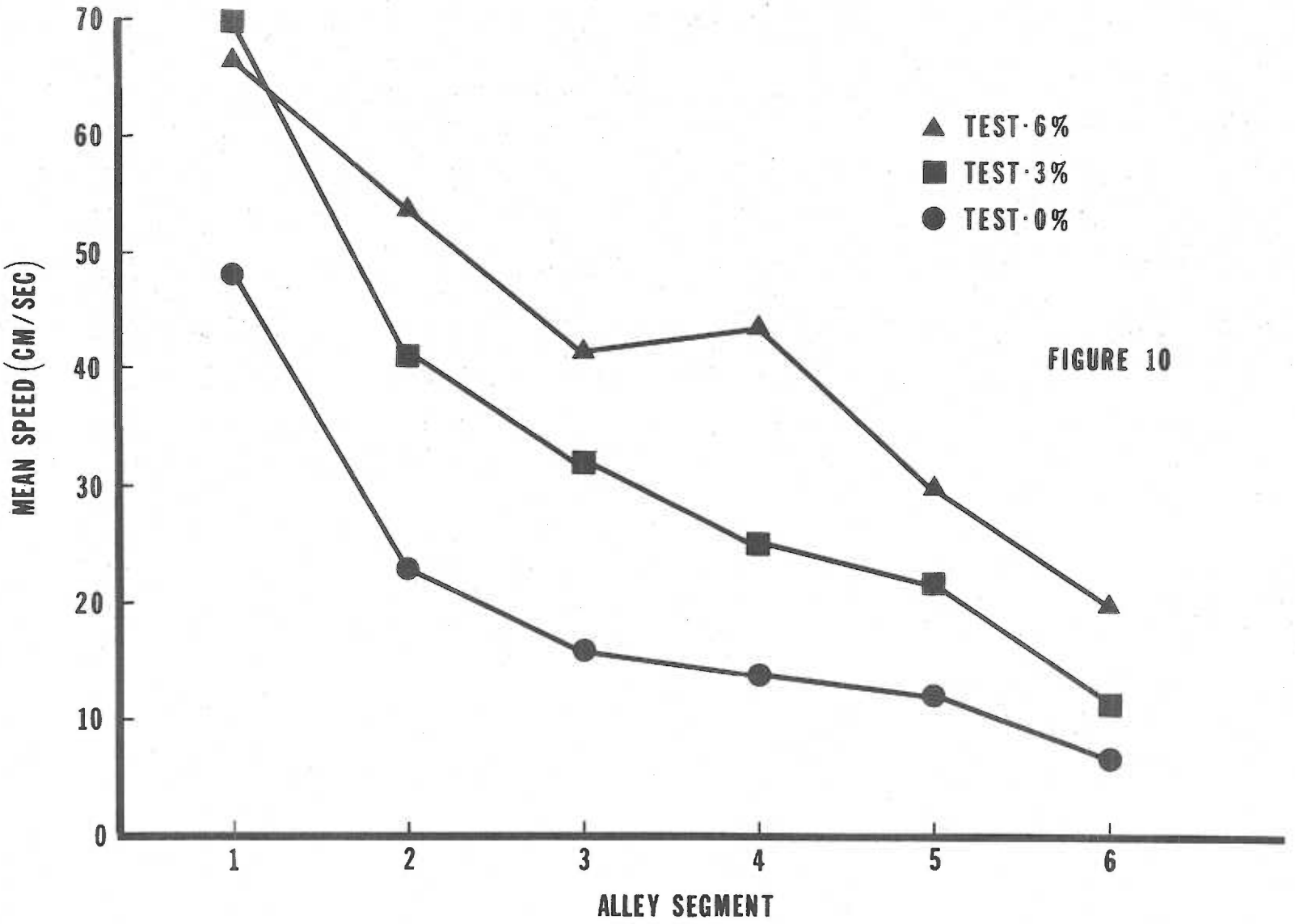

70
60
50
40
30
20
10
0
MEAN SPEED (CM/SEC)
1
2
3
4
5
6
ALLEY SEGMENT
TEST·6%
TEST·3%
TEST·0%

FIGURE 10

animals ($p < .05$, p .01), however, Test-3% rats did not differ significantly from Test-6% animals.

As described previously, if an animal failed to enter any alley segment, a 0.0 cm/sec score was assigned for that segment. To examine the possibility that this procedure introduced bias, all animals that were assigned zero scores in any segment on both end-start trials were excluded from an additional analysis. This manipulation reduced the size of the groups from 8 to 4 animals per group. The new analysis yielded a significant main effect of drug concentration during testing [$F(2, 27) = 6.78$, $p < .01$], and a significant main effect of alley segment [$F(5, 135) = 68.32$, $p < .001$]; however, the effect of drug during training, although in the same direction, was no longer significant.

One way to assess further the strength of the relation between ethanol and locomotor conflict behavior would be to examine the correlation between dose and behavior on the two test days. To this end, Pearson product-moment correlation coefficients were calculated between ethanol dose during conflict tests and running speed in each of the six alley segments, and in all six segments combined. Data from the two end-start trials for each of the 72 rats in the two replications were used (excluding trials for which data were missing), yielding 68 pairs for each correlation. These correlation coefficients, along with associated levels of significance and coefficients of determination are listed in Table 4. It is apparent that these correlations, though generally low, were all significant save one, with ethanol dose level accounting for up to 16% of the variance in running speed scores.

Table 4. Pearson product-moment correlation coefficients for ethanol testing dose and running speeds, for the first and second end-start trials. Coefficients of determination indicate the percentage of the variance in performance scores that may be accounted for by ethanol dose level.

	Alley Segment	Correlation Coefficient	p	Coefficient of Determination (r^2)
First End Trial	1	.34	.01	.12
	2	.40	.01	.16
	3	.28	.05	.08
	4	.27	.05	.07
	5	.28	.05	.08
	6	.26	.05	.07
	Six segment mean	.39	.01	.15
Second End Trial	1	.14	NS	.02
	2	.31	.01	.10
	3	.29	.05	.08
	4	.31	.01	.10
	5	.29	.05	.08
	6	.26	.05	.07
	Six segment mean	.32	.01	.10

Oscillation Range. A behavioral measure especially pertinent to an evaluation of the Brown-Crowell conflict model is the range of oscillation around the center point of the alley. From the position reports obtained every .2 sec during the conflict test trials, measurements were made of how closely each rat approached each end of the alley during the 15-sec test period. The distance between these extreme points was designated the oscillation range. To avoid recording end starts as approaches to end regions, no approach measurements were taken until after an animal had made one reversal in direction of at least 10 cm in length. Mean oscillation ranges, comprised of scores from the four conflict test trials, were used in a three-way analysis of variance, with ethanol concentration during training, ethanol concentration during testing, and replication as factors. These data, collapsed across replications, are plotted in Figure 11, where it may be seen that oscillation range was inversely related to ethanol concentration during training, but directly related to ethanol concentration during testing. Significant main effects of training concentration [$F(2, 54) = 6.56$, $p < .005$], and of testing concentration [$F(2, 54) = 10.70$, p .001], confirm these observations. Newman-Keuls tests showed that all oscillation range differences between training groups were significant ($ps < .05$), with the exception of the difference between Train-0% and Train-3% groups. All differences between testing groups were significant ($ps < .05$). Although there was a significant main effect of replications [$F(1, 54) = 9.39$, $p < .005$], there were no significant interactions of replications with other factors, and a comparison

Figure 11. Oscillation range scores during conflict tests. The concentration of ethanol in solutions consumed just prior to conflict tests is indicated across the abscissa, while ethanol concentration during training is indicated with circles (Train-0%), squares (Train-3%), or triangles (Train-6%).

Figure 12. Total movement scores during conflict tests. The concentration of ethanol is solutions consumed just prior to conflict tests is indicated across the abscissa, while ethanol concentration during training is indicated with circles (Train-0%, squares (Train-3%), or triangles (Train-6%).

FIGURE 11

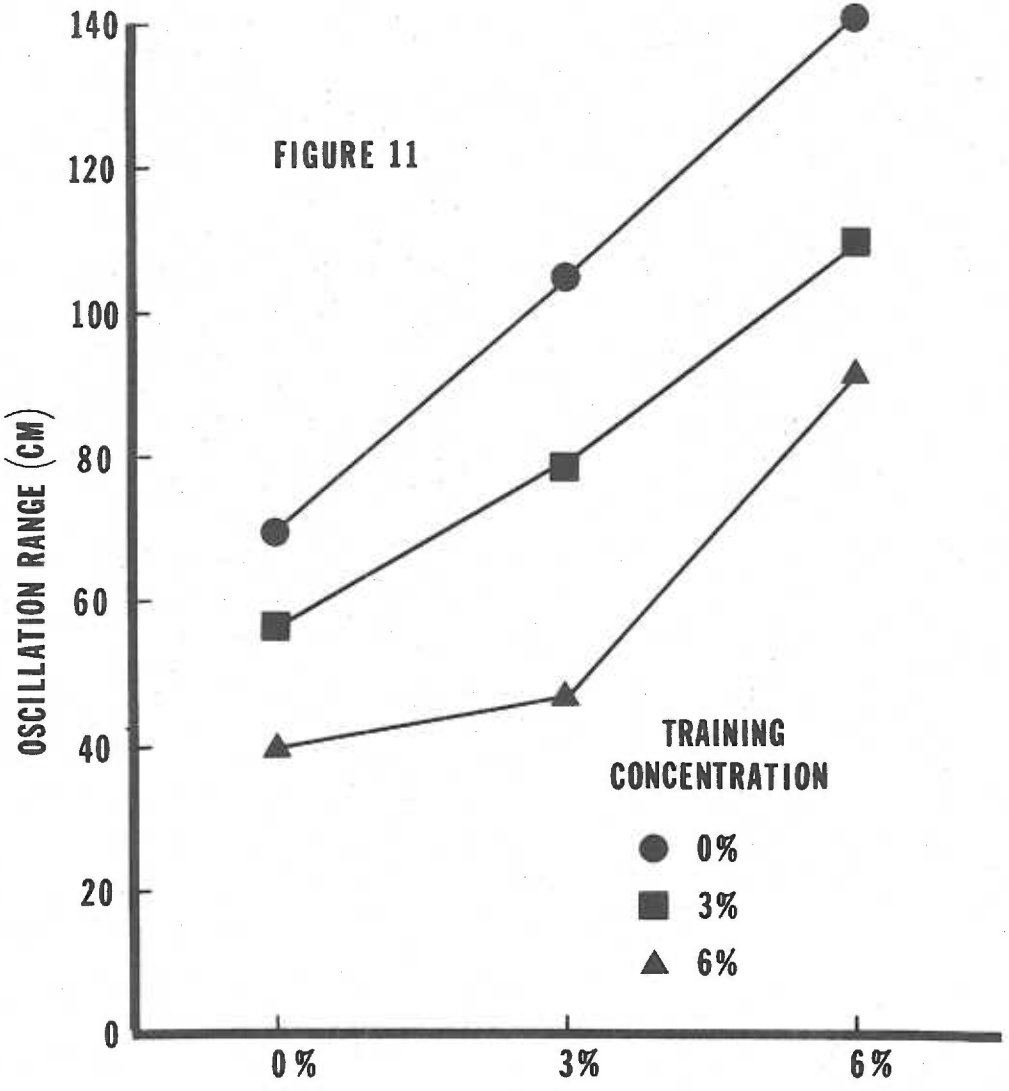
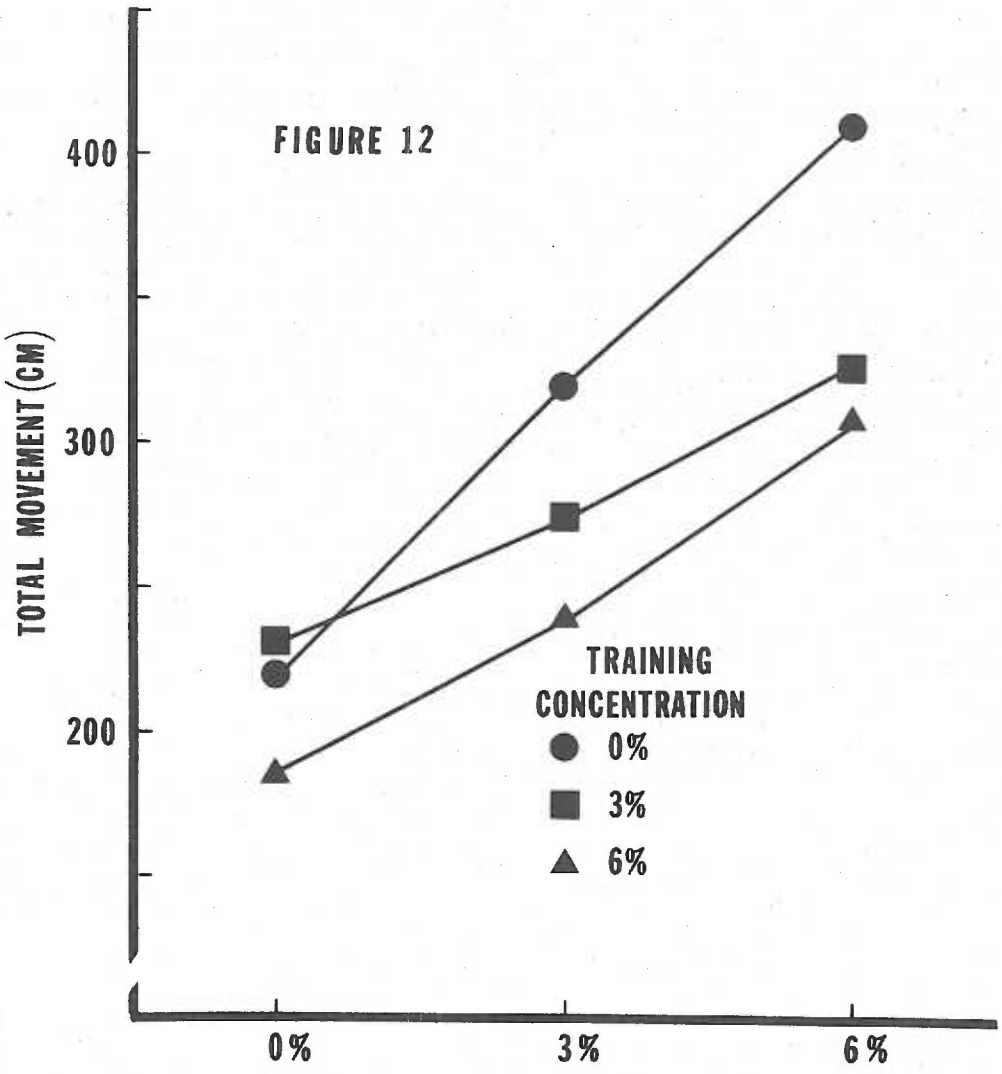


FIGURE 12



ETHANOL TESTING CONCENTRATION

of the data indicated that though all groups in Replication 2 had elevated oscillation range scores, the relationship between groups remained the same for both replications.

Total Movement. Total movement scores were defined as the cumulative distance traveled (regardless of direction) during the 15-sec trial period, and thus reflected general locomotor activity. Total movement scores were analyzed in the same manner as oscillation range scores, and these results are plotted (collapsed across replications) in Figure 12. Here too, total movement scores were inversely related to ethanol concentration during training, and directly related to concentration of ethanol during testing. A three-way analysis of variance yielded a significant main effect of ethanol concentration during training [$F(2, 54) = 4.01$, $p < .05$], and a significant effect of ethanol concentration during testing [$F(2, 54) = 15.32$, $p < .001$]. Newman-Keuls tests indicated that increasing the ethanol concentration from 0% to 3% to 6% (and hence increasing dose level) during testing produced concomitant, significant increases in total movement scores (all ps $< .05$). Though the difference in total movement scores between Train-0% and Train-6% animals was significant ($p < .05$), Train-3% animals did not differ significantly from the other training groups. Rats in the second replication exhibited significantly higher total movement scores [$F(1, 54) = 11.82$, $p < .001$], though there were no significant interactions between replications and other factors, indicating that in each replication the relations among groups were similar.

For both oscillation range and total movement scores, dose-response relations were further examined by computing correlations between ethanol dose on any test day and the performance score (averaged over two trials) for that day. Separate correlations for each combination of test day, replication, and behavioral measure are listed in Table 5, each correlation being based on 36 pairs of data. For oscillation range, the correlations ranged from .29 (not significantly different from zero) to .52 ($p < .01$), with ethanol dose level accounting for up to 27% of the variance in the oscillation range scores. Correlation coefficients for total movement scores were moderate, ranging from .41 to .65, with dose level accounting for 17% to 42% of the variance in movement scores.

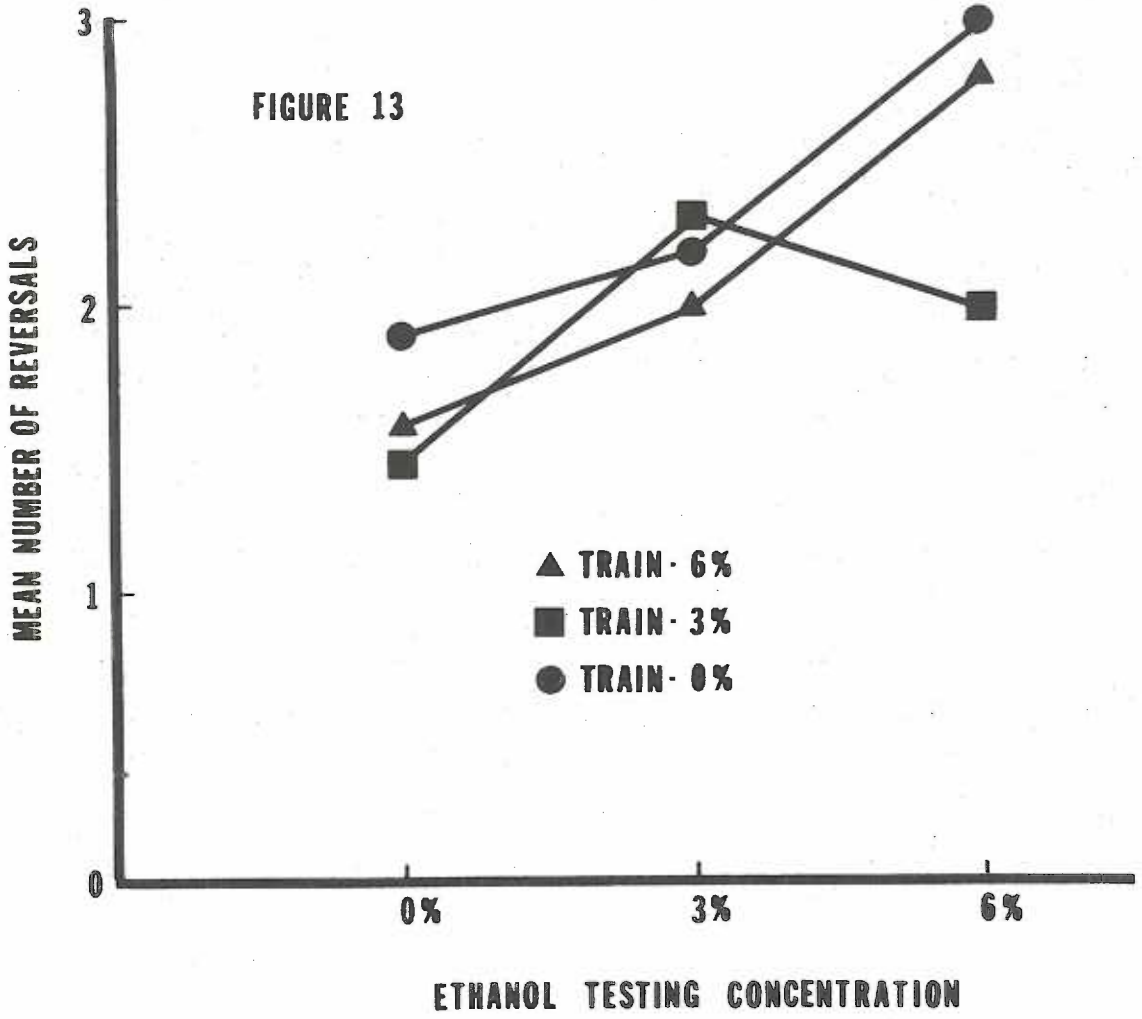
Reversals In Direction Of Travel. A reversal in direction of travel was scored when a rat turned around (or possibly backed up) and moved 10 cm in a direction opposite to that in which it had been traveling. Ten cm of continuous movement in one direction at the beginning of a trial was the criterion for establishing an initial direction of travel. Mean reversal scores based on four conflict test trials for each rat were used in a three-way analysis of variance involving the factors of drug concentration during training, drug concentration during testing, and replication. These data (collapsed across replications) are plotted in Figure 13. From this figure it can be seen that, with the possible exception of groups trained after ingesting 3% ethanol, reversals increased with ethanol dose level during testing. There appeared to be no differences between rats trained after drinking different ethanol concentrations. These

Table 5. Pearson product-moment correlation coefficients for all combinations of behavioral measure, replication, and test day. Coefficients of determination indicate the percentage of the variance in conflict test performance scores that may be accounted for by ethanol dose level.

Measure	Replication	Test Day	Correlation Coefficient	p	Coefficient of Determination
Oscillation Range	1	1	.52	.01	.27
Oscillation Range	1	2	.29	.1	.08
Oscillation Range	2	1	.45	.01	.20
Oscillation Range	2	2	.47	.01	.22
Total Movement	1	1	.54	.01	.29
Total Movement	1	2	.41	.05	.29
Total Movement	2	1	.59	.01	.35
Total Movement	2	2	.65	.01	.42

Figure 13. Reversals in direction of travel during conflict tests. The concentration of ethanol in solutions consumed just prior to conflict tests is indicated across the abscissa, while ethanol concentration during training is indicated with circles (Train-0%), squares (Train-3%), or triangles (Train-6%).

FIGURE 13


3
2
1
0
MEAN NUMBER OF REVERSALS
TRAIN - 6%
TRAIN - 3%
TRAIN - 0%
0%
3%
6%
ETHANOL TESTING CONCENTRATION

observations were confirmed by the finding of a significant main effect of ethanol concentration during testing [$F(2, 54) = 4.45$, $p < .05$], and the lack of a significant main effect of ethanol concentration during training. While a Newman-Keuls test revealed that mean reversal scores increased significantly as testing concentration changed from 0% to 6% ethanol ($p < .05$), Test-3% animals did not differ significantly from the other groups. Rats in the second replication had significantly higher mean reversal scores than those in the first replication [$F(1, 54) = 5.77$, $p < .01$]. Once again, however, there were no significant interactions involving replications and other factors, indicating that the relations among treatment groups in each replication were similar.

DISCUSSION

In this experiment, rats were initially trained to escape from electric shock by running in one direction in a white alley, and in the opposite direction in a black alley. Administration of ethanol just prior to these training trials resulted in dose-related decreases in the speeds with which rats escaped shock. In subsequent shock-free conflict tests, the rats were placed into an alley with one black wall and one white wall, an environment in which competing tendencies to avoid both ends of the alley were presumably aroused. In such avoidance-avoidance conflict tests, rats that had previously received shock-escape training after drinking ethanol ran more slowly, and exhibited lower total movement and oscillation range scores than did animals trained after drinking plain sugar-water solutions. Administration of ethanol just prior to the avoidance-avoidance conflict tests resulted in dose-related increases in running speeds, total movement scores, and oscillation ranges. In addition, rats tested under the influence of ethanol exhibited a higher number of reversals in direction of travel than did sugar-water controls.

The experiment was carried out in two replications and the younger rats of the second replication consistently exhibited higher total movement, oscillation range, and reversal scores. However, lack of interactions between the factors of replication and ethanol concentration during training or testing indicated that for the younger animals, the performance of all groups was elevated similarly, and for this reason, the results of the two replications will, for the most part, be discussed jointly.

During the training phase, three groups of rats underwent shock-escape training shortly after drinking solutions containing either 0%, 3%, or 6% ethanol. Mean ethanol doses for these groups were 0.0 g/kg, 1.7 g/kg, and 3.0 g/kg, respectively. The finding that escape speeds were inversely related to ethanol dose is consistent with results reported by Mansfield, et al. (1977) and by Skurdal, Eckardt, and Brown (1975). In these studies the presence of ethanol during shock-escape training resulted in slower starting and running speeds. To account for these results, it is not necessary to appeal to an emotional effect of the drug. Motor impairment and analgesia are well documented effects of ethanol (Ritchie, 1974; Barry & Miller, 1965) that could easily degrade shock-escape performance.

Ethanol during shock-escape training trials also significantly influenced performance in the later conflict tests. Summaries of these results and of those from an earlier avoidance-avoidance study (Mansfield, et al., 1977) are presented for comparison in the upper half of Table 6. Despite considerable procedural differences between the two studies, the results are quite similar. In both investigations, rats that were under the influence of ethanol during training had lower oscillation range and total movement scores, and slower running speeds during subsequent shock-free conflict tests than did rats that had drunk plain sugar-water solutions. In neither study did ethanol during training affect the number of reversals during conflict trials, and in the present study, it had no effect on starting speeds during conflict tests.

Table 6. A comparison of the effects of ethanol on avoidance-avoidance conflict test behavior. The top panel summarizes the effects of ethanol administered during training, while the lower panel summarizes the effects of ethanol administered during testing.

Effects of Ethanol During Training	Mansfield, Eaton, Cunningham, & Brown (1977)	Mansfield (1977)
Oscillation Range	5% < 0%	6% < 3%, 0%
Total Movement	5% < 0%	6% < 0%
Starting Speed	5% < 0%	No effect
Running Speeds	5% < 0%	6% < 0%
Reversals	No effect	No effect

Effects of Ethanol During Testing		
Oscillation Range	5% > 0%	6% > 3% > 0%
Total Movement	5% > 0%	6% > 3% > 0%
Starting Speed	No effect	Rep. 1: No effect Rep. 2: 6%, 3% > 0%
Running Speeds	5% > 0%	6% > 0%
Reversals	5% > 0%	6% > 0%

Systematic differences among groups in total exposure to ethanol can be ruled out as a factor contributing to between-group differences in test performance in the present experiment. All animals in this study had equal exposure to the three solutions; thus any potentially deleterious effects of long term ingestion of the drug (cf. Freund & Walker, 1971) would have been equivalent for all groups. Additionally, the effects of ethanol during training on subsequent conflict test performance were not due to the presence of the drug in the body at the time of testing and hence could not have been due to ataxia or analgesia. Hence, they indicate that ethanol affected the acquisition of avoidance tendencies during the training phase of the experiment.

One interpretation offered by Mansfield, et al., (1977) to explain similar results, was that due to motor impairment or analgesia rats trained under the influence of ethanol were learning a "slow running" habit. According to this view, which is similar to Logan's (1956) micromolar theory, the slow and fast shock-escape reactions exhibited by the ethanol-trained and sugar-water-trained rats, respectively, are considered to be different responses, not quantitatively different levels of the same response. Differential performance during conflict tests would therefore be based on the learning of different responses during prior escape training. In both conflict studies, rats under the influence of ethanol during training did indeed escape shock more slowly, and subsequently showed reduced oscillation range, total movement, and running speed scores during conflict tests, findings which are supportive of such an interpretation. Two results of the present study not consistent with such a micromolar

interpretation are that escape speed differences among training groups had disappeared by the final day of training and that ethanol during training did not affect starting speeds during the later conflict tests.

An alternative explanation of these results, following a suggestion by Anisman (1972), is that ethanol interfered with the acquisition of conditioned fear during escape training. That ethanol-trained rats ran more slowly when running from the end regions during shock-free conflict tests may be indicative of weakened avoidance tendencies resulting from lower levels of conditioned fear. Though this interpretation is consistent with a tension-reduction position, it should be noted that an ethanol-produced decrement in the acquisition of conditioned fear may involve different mechanisms than an ethanol-produced mitigation of an already existing conditioned fear.

The effects of ethanol on behavior during avoidance-avoidance conflict tests bear upon both the Brown-Crowell (1974) conflict analysis and the tension-reduction hypothesis. In the present study, consumption of ethanol prior to conflict tests resulted in dose-related increases in oscillation range, total movement, and running speeds. Additionally, rats tested after drinking a 6% ethanol solution made significantly more reversals than did those tested after drinking plain sugar-water. Starting speeds were significantly affected by ethanol only in the second replication, where the Test-6% and Test-3% groups had faster speeds than the Test-0% groups. These results are summarized in the lower half of Table 6, where it may be seen that the results of the present study are again in substantial

agreement with those reported earlier by Mansfield, et. (1977). Further, the dose-related nature of the present results adds appreciably to their generality.

Of possible relevance is the observation that during both training and testing, the groups differed not only in the self-administered ethanol dose, but also in the absolute amounts of fluid consumed just prior to training or testing trials. It is therefore conceivable that group differences in performance were due in part to the effects of differential stomach loading, body weight, or level of thirst. The relation of fluid intake to locomotor speeds during training and testing bears on this problem. During conflict tests, several measures showed a clear inverse relationship to fluid intake; rats that drank higher ethanol concentrations (and lower amounts of fluid) displayed faster running speeds and higher oscillation range and total movement scores. It might be argued that the rats drinking less fluid were more thirsty, and ran faster because of higher drive levels. Alternatively, it could be argued that the animals that drank more fluid were weighed down by full stomachs and thus were more sluggish. Either argument however, would predict a similar relation between fluid intake and motor speeds during training, a finding that was not obtained. In fact, escape speeds during training were directly related to fluid intake; rats that drank more fluid ran more quickly while escaping shock. Thus, fluid intake was <u>inversely</u> related to running speeds and other activity measures during conflict tests, yet <u>directly</u> related to escape speeds during training. Such disparate effects do not lend themselves readily to an explanation based soley on differential fluid consumption.

Additionally, if fluid intake alone were an important determinant of locomotor behavior, one would expect a significant correlation between performance scores and the amount of fluid consumed prior to conflict tests. Accordingly, correlation between fluid intake and total movement scores (reflecting general locomotor activity during conflict tests) were examined for Test-0% animals, for all combinations of replication and test day. For these groups, fluid intake was not confounded with ethanol dose level. None of these correlations differed singificantly from zero, indicating that fluid intake was not related to conflict test performance.

As all the animals had equal exposure to ethanol throughout the experiment, it is possible to rule out any effect of the "novelty" of ethanol at the time of testing (cf. Amit, Ziskind, & Baum, 1973). In addition, the factorial design of the experiment allowed for evaluation of state-dependency or stimulus generalization decrement effects due to a change from drug to no-drug conditions (or vice versa) from training to testing. The analyses of all performance measures yielded no significant interactions between the factors of drug concentration during training and drug concentration during testing. The lack of such interactions indicates that the effects of ethanol during testing were the same, regardless of which concentration had been used during training; hence, no evidence of state-dependency or other effect of stimulus change from training to testing was obtained (cf. Miller, 1950; Grossman & Miller, 1961).

The increased oscillation range produced by ethanol during conflict tests reflects closer approach to the punishment regions of

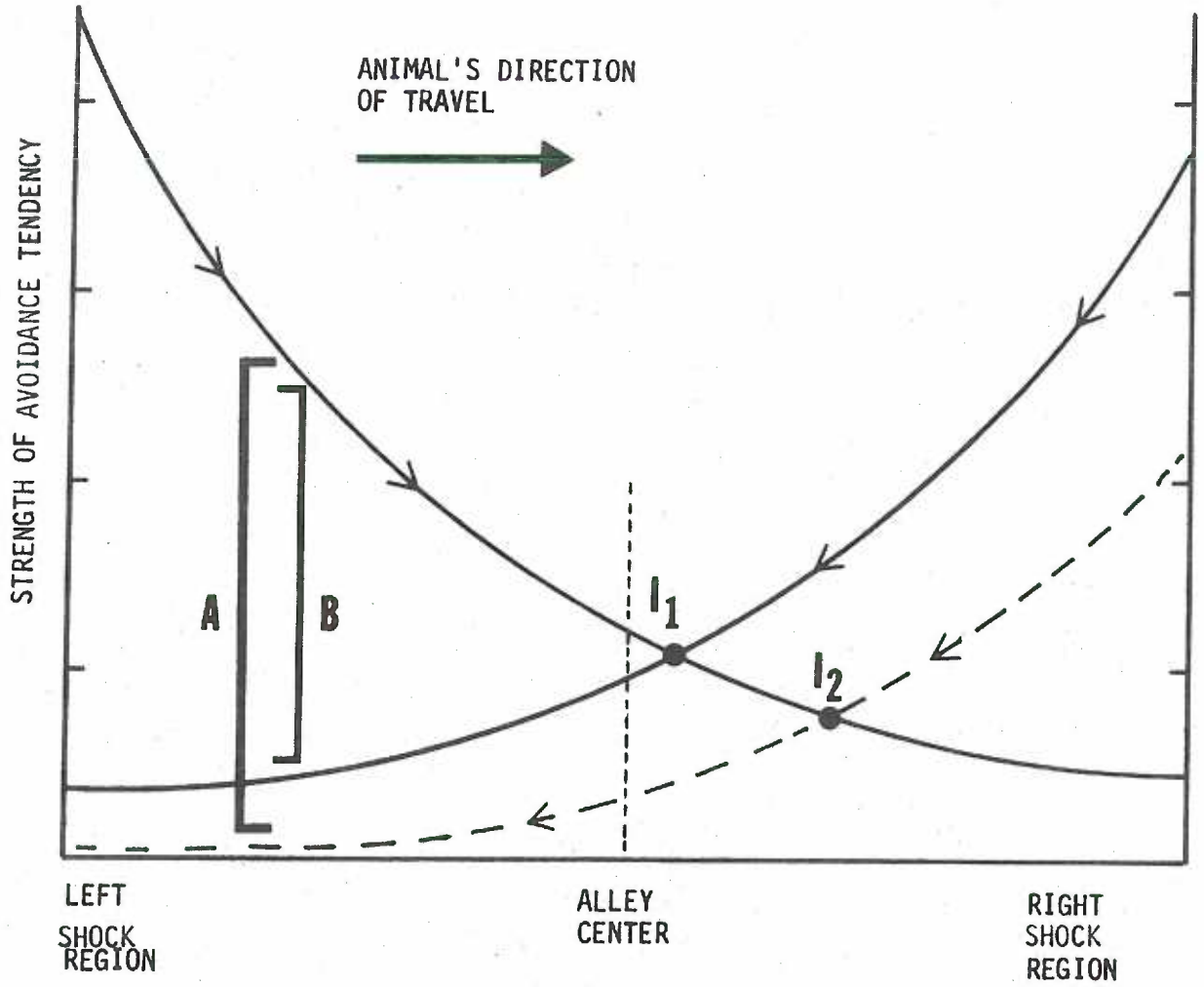
the alley, and is consistent with the results of the earlier approach-avoidance studies (Conger, 1951; Freed, 1967, 1968a, 1968b; Grossman & Miller, 1961; Masserman & Yum, 1946), and with the tension-reduction hypothesis. Within the Brown-Crowell framework, such an effect would be interpreted as resulting from a reduction in the conditioned fear supporting the avoidance tendencies. By referring again to Figure 1, and recalling that the net tendency to move in any direction is assumed to be a function of the algebraic difference between the two opposing gradients, it will be seen that if ethanol symmetrically reduces the heights and slopes of both gradients, a greater spatial separation of the hypothetical points I_1 and I_3 should be produced, and should result in a wider range of oscillation.

The increases in starting and running speeds, however, are clearly not predicted by the Brown-Crowell analysis, according to which, running speeds and oscillation range are expected to be inversely related. That is, ethanol should result in slower starting speeds and slower running throughout the alley, since the decrease in heights and slopes of the gradients would reduce the net difference between the avoidance gradients at all points.

To account for a similar pattern of results (faster running and starting speeds, and wider oscillation ranges produced by ethanol), in their avoidance-avoidance conflict study, Mansfield, et al. proposed what was described as an asymmetry hypothesis. This hypothesis involves modifications in two assumptions of the Brown-Crowell (1974) conflict analysis. In that analysis, it was assumed that, following escape training during which separate tendencies

to avoid the ends of the alley were established, when both avoidance tendencies were simultaneously aroused in the conflict alley, they could be accurately represented by symmetrical avoidance gradients such as those portrayed in Figure 1. However, Mansfield, et al. suggested that when an animal was actually in the conflict alley at or near one end, facing the opposite end, the gradients would in fact, be asymmetrical. As a detailed example, consider the stimulus complex confronting a rat dropped into the left end of the black-white conflict alley, facing the far end. For such an animal, the environmental cues associated with shock in the left end of the alley are, with the exception of alley color and the absence of shock, almost identical to conditions extant during training trials. Thus, the conditioned tendency to avoid the left end of the alley should be near full strength. Recall that during such conflict tests, there are cues also associated with shocks administered at the right end of the alley. However, for a rat at the left end, the cues at the right end are viewed from a distance and hence from a different perspective than they were when the animal was escaping from shock at the right. Therefore, though the conditioned avoidance tendencies associated with both end regions should be slightly weakened by the change from training to testing conditions, the avoidance tendency associated with the right end of the conflict alley should be disproportionately weakened for a rat moving toward that end from the left. Thus, the opposing avoidance tendencies for a rat at the left end might better be described, not as symmetrical gradients as in Figure 1, but as asymmetrical gradients. The solid-line gradients in Figure 14

Figure 14. Asymmetrical opposing avoidance gradients, hypothesized to represent avoidance tendencies during a conflict trial, for an animal at the left side of the alley, moving toward the right. Solid lines represent the hypothetical gradients for untreated animals, with the tendency to avoid the right end disproportionately weakened as described in the text. The lower, dashed line represents a further weakening of the avoidance tendency for the region of the alley being approached, as hypothesized to be produced by ethanol. Brackets B and A delineate the differences between opposing gradients at a point near the left end of the alley, under normal conditions (B), and under conditions produced by ethanol (A), respectively. Points I_1 and I_2 denote the intersections of the gradients under different conditions.


ANIMAL'S DIRECTION
OF TRAVEL
STRENGTH OF AVOIDANCE TENDENCY
A
B
I_1
I_2
LEFT
SHOCK
REGION
ALLEY
CENTER
RIGHT
SHOCK
REGION

depict this assumption; the tendency to avoid the right end of the alley being shown as weaker than the opposing tendency. Note that the intersection of the gradients (Point I_1) has been displaced toward the right, from the alley center. Similar considerations for a rat placed in the right side of the conflict alley would yield a mirror image diagram of the asymmetry; the avoidance tendency associated with the left side of the alley being weakened relative to the tendency to avoid the right side, and the intersection of the gradients being displaced toward the left. Consequently, when an animal is started at either end of the alley, it would be expected to run past the center point of the alley, even though equally strong avoidance tendencies had been established during training. Consistent with this prediction is the finding that in the present study, on 85% of the conflict test trials, the rats did indeed run past the center.

Additionally, as the rat moves back and forth, and turns around in the alley, the attendant changes in perspective would be expected to produce changes in the relative strengths of the gradients. As the rat moves toward the left, the tendency to avoid the left end would be weakened. However, when the same rat faces the other way and moves back toward the right end, the avoidance tendency associated with that end would be the weaker one. By itself, this would result in a back and forth shifting of the intersection of the opposing gradients, which would be reflected in oscillation around the center point of the alley. Furthermore, this shifting of the intersection, and hence the range of oscillation, should vary as a direct function of the degree of asymmetry between the opposing gradients.

The second assumption involved in the asymmetry hypothesis is that, instead of reducing the heights and slopes of both avoidance gradients equally as proposed by Brown and Crowell, ethanol may weaken the tendency to avoid the punishment region being approached more than it does the tendency to avoid the region being left behind. Two outcomes of this selective weakening are apparent from an inspection of Figure 14, where the drug-produced reduction in the height and slope of the gradient for the region being approached is represented by the lower, dashed line. The first result would be a displacement of the intersection of the gradients toward the approached end (i.e. from I_1 to I_2). Behaviorally, this should be reflected in closer approach to the end regions with concomittant increases in the width of oscillation around the center of the alley. In addition, a second consequence of such a selective ethanol effect would be an increased net tendency to move toward the opposite end of the alley. This increased difference between opposing gradients may be seen by comparing the magnitudes A and B in Figure 14, where the difference between the gradients at a point near the left end of the alley is indicated by B, under normal conditions, and by A, under the influence of ethanol. This should result in faster running speeds and greater total movement during the test trials. Thus, the asymmetry hypothesis can account for the increased oscillation range and total movement scores observed for ethanol-tested animals, as well as for increased running speeds in the alley. How starting speeds might be affected would depend upon the relation between the

actual slopes of the opposing avoidance gradients. As the gradients are depicted in Figure 14, for example, one might expect faster starting speeds to result from ethanol administration.

Support for the above line of reasoning may be gained from a consideration of similarities between the avoidance-avoidance conflict situation and a shuttle avoidance task. The shuttle (or two-way) avoidance task typically involves a short, straight alley, divided by a small door or hurdle into two, similar compartments. During training, the animal is required, following the onset of a conditioned stimulus (CS) such as a light or a tone, to move into the opposite compartment to avoid or escape electric shock. As acquisition proceeds, fear may become conditioned not only to the CS, but also to the environmental cues associated with each compartment (see McAllister & McAllister, 1962; McAllister, McAllister, & Douglass, 1971). Thus, in both the shuttle avoidance task, and the avoidance-avoidance conflict situation, any movement is necessarily toward an area previously associated with pain or fear. For this reason, the shuttle avoidance task, like an avoidance-avoidance conflict, also involves opposing avoidance tendencies, presumably somewhat like those diagrammed in Figures 1 or 14.

The hypothesis that ethanol differentially weakens conditioned avoidance tendencies associated with the region being approached is consistent not only with the wider oscillation ranges and faster running speeds found in the avoidance-avoidance conflict situation, but also with improvements in shuttle avoidance performance produced by the administration of ethanol (Chesher, 1974; Crow, 1966; Holloway,

1972). Conceivably, such improvements may have resulted from a reduction in the conditioned fear supporting the tendency to avoid the approached compartment. Support for this idea is found in a two-way avoidance study by Freedman, Henessey, & Groner (1974) in which the shock level associated with each side of the shuttle apparatus was varied independently. Moving in one direction in the shuttle apparatus thus involved running between two compartments, each associated consistently with a high, meduim, or low shock level, for different groups of rats. Although no shock was present in the shuttle compartment into which the rats ran during each avoidance trial, responding involved moving into a compartment previously asso ated with shock. These investigators found that avoidance responding improved as the shock level associated with the approached compartment was decreased from high to medium to low. This manipulation produced a selective weakening of tendencies to avoid the compartments associated with lower shock levels, much in the same manner as ethanol was hypothesized to weaken selectively the avoidance tendency associated with the punishment region being approached in the conflict situation. Thus in both avoidance-avoidance conflict and shuttle avoidance situation, experimental manipulations hypothesized to reduce conditoned fear produced changes in behavior consistent with a selective weakening of tendencies to avoid the punishment region being approached.

The utility of the above analysis may be further demonstrated by its application to an apparent contradiction noted by Cappell and Herman (1972). Their comprehensive review revealed what appeared to

be a discrepancy between the results of two types of studies used to evaluate the tension-reduction hypothesis. That is, avoidance studies yielded equivocal or contradictory results while conflict studies generally supported the tension-reduction position. Pointing out that the action of ethanol is hypothesized to be fear or tension reduction in both types of studies, Cappell and Herman concluded that "the discrepancy between the two bodies of research remains to be explained . . . in terms which can be accommodated by the tension-reduction hypothesis" (1972, p. 49). This apparent discrepancy may be resolved by consideration of several related methodological and theoretical issues.

First, it appears difficult , if not impossible, to design a one-way avoidance study that is free of the confounding influences of ethanol-produced motor impairment or analgesia. In the typical one-way avoidance task, animals are trained to avoid shock by making a response that is unidirectional, for example, running from a start box to a goal box. As this avoidance behavior is usually assumed to be motivated by conditioned fear, the expected effect of a drug which mitigates fear or anxiety would be a decrement in avoidance performance. Unfortunately, such a prediction is perfectly confounded with a possible motor impairment produced by ethanol. Therefore, while reports that ethanol impairs performance in one-way avoidance tasks do not contradict a fear-reduction position, they cannot be viewed as strong support. In conflict studies, by contrast, behavioral measures can usually be interpreted independently of possible motor impairment effects of the drug. For example, the predicted outcomes

derived from a fear-reduction bypothesis, such as wider oscillation range, or closer approach to bivalent goals, cannot be easily attributed to ethanol produced ataxia.

Second, since behavior in both one-way and two-way avoidance tasks is considered to be supported by conditioned fear, it is often deemed contradictory that ethanol retards performance in the former tasks, yet in some cases, improves performance in the latter. However, analysis of behavior based on theoretical spatial avoidance gradients predicts both ethanol-produced decrements in one-way avoidance tasks and, based on the aforementioned comparison between shuttle avoidance and avoidance-avoidance conflict situations, ethanol-produced enhancement of performance in shuttle avoidance tasks. Thus, it is clear that such differential effects may be interpreted in a manner consistent with a tension-reduction position.

Third, an additional related consideration is the previously mentioned problem of dose-response interactions. While ethanol during conflict tests resulted in dose-related increases in locomotor activity in the present experiment, if higher doses had been administered, decreases in activity would doubtless have appeared, at a dose level depending on age, tolerance to the drug, and other factors. Nominally, the mean dose levels for the Test-3% and Test-6% animals in the present study were 1.9 g/kg and 2.8 g/kg, respectively. For comparison purposes, however, it should be noted that the peak blood-ethanol levels produced by ethanol consumption spread over the 15-min drinking period were probably lower than if comparable doses had been administered via intraperitoneal injection. Though

ethanol is rapidly absorbed from the gastrointestinal tract (especially with an empty stomach), even faster absorption, with higher peak blood-drug levels would result from intraperitoneal administration (Kalant, 1971). An additional factor to be considered is that in the present study, the animals may have developed some tolerance to ethanol by the time of conflict testing.

In summary, one-way avoidance studies provide equivocal support for tension-reduction theories because of a serious confounding involving motor impairment or analgesic effects of the drug, while the results of conflict studies can be more easily interpreted independently of such effects. Additionally, the apparent contradictory effect of ethanol on one-way and shuttle avoidance behavior may be understood in terms of the aforementioned conflict theory and the asymmetry hypothesis. Thus, both the apparent contradictions within the avoidance literature, and the apparent discrepancies between avoidance and conflict studies may be resolved.

SUMMARY AND CONCLUSIONS

In this experiment, the effects of ethanol on avoidance-avoidance conflict behavior were examined, utilizing a 3 X 3 factorial design in which rats were trained, and tested after drinking sugar-water solutions containing 0%, 3%, or 6% ethanol. Rats were initially trained to escape from electric shock by running in one direction in a white alley, and in the opposite direction in a black alley. Administration of ethanol just prior to these training trials resulted in dose-related decreases in the speeds with which rats escaped shock. In subsequent shock-free conflict tests, the rats were placed into an alley with one black wall and one white wall, an environment in which competing tendencies to avoid both ends of the alley were presumably aroused. In such avoidance-avoidance conflict tests, rats that had previously received shock-escape training after drinking ethanol ran more slowly, and exhibited lower total movement and oscillation range scores than did animals trained after drinking plain sugar-water solutions. Administration of ethanol just prior to the avoidance-avoidance conflict tests resulted in dose-related increases in running speeds, total movement scores, and oscillation ranges. In addition, rats tested under the influence of ethanol exhibited a higher number of reversals in direction of travel than did sugar-water controls.

The effects of ethanol during training, on shock escape, and on later conflict test performance may have been due to analgesia or ataxia produced by the drug. The effects of ethanol consumed just prior to conflict tests on performance during those tests were

interpreted within a theoretical framework involving spatial avoidance gradients. It was postulated that ethanol asymmetrically weakens the tendency to avoid the punishment region being approached more than the tendency to avoid the region being left behind.

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APPENDIX

Data for both Replications 1 and 2, including escape speeds during training, and starting speeds, running speeds, oscillation range, total movement, and reversal scores during conflict tests.

Table A1. Escape Speeds During Training, Replication 1. Each figure represents a mean of two shock-escape trials.

Group	Animal Number	Training Day				
		1	2	3	4	5
Train-6%	1			50.0	50.0	50.0
	2			29.4	43.8	50.0
	3			50.0	43.8	21.3
	4			8.9	35.6	23.2
	5			40.0	33.8	40.0
	6			50.0	43.8	43.8
	7			33.8	33.8	43.8
	8			43.8	50.0	33.8
	9			40.0	23.4	21,8
	10			29.7	43.8	31.3
	11			20.0	37.5	43.8
	12			40.0	50.0	43.8
Train-3%	13			37.5		40.0
	14			43.8		43.8
	15			33.8		37.5
	16			43.8		37.5
	17			43.8		40.0
	18			40.0		50.0
	19			33.8		27.1
	20			29.5		40.0
	21			33.8		43.8
	22			37.5		50.0
	23			43.8		30.0
	24			37.5		40.0
Train-0%	25			43.8	40.0	43.8
	26			43.8	50.0	43.8
	27			43.8	43.8	37.5
	28			40.0	43.8	43.8
	29			37.5	23.8	43.8
	30			50.0	50.0	43.8
	31			50.0	50.0	43.8
	32			43.8	33.4	37.5
	34			33.8	37.5	50.0
	35			33.8	37.5	40.0
	36			40.0	43.8	33.8

Note: All speeds are expressed in cm/sec. Blank spaces indicate missing data.

Table A2. Escape Speeds During Training, Replication 2. Each figure represents a mean of two shock-escape trials. All speeds are expressed in cm/sec.

Group	Animal Number	Training Day				
		1	2	3	4	5
Train-6%	1	29.5	22.0	2.4	4.3	29.5
	2	7.6	37.5	43.8	40.0	43.8
	3	20.8	37.5	40.0	37.5	43.8
	4	32.5	27.5	37.5	26.3	14.2
	5	25.7	31.3	33.8	43.8	33.8
	6	2.0	30.0	24.1	33.8	40.0
	7	18.8	37.5	33.8	33.8	33.8
	8	18.1	43.8	50.0	40.0	37.5
	9	25.0	7.3	3.7	16.7	27.5
	10	18.1	40.0	26.8	26.8	37.5
	11	37.5	43.8	27.4	6.1	33.8
	12	23.8	40.0	40.0	27.5	40.0
Train-3%	13	33.8	43.8	22.0	21.1	4.0
	14	9.5	31.3	27.5	37.5	30.0
	15	29.5	30.0	40.0	37.5	33.8
	16	16.0	21.1	26.3	43.8	37.5
	17	31.8	40.0	32.5	37.5	43.8
	18	20.4	43.8	50.0	50.0	50.0
	19	33.8	40.0	43.8	40.0	43.8
	20	28.2	50.0	50.0	27.5	37.5
	21	20.1	37.5	50.0	37.5	43.8
	22	31.3	33.4	20.4	37.5	43.8
	23	25.7	30.0	33.8	40.0	37.5
	24	30.7	43.8	34.4	50.0	43.8
Train-0%	25	28.2	37.5	27.1	43.8	43.8
	26	43.8	43.8	43.8	43.8	40.0
	27	40.0	37.5	43.8	50.0	40.0
	28	20.1	43.8	50.0	43.8	28.1
	29	35.7	40.0	43.8	37.5	35.7
	30	37.5	30.0	29.5	43.8	43.8
	31	33.8	50.0	50.0	43.8	43.8
	32	40.0	40.0	33.8	26.3	43.8
	33	37.5	50.0	37.5	43.8	37.5
	34	40.0	50.0	37.5	43.8	40.0
	35	21.8	43.8	43.8	43.8	37.5
	36	50.0	43.8	43.8	35.7	43.8

Table A3. Starting Speeds During Conflict Tests, Replication 1. All speeds are expressed in cm/sec. The first figure in the Training and Testing Concentration column indicates ethanol concentration during training while the second figure indicates ethanol concentration during testing.

Training and Testing Concentration	Animal Number	Starting Position (In cm from the left end of the alley) 5	34	143	177
6%-0%	3	30.0	50.0	75.0	50.0
	9	6.2	12.5	8.3	75.0
	11	37.5	30.0	2.0	50.0
	12	16.7	30.0	9.4	37.5
6%-3%	1	37.5	6.8	2.0	2.0
	2	30.0	30.0	3.3	37.5
	5	50.0	37.5	75.0	37.5
	6	37.5	50.0	75.0	13.6
6%-6%	4	2.6	2.0	2.0	4.7
	7	37.5	30.0	50.0	75.0
	8	37.5	25.0	30.0	37.5
	10	18.8	25.0	50.0	75.0
3%-0%	13	50.0	30.0	75.0	75.0
	18	30.0	30.0	50.0	37.5
	19	30.0	30.0	37.5	50.0
	20	30.0	37.5	50.0	37.5
3%-3%	14	30.0	50.0	50.0	50.0
	21	30.0	5.8	50.0	30.0
	22	50.0	11.5	37.5	37.5
	23	37.5	30.0	12.5	50.0
3%-6%	15	37.5	30.0	37.5	75.0
	16	25.0	2.0	30.0	50.0
	17	50.0	30.0	37.5	75.0
	24	37.5	10.0	75.0	75.0
0%-0%	28	25.0	2.9	37.5	50.0
	29	37.5	30.0	37.5	75.0
	31	50.0	25.0	30.0	50.0
	36	37.5	30.0	8.3	37.5
0%-3%	27	37.5	25.0	30.0	50.0
	33	4.6	37.5	2.0	2.4
	34	37.5	37.5	37.5	75.0
	35	37.5	30.0	11.5	37.5
0%-6%	25	21.4	30.0	37.5	37.5
	26	50.0	25.0	30.0	50.0
	30	50.0	30.0	50.0	37.5
	32	30.0	30.0	30.0	50.0

Table A4. Starting Speeds During Conflict Tests, Replication 2. All speeds are expressed in cm/sec. Training and testing ethanol concentrations are indicated as in Table A3. Missing data are indicated by blanks.

Training and Testing Concentration	Animal Number	Starting Position (In cm from the left end of the alley) 5	34	143	177
6%-0%	5	50.0		30.0	30.0
	6		2.0	37.5	50.0
	7	2.0	2.0	2.0	
	8		37.5	30.0	50.0
6%-3%	2	50.0		37.5	50.0
	3	37.5		37.5	37.5
	11	30.0	30.0	37.5	37.5
	12	37.5	30.0	50.0	37.5
6%-0%	1	30.0	30.0	37.5	
	4	30.0	10.7	37.5	
	9	30.0	30.0	37.5	
	10	30.0		50.0	50.0
3%-0%	14	21.4	2.0	2.0	2.0
	15	37.5	2.0	7.5	30.0
	20	50.0	30.0	21.4	3.6
	22	21.4	2.5	30.0	25.0
3%-3%	16	50.0	50.0	30.0	50.0
	17	37.5	37.5	2.0	50.0
	19	37.5	50.0	25.0	50.0
	21	50.0	50.0	37.5	50.0
3%-6%	13	2.0	2.2	7.2	3.8
	18	50.0	37.5	37.5	37.5
	23	30.0	30.0	21.4	75.0
	24	30.0	37.5	30.0	50.0
0%-0%	25	21.4	50.0	3.8	75.0
	26	37.5	30.0	30.0	37.5
	28	3.9	37.5	3.2	3.4
	29	8.8	21.4	21.4	18.8
0%-3%	27	50.0	30.0	25.0	37.5
	30	37.5	37.5	30.0	30.0
	32	37.5	37.5	30.0	50.0
	33	30.0	30.0	37.5	37.5
0%-6%	31	37.5	37.5	37.5	37.5
	34	37.5	25.0	37.5	50.0
	35	30.0	37.5	37.5	37.5
	36	37.5	37.5	37.5	8.3

Table A5. Running Speeds in Six, Central Alley Segments. Each score represents a mean of two end-start trials, with speed expressed in cm/sec. Training and testing concentrations are designated as in Table A3.

Group	Animal Number	Alley Segments					
		1	2	3	4	5	6
0%-6%	25	125.00	91.24	34.38	21.25	5.82	1.88
	26	91.25	67.50	31.88	30.63	20.40	21.67
	30	46.25	117.50	144.38	207.50	135.00	61.25
	32	50.00	66.25	48.54	52.96	28.00	45.42
	31	110.00	115.84	92.50	85.00	70.00	30.00
	34	85.00	75.00	96.25	117.50	88.75	60.00
	35	72.50	77.50	51.25	41.25	30.84	20.00
	36	60.00	16.00	42.50	70.00	0.00	0.00
0%-3%	27	57.50	5.95	2.00	0.00	0.00	0.00
	33	1.70	2.14	0.00	0.00	0.00	0.00
	34	117.50	55.72	72.50	8.13	22.50	17.50
	35	95.00	54.17	70.00	42.50	70.00	41.67
	27	80.00	60.00	66.25	55.00	35.00	20.00
	30	41.25	49.17	42.50	33.34	17.12	23.00
	32	67.50	36.00	20.00	4.59	5.00	0.00
	33	77.50	64.38	72.50	87.50	107.50	70.63
0%-0%	28	35.00	22.67	16.88	12.50	10.50	6.95
	29	45.00	11.67	5.75	1.67	0.00	0.00
	31	72.50	1.91	1.65	0.00	0.00	0.00
	36	55.00	27.50	13.75	10.84	6.00	3.60
	25	91.25	75.00	70.00	65.00	60.00	50.00
	26	57.50	27.67	32.50	29.50	16.58	4.75
	28	2.65	0.00	0.00	0.00	0.00	0.00
	29	8.16	7.88	11.81	.84	0.00	0.00

Note: The first four animals in each group are from Replication 1, the second four from Replication 2.

Table A5, continued.

Group	Animal Number	Alley Segments					
		1	2	3	4	5	6
3%-6%	15	112.50	92.50	65.00	30.40	22.50	21.67
	16	38.00	3.94	8.22	7.50	.55	0.00
	17	120.00	46.25	42.50	51.67	54.17	27.09
	24	79.17	5.63	33.67	23.88	6.20	7.74
	13	1.44	0.00	0.00	0.00	0.00	0.00
	18	95.00	66.25	70.00	68.25	56.67	35.00
	23	81.25	31.79	33.75	36.25	25.50	16.25
	24	92.50	82.50	57.50	43.33	40.63	19.75
3%-3%	14	82.50	30.34	27.50	11.21	.72	0.00
	21	4.88	6.02	3.28	.31	0.00	0.00
	22	41.88	15.31	39.86	53.75	59.17	8.78
	23	25.00	39.43	2.45	.31	0.00	0.00
	16	97.50	65.63	21.67	31.25	22.50	4.17
	17	97.50	72.50	26.07	28.75	27.50	2.92
	19	92.50	51.67	31.72	30.00	30.00	12.00
	21	105.00	74.17	105.00	107.50	65.00	19.49
3%-0%	13	62.50	12.19	21.17	7.70	6.50	1.53
	18	55.00	15.72	16.50	17.39	15.79	9.68
	19	96.25	57.50	33.34	29.38	16.75	8.75
	20	95.00	10.75	38.34	4.60	12.50	2.92
	14	1.23	0.00	0.00	0.00	0.00	0.00
	15	12.95	15.00	5.88	5.25	0.00	0.00
	20	26.11	7.50	25.00	28.75	10.84	7.86
	22	10.73	11.41	.42	0.00	0.00	0.00

Table A5, continued.

Group	Animal Number	Alley Segments					
		1	2	3	4	5	6
	4	1.41	7.81	.50	0.00	0.00	0.00
	7	60.89	18.07	0.00	0.00	0.00	0.00
	8	52.50	29.86	58.75	49.17	46.25	31.84
	10	2.66	.84	0.00	0.00	0.00	0.00
	1	50.00	90.00	7.22	0.00	0.00	0.00
	4	120.00	65.00	46.67	45.00	52.50	31.25
	9	30.00	77.50	7.73	45.00	8.00	24.00
	10	47.50	51.67	31.91	24.02	43.34	10.11
	1	7.50	2.15	0.00	0.00	0.00	0.00
	2	9.62	3.22	10.50	12.50	4.17	1.38
	5	110.00	71.67	41.00	4.02	5.39	7.92
	6	95.00	43.75	30.34	32.32	33.34	8.07
	2	107.50	78.75	57.50	33.75	29.17	14.17
	3	68.75	32.92	20.84	10.84	4.38	.58
	11	107.50	55.90	2.50	0.00	0.00	0.00
	12	65.20	.25	0.00	0.00	0.00	0.00
	3	88.13	36.50	29.79	28.13	24.84	5.75
	9	0.00	0.00	0.00	0.00	0.00	0.00
	11	61.25	.41	0.00	0.00	0.00	0.00
	12	4.55	12.75	4.16	4.81	.58	0.00
	5	64.17	57.92	39.50	38.75	17.50	7.65
	6	120.00	40.00	11.36	7.50	38.33	17.50
	7	.17	0.00	0.00	0.00	0.00	0.00
	8	90.00	75.00	10.00	47.50	52.50	20.00

Table A6. Oscillation Range Scores for Replication 1. All scores are expressed in cm. Groups are labeled as in Table A3.

Group	Animal Number	Test Day 1 Trial 1	Test Day 1 Trial 2	Test Day 2 Trial 1	Test Day 2 Trial 2
6%-0%	3	0	39	161	98
	9	40	13	41	46
	11	20	12	14	21
	12	23	0	31	0
6%-3%	1	19	0	0	38
	2	47	21	0	34
	5	30	41	39	0
	6	86	80	111	88
6%-6%	4	12	27	0	39
	7	58	34	25	19
	8	108	110	162	166
	10	34	49	91	40
3%-0%	13	64	15	52	123
	18	0	14	28	12
	19	91	62	134	128
	20	0	90	25	87
3%-3%	14	163	92	57	129
	21	0	0	11	15
	22	32	109	81	65
	23	0	73	47	31
3%-6%	15	162	163	155	158
	16	22	18	103	0
	17	152	107	163	160
	24	47	0	109	56
0%-0%	28	28	0	30	55
	29	76	79	56	36
	31	0	47	12	0
	36	15	36	50	76
0%-3%	27	33	0	34	32
	33	65	32	42	72
	34	155	133	153	155
	35	165	160	171	166
0%-6%	25	64	116	65	126
	26	153	95	144	154
	30	171	175	166	175
	32	104	123	104	164

Table A6, continued. Blank spaces indicate missing data.
(Replication 2)

Group	Animal Number	Test Day 1 Trial 1	Test Day 1 Trial 2	Test Day 2 Trial 1	Test Day 2 Trial 2
6%-0%	5	126	111	158	
	6	19	15	24	
	7	19	11	31	
	8	21	12	0	
6%-3%	2	164	97	161	
	3	16	45	26	
	11	38	64	43	76
	12	41	0	30	90
6%-6%	1	74	36	161	
	4	127	154	161	
	9	163	160	171	
	10	132	59	128	
3%-0%	14	40	41	32	20
	15	38	31	0	37
	20	169	172	161	135
	22	21	0	0	0
3%-3%	16	74	47	147	112
	17	43	55	126	148
	19	27	49	90	132
	21	158	173	81	163
3%-6%	13	49	54	47	19
	18	105	168	169	160
	23	146	134	158	163
	24	161	149	142	140
0%-0%	25		159	135	147
	26	145	88	128	87
	28	59	61	67	132
	29	23	47	123	91
0%-3%	27	158	162	165	162
	30	98	59	162	158
	32	161	54	81	103
	33	125	169	159	159
0%-6%	31	170	160	158	128
	34	164	169	167	164
	35	166	169	116	161
	36	166	164	143	50

Table A7. Total Movement Scores for Replication 1. All scores are expressed in cm. Groups are labeled as in Table A3.

Group	Animal Number	Test Day 1 Trial 1	Test Day 1 Trial 2	Test Day 2 Trial 1	Test Day 2 Trial 2
6%-0%	3	200	220	388	282
	9	149	161	201	200
	11	154	96	134	132
	12	108	169	120	135
6%-3%	1	133	109	130	222
	2	152	146	197	140
	5	131	265	178	231
	6	295	187	358	230
6%-6%	4	90	155	174	137
	7	264	123	188	116
	8	328	344	365	370
	10	252	170	255	418
3%-0%	13	189	208	181	311
	18	185	164	152	243
	19	303	213	339	284
	20	187	259	202	258
3%-3%	14	480	267	648	255
	21	127	115	132	139
	22	182	317	318	334
	23	162	172	164	196
3%-6%	15	408	480	527	452
	16	165	106	222	105
	17	424	331	477	370
	24	229	144	182	337
0%-0%	28	122	140	235	129
	29	201	248	174	112
	31	135	166	85	99
	36	209	117	197	246
0%-3%	27	128	106	131	158
	33	198	136	133	258
	34	324	285	385	336
	35	389	384	412	396
0%-6%	25	331	365	200	379
	26	359	266	353	371
	30	425	557	472	487
	32	259	366	335	431

Table A7, continued. Blank spaces indicate missing data.
(Replication 2)

Group	Animal Number	Test Day 1 Trial 1	Test Day 1 Trial 2	Test Day 2 Trial 1	Test Day 2 Trial 2
6%-0%	5	126	111	158	
	6	173	209	273	
	7	113	156	108	
	8	254	189	95	
6%-3%	2	384	329	384	
	3	240	209	274	
	11	218	349	209	378
	12	179	154	270	387
6%-6%	1	377	357	516	
	4	332	352	472	
	9	427	325	426	
	10	372	298	304	
3%-0%	14	185	163	162	212
	15	197	119	136	134
	20	373	605	366	303
	22	160	115	103	103
3%-3%	16	292	242	374	381
	17	160	125	280	357
	19	149	160	289	393
	21	374	384	364	387
3%-6%	13	173	179	153	166
	18	251	396	570	411
	23	310	415	492	352
	24	368	399	342	450
0%-0%	25		276	270	355
	26	370	247	321	339
	28	222	211	226	250
	29	158	207	287	344
0%-3%	27	351	391	368	378
	30	288	331	442	361
	32	379	217	382	255
	33	347	598	450	605
0%-6%	31	385	504	448	499
	34	492	510	467	394
	35	395	418	360	490
	36	497	639	407	310

Table A8. Number of Reversal During Conflict Tests, Replication 1. Groups are labeled as in Table A3.

Group	Animal Number	Test Day 1 Trial 1	Test Day 1 Trial 2	Test Day 2 Trial 1	Test Day 2 Trial 2
6%-0%	3	0	3	1	4
	9	2	1	2	1
	11	1	2	1	1
	12	1	0	1	0
6%-3%	1	2	0	0	5
	2	1	3	0	2
	5	1	3	3	0
	6	1	2	1	2
6%-6%	4	1	1	0	1
	7	5	3	2	1
	8	1	3	1	1
	10	7	2	4	5
3%-0%	13	2	2	1	1
	18	0	1	2	3
	19	1	1	3	1
	20	0	2	1	2
3%-3%	14	1	3	6	2
	21	0	0	1	1
	22	3	1	2	2
	23	0	2	2	2
3%-6%	15	3	4	3	5
	16	1	1	2	0
	17	2	3	2	1
	24	1	0	1	3
0%-0%	28	1	0	1	1
	29	2	1	2	2
	31	0	2	1	0
	36	2	1	2	3
0%-3%	27	1	0	1	2
	33	4	1	1	1
	34	1	2	5	6
	35	1	1	1	2
0%-6%	25	2	2	2	3
	26	1	1	2	3
	30	2	4	5	5
	32	3	1	3	3

Table A8, continued for Replication 2. Blank spaces indicate missing data.

Group	Animal Number	Test Day 1 Trial 1	Test Day 1 Trial 2	Test Day 2 Trial 1	Test Day 2 Trial 2
6%-0%	5	1	2	1	
	6	4	1	3	
	7	1	1	3	
	8	3	1	0	
6%-3%	2	3	2	2	
	3	2	2	2	
	11	3	4	5	4
	12	4	0	3	1
6%-6%	1	9	7	5	
	4	1	1	4	
	9	2	1	3	
	10	1	3	1	
3%-0%	14	2	4	1	3
	15	1	1	0	1
	20	1	5	2	2
	22	1	0	0	0
3%-3%	16	5	6	4	7
	17	3	1	1	2
	19	3	2	2	2
	21	2	1	3	1
3%-6%	13	1	1	2	2
	18	1	1	3	3
	23	1	2	2	2
	24	3	2	2	4
0%-0%	25	2	1	4	2
	26	3	1	3	3
	28	4	2	2	2
	29	1	3	1	5
0%-3%	27	1	1	1	3
	30	1	4	4	2
	32	2	4	4	2
	33	3	3	2	3
0%-6%	31	1	3	4	2
	34	3	6	3	2
	35	1	3	4	2
	36	4	6	3	5

Table A1. Escape Speeds During Training, Replication 1. Each figure represents a mean of two shock-escape trials.

Group	Animal Number	Training Day				
		1	2	3	4	5
Train-6%	1			50.0	50.0	50.0
	2			29.4	43.8	50.0
	3			50.0	43.8	21.3
	4			8.9	35.6	23.2
	5			40.0	33.8	40.0
	6			50.0	43.8	43.8
	7			33.8	33.8	43.8
	8			43.8	50.0	33.8
	9			40.0	23.4	21,8
	10			29.7	43.8	31.3
	11			20.0	37.5	43.8
	12			40.0	50.0	43.8
Train-3%	13			37.5		40.0
	14			43.8		43.8
	15			33.8		37.5
	16			43.8		37.5
	17			43.8		40.0
	18			40.0		50.0
	19			33.8		27.1
	20			29.5		40.0
	21			33.8		43.8
	22			37.5		50.0
	23			43.8		30.0
	24			37.5		40.0
Train-0%	25			43.8	40.0	43.8
	26			43.8	50.0	43.8
	27			43.8	43.8	37.5
	28			40.0	43.8	43.8
	29			37.5	23.8	43.8
	30			50.0	50.0	43.8
	31			50.0	50.0	43.8
	32			43.8	33.4	37.5
	34			33.8	37.5	50.0
	35			33.8	37.5	40.0
	36			40.0	43.8	33.8

Note: All speeds are expressed in cm/sec. Blank spaces indicate missing data.

APPENDIX

Data for both Replications 1 and 2, including escape speeds during training, and starting speeds, running speeds, oscillation range, total movement, and reversal scores during conflict tests.