1972

The Effect of Intermittent Electric Shock on the Consumption of Alcohol in Rats

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THE EFFECT OF INTERMITTENT ELECTRIC SHOCK ON THE CONSUMPTION OF ALCOHOL IN RATS

BY

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A Thesis submitted to the faculty of the Graduate School of Loyola University in Partial Fulfillment of the requirements of the degree of Doctor of Philosophy

May, 1972

This study was undertaken with the support of the Wood V.A. Center, Milwaukee, Wisconsin, during my internship, 1970-1971.

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Acknowledgements

The author is primarily indebted and especially grateful to Dr. William Hunt and Dr. Arthur Wilson for their help, interest, support and encouragement. Gratitude is also expressed to Dr. Robert Solso and Dr. Thomas Parker. The help of Dr. Edward Meyer, Dr. Emil Posavac and Mr. Kenneth Tetrick was greatly appreciated. The author is also thankful to numerous others who contributed in no minor way to the outcome of the experiment.

Introduction

Alcoholism is one of the most prominent social problems in our society. In the year 1965, for example, the city of Washington, D.C., had an estimated population of 802,000 people. There were 44,792 arrests made for drunkenness which accounted for 51.8 percent of the total number of arrests recorded by the Washington Police Department (President's Commission on Law Enforcement, 1967)

In an attempt to understand alcoholism, our attention is focused on the experimental evidence related to alcohol consumption. The literature in this field has divided into three general areas (Clay, 1964; Mendelson et al., 1964). The first area involves experiments emphasizing the role of alcohol as a type of food and attempting to correlate alcohol consumption with nutritional and vitamin deficiencies (Mardones, 1951; Righter, 1941, 1953; Westernfeld and Lawrow, 1953; Wilson et al., 1968). The second general area is the genetic area. It has been suggested that genetic factors might be important determinants of alcohol consumption and experimental evidence has shown that different strains of rats have different drinking patterns (McClearn and Rogers, 1959, 1961; Poley et al., 1970; Royce et al., 1970). The present paper is concerned with some of the aspects of the final category: emotional factors influencing alcohol intake.

The Experimental Neurosis Model

Although the hypothesis that alcohol relieves tension is hardly novel, it was not until 1946 that Masserman's famous experiments documented this phenomena in a scientific way. Masserman and Yum (1946) trained cats to do complex patterns of behavior. The animals were required in sequence to open a box during the period a light was on and then to operate an electric switch to get a pellet of food. When the animals were fully trained, they subjected them to a shock or a blast of air as they approached the feeding area. Consequently these animals developed an "experimental neurosis" which was described as "feeding inhibitions, startle and phobic responses, loss of group dominance and aversive behaviors to food". Following the definite establishment of these symptoms, Masserman gave them alcohol by injection. As the amount of alcohol injected was increased, the variety and incidence of the neurotic symptoms diminished. These results are shown in Figure 1 taken from his study. It also was found that the animals having experienced relief from the neurotic symptoms through the alcohol injection developed a tendency to consume alcohol voluntarily. Other experiments support these conclusions (Smart, 1964, 1965). Masserman then sought to determine the effects of alcohol if given prior to the inducement of neurotic symptoms (Masserman, Jaques and Nicholson, 1945, Masserman, 1959). He proceeded to train ten cats in the manner described above. By depriving the

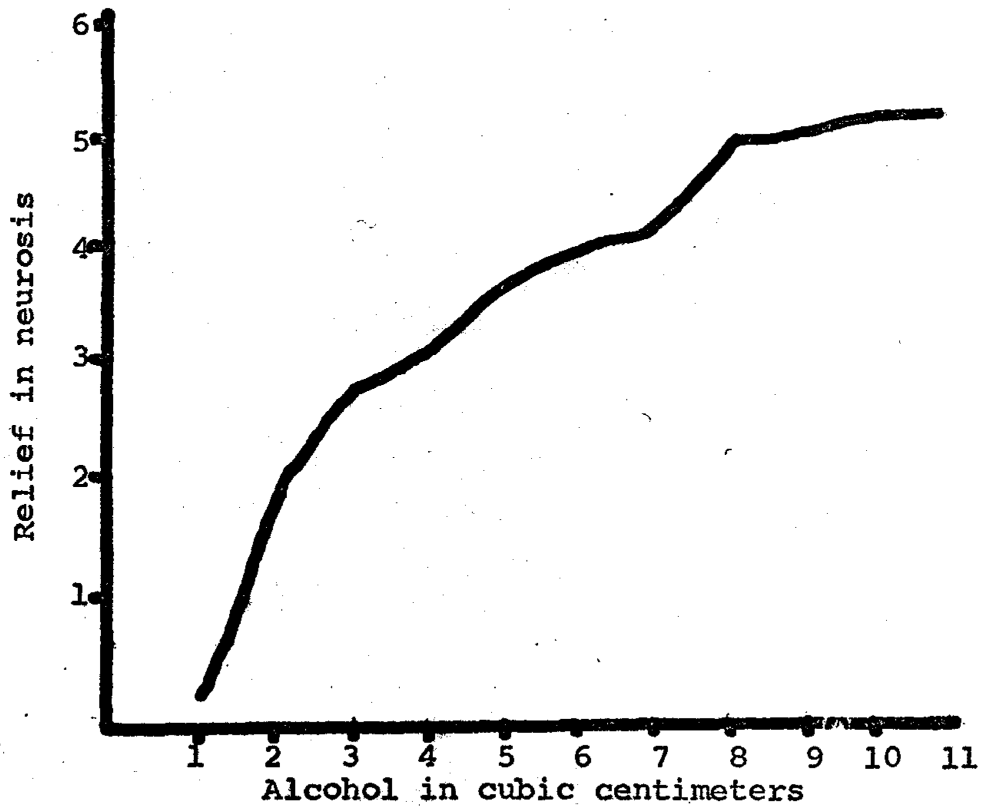

Figure 1: Masserman's curve representing the relief of neurotic symptoms as a function of the amount of alcohol injected (Masserman and Yum, 1946, p.45).

animals of all fluids Masserman was able to force six of them to drink a considerable amount of alcohol (2.00 to 2.55 cc. per kg.). The animals were then given a shock or a blast of air as they ate. The intoxicated animals showed much milder repulsion to the noxious stimulii. When the trauma was repeated without intoxication, "neurotic reactions" developed.

Masserman explained his results in terms of the complexity and latency of the behavior. Alcohol, he explained, tends to disrupt behavior selectively. The more complex and the more recent the behavior is, the more it will suffer, "leaving the simpler, more deeply ingrained reactions relatively intact". In his experiments the more complex and recent behavior that the cats had acquired was the neurotic behavior. This behavior, he reasoned, would therefore tend to diminish as his results demonstrate (Masserman and Yum, 1946).

The Conflict Model: Alley Studies

Masserman's conclusions have been subject to controversy. His theory that alcohol desintegrates complex patterns of behavior gained an opponent in J.J. Conger. Although Conger (1951) believed in the disappearance of the neurotic behavior, he favored explaining the phenomenon in terms of an approach-avoidance conflict. His experimentation utilized a group of rats which had been trained to feed at one end of a wooden alley. The rats were administered electric shocks while eating until they developed an aversion to the feeding area. The animals were subsequently injected with an alcohol solution and returned to the alley. The number of trials required for the animals to approach the eating area was noted. Conger's results demonstrate that animals which received injections required less trial approaches to the feeding area before eating. Similar supporting evidence was reported more recently by Ahlfors (1957). Grossman and Miller (1961) conducted a variation of this experiment by injecting a placebo in the non-alcohol, control animals and again observed that the alcohol receiving rats resolved the conflict situation more quickly. Rats which received the placebo or alcohol injections prior to learning the approach-avoidance conflict showed no significant difference from those that were trained and then injected. Similarly Cicala and Hartley (1967) reported that no significant change accompanies variations in the injection-shock sequence.

The studies reviewed above essentially represent slightly varied replications of Masserman's investigations (1946). None of these studies were designed to consider the various forces present in the conflict. Conger (1951) postulated that in order to investigate the situation effectively, some measure of the approach-avoidance tendency was necessary. To obtain this objective he trained some rats to eat at the end of the alley. He gave alcohol to half of them and recorded the strength of pull exerted by the rats against a calibrated spring in their effort to reach the feeding area. Conger also trained a group of rats to avoid the end of the alley by shocking them and proceeded, as before, to intoxicate half and record the strength of pull. The results, shown in Figure 2, demonstrate that under the alcohol condition the avoidance tendency was reduced. The approach tendency remained constant.

Barry and Miller (1962) conducted an experiment similar to Conger's in which they associated variations of shock intensity with comparable variations of the length of the alley as a warning signal. They found that alcohol consumption increased the speed of approach in the shock trials and the proportion of trials completed. Their findings have been replicated by Freed (1967).

In subsequent follow-up studies, Freed (1967a, 1967b, 1968) attempted to correct one of the weaknesses of the experimental design used by Barry and Miller (1962) by providing for a measure of the blood alcohol level as an intoxication indicator. Although it has been shown that a number of factors can influence the level of intoxication in addition to the amount of alcohol ingested, factors such as body weight, heredity and diet are outside the realm of the present paper and will not be discussed. Leikola (1962) has shown, however, even stress produced by making the rats swim, can lower the level of intoxication of the animal. Taking this factor into account, Freed trained 80 rats in a fifteen

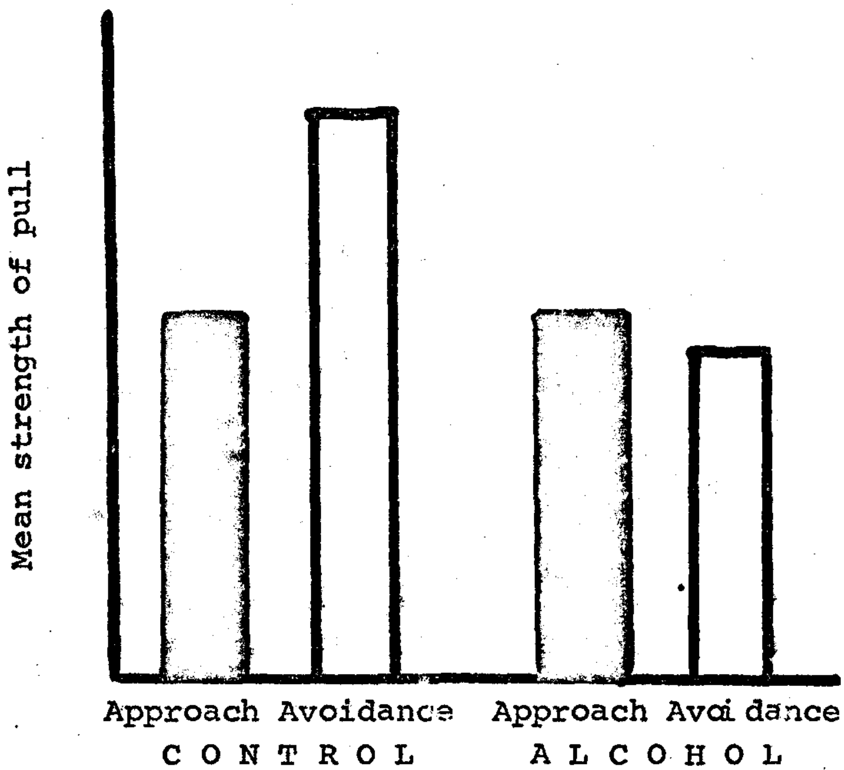

Figure 2: Mean strength of pull (in grams) of approach or avoidance groups measured after injections of water (control) or of alcohol. From Conger, 1951, p.13.

foot alley and presented them with an approach-avoidance conflict as in Conger's experiment. Food deprivation and the intensity of shock were varied and three alcohol solutions of different concentrations were administered. Freed noted deviations in the distance traveled toward the goal and the number of animals that ate. The blood alcohol level proved to be of negligible value since the relationship between the blood analysis levels and the concentration of the alcohol consumed was essentially linear. This would indicate that the alcohol ingestion is directly proportional to the blood alcohol concentration. Results otherwise confirmed that the intoxicated rats were able to resolve the conflict and eat. The increase of concentrations of alcohol, however, was accompanied by a proportional increase in the distance traveled toward the goal only to a certain point as shown in Figure 3. After that point, further increases in alcohol tend to hinder performance.

The implication of the curvilinear effect of alcohol just described is not clear. One possible interpretation might be that alcohol delivers relief from the conflict situation as a function of the amount of alcohol ingested in a curvilinear mode. It should be noted that this interpretation is inconsistent with Masserman's results (1946). In his study Masserman reported a linear relationship: the more alcohol the rat drank, the less neurotic its behavior was found to be (see Figure 1). There is, however, the possibility that

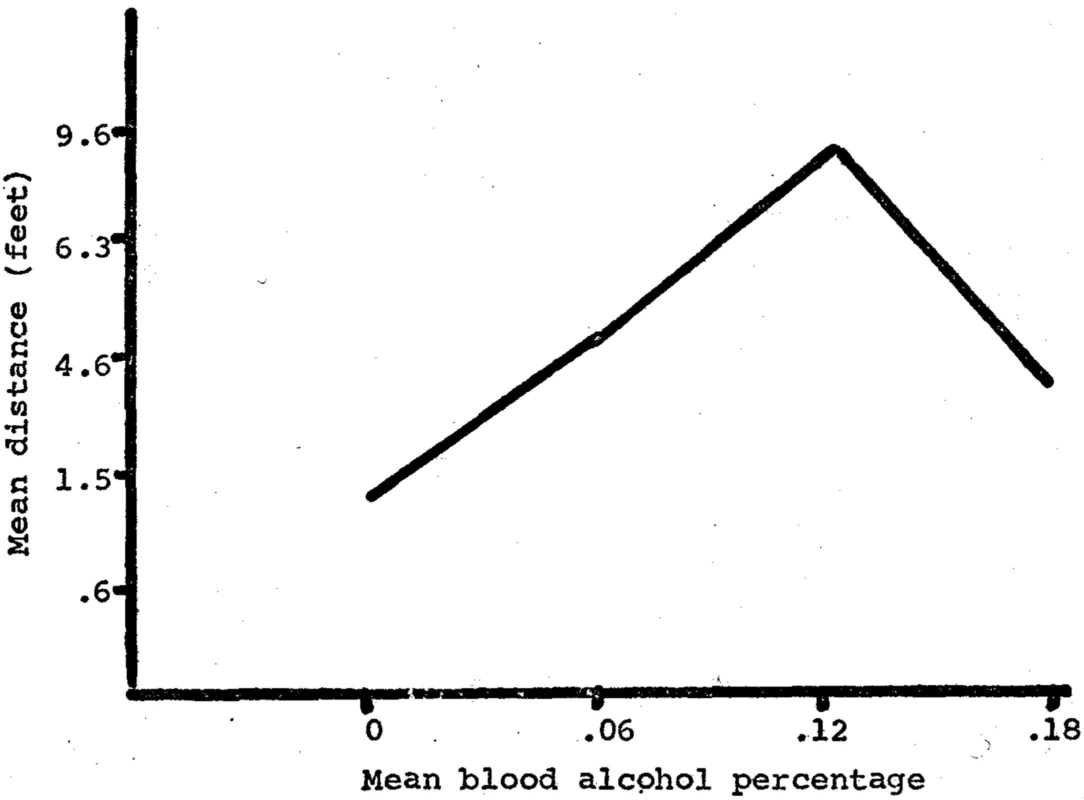

Figure 3: Relation of the mean blood alcohol concentration to mean maximal distance traveled after injection. Taken from Freed, 1967, p.245.

Masserman did not administer enough alcohol in order to observe an upper limit and obtain the renewed increase of neurotic behavior. An alternate interpretation of this curvilinear relationship suggests that the amount of alcohol and the amount of relief from tension are directly related in a linear way: the more alcohol, the more relief. To take into account Freed's results we would need to distinguish between two effects of alcohol: (1) reduced anxiety in the conflict situation and (2) reduced coordination of motor abilities. Freed demonstrated the first effect by showing that the intoxicated animal would eat more often. His finding that after a certain point, increases in alcohol level were related to less distance traveled in the maze might be a demonstration of the second effect. What is suggested here is that the rats might lack the coordination to perform appropriately after getting a substantial amount of alcohol.

The effects of alcohol on motor coordination are well documented in the literature. Baum (1969) trained 120 rats to avoid an electric shock and injected different amounts of alcohol intraperitoneally. He found that the high dosage group was physically incapacitated and had, as a result, a higher response latency. The alcohol increased the number of responses made in extinction by only the intermediate group. Similar findings by Buckalew and Cartwright (1968), Reynolds and Van Sommers (1960) and Crow (1969) also support this hypothesis. Barry and Miller (1962) in an experiment described above, observed that large doses of alcohol decreased the speed of approach in the maze. This alcohol-motor coordination limitation must be considered in evaluating all studies where resolution of the conflict requires movement on the part of the animal.

Pawloski, Denenberg and Zarrow (1961) tried to demonstrate the effects of alcohol on the learning process. They designed a two chamber box in which shock could be delivered to the animals. A tone indicated the begining of the shock which the animal could avoid by running into the other chamber. During the experiment half the animals were given alcohol and the other half were given saline water to drink. An analysis of variance showed that the intoxicated rats ran significantly slower and took significantly shorter time to stop running in the extinction trials. Kaplan (1956) and Crow (1966) using a similar situation, found again that the intoxicated animals made fewer escape responses. Harris, Piccolino, Roback and Sommer (1964) and McMurray and Jaques (1959) however, noted no difference after the alcohol injections. Weiss (1958) utilized the natural tendency of rats to keep away from the center of an open field as an avoidance tendency. She found that intoxicated rats were slower to eat food positioned in the center of the open area than the control group. Thus the hypothesis that alcohol reduces conflict was not supported in this case. Again, these findings are difficult to interpret since they could mean that the intoxicated animals showed less fear, lower learning ability or poorer coordination. Variance in the levels of intoxication might constitute the probable cause for conflicting results.

The Conflict Model: Instrumental Conditioning Studies

A number of studies have used instrumental conditioning in the Skinner box. Scarborough (1957) defined anxiety in terms of bar pressing responses where the animals were previously shocked and concluded that the alcohol served to reduce anxiety. The Miller group (Barry, Wagner and Miller, 1963) trained their rats in a similar manner. They found that alcohol produced slight and non-significant decreases in the number of bar presses during the warning tone and large decreases during the safe period. In this study, as before, is hard to determine what part of their findings is due to a lowering of the avoidance tendency. The results could also be due to a general lowering of coordinated movement since this would produce less of a decrease in the already low number of bar presses in the danger period.

An equally inconclusive study by Moskowitz and Asato (1966) using the Skinner box attempted to show that the approach and avoidance tendencies were equally affected by alcohol. In this study the rats were required to press one lever in the presence of one tone to obtain food, and a second lever in the presence of a second tone in order to avoid a blast of hot air. Alcohol tended to increase the latency in both situations.

The Free Choice Model

All the experiments discussed up to this point used the forced-alcohol situation. Forced intoxication was accomplished in one of two ways: (1) alcohol was forced into the organism through an injection or via a stomach tube or (2) the animals were kept in cages where alcohol was the only available fluid. So far the typical experiment forced intoxication, produced a stress, and observed some measure of "emotionality" or conflict solution as a result of the intoxication. In the light of their findings it would be reasonable to expect that an animal in a conflict situation would prefer alcohol to another fluid, even when the taste (Amit, 1969) and smell (Kahn and Stellar, 1960) of alcohol is aversive to them.

Segal (1959) found that stimulation of a "punishment system" in the brain of rats through implanted electrodes led to increased alcohol consumption. Clark and Polish (1960) trained two monkies in a Skinner box to press a lever in order to avoid an electric shock. In one of their experimental conditions they had both alcohol and water present. Their finding was that the two animals drank significantly more alcohol and less water when under this kind of stress. After the avoidance situation the level of alcohol intake decreased for both monkies although it never returned to the pre-avoidance level.

Casey (1960) followed basically the same procedure. He administered unavoidable shock while measuring alcohol consumption where water and food were also available ad lib. He used the first sixteen days of the experiment to establish a baseline. The animals were then subjected to a continuing series of shocks on a variable interval schedule averaging about one shock each ten minutes. The stress period lasted another sixteen days. Casey then kept the animals in the same cages until the consumption level returned to the baseline. Comparing the baseline periods (days 4 to 6 and 60 to 64) to the rest of the graph, Casey found singnificantly more drinking during the stress period. These results are shown in Figure 4.

It is interesting to note that the maximum alcohol consumption, contrary to expectation, occurs after the shocks have been terminated. Also, in every new situation the alcohol consumption appears to increase and then tends to diminish. It is conceivable that the rats are not responding to the shock alone but also to the onset of a new situation. If this is true, after the animals become acclimated to the new environment, alcohol intake returns to the base level.

Casey's results are further complicated by the conflicting findings of recent studies. Myers and Holman (1967) conducted a similar study changing the position of the water and alcohol bottles and found no significant difference in the amount of alcohol consumed under stress. Senter and Persensky (1968) however, found an increase in alcohol intake when rats stayed in the cage where the shock was administered after the experi-

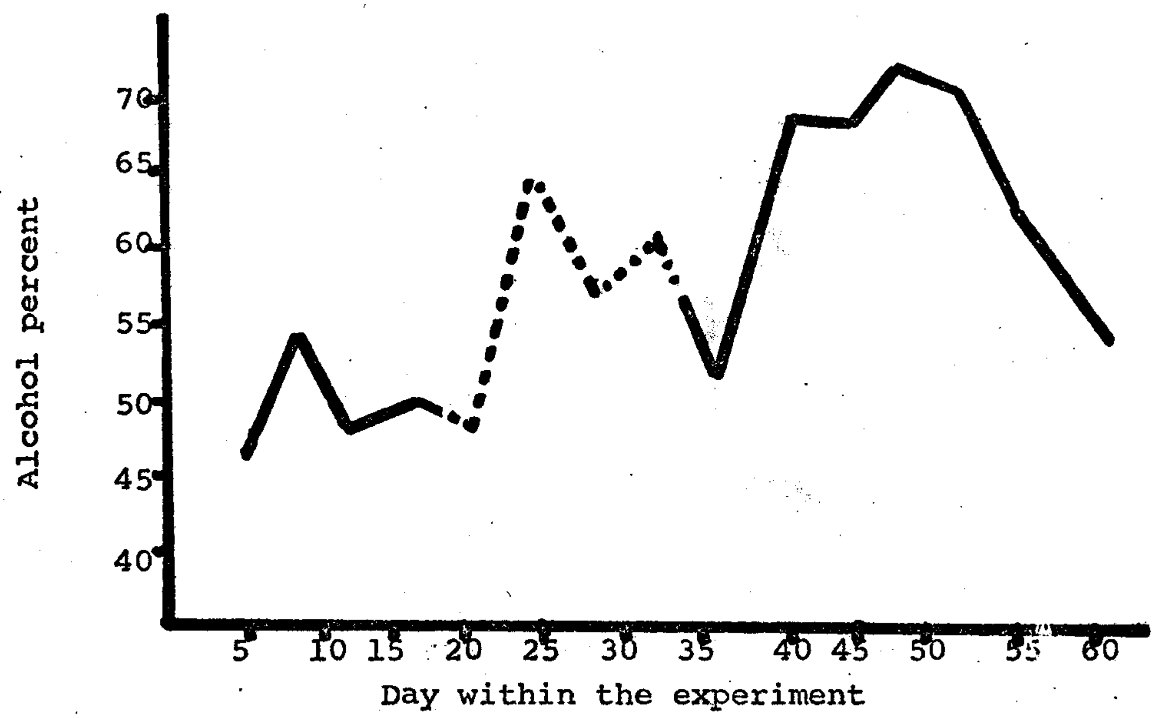

Figure 4: Mean percent intake of alcohol during stress (broken line) and non-stress period. Graph taken from Casey, 1960, p. 211.

mental situation. If the animals were returned to the home cage there was no increase in the alcohol intake. Most recently Von Wright and his co-workers (1971) used "conflict" and "stress" conditions in replicating Casey's work. The conflict rats received an electric shock when they pressed the lever to obtain food. The stress rats were submitted to random shocks. These investigators found that the conflict rats increased their alcohol intake during the conflict situation, returning to normal drinking shortly afterwards. The stress animals, on the other hand, showed a non-significant increase during the stress but drank considerably more alcohol shortly after the termination of the stress situation. Their findings are considered to be in agreement with Casey's results.

Several attempts have been made to use something other than electric shock as the stressing stimulus. Moore and his associates (1952) concluded that animals increase their alcohol consumption when subjected to intense sonic stimulation. Cicero (1969) found that rats significantly increased their preference for alcohol when they are exposed to the "psychological stress" of an unpredictable environment. Most recently Geller (1971) placed rats in an environment of total darkness and obtained a significant increase of ethanol intake accompanied by a decrease in water intake when compared to the control animals.

The Present Experiment

Casey's results showing that alcohol consumption increases when the electric shock is discontinued could mean one of two things: (1) alcohol intake is not directly related to stress in that situation or (2) alcohol intake is directly related to stress but the termination of the electric shock is perceived by the animal as a stressful situation.

The present experiment constitutes an attempt to determine which of the above alternatives is the case by observing stress through physiological measures. The physiological measures used were heart rate, random movement and the number of feces excreted. The hypothesis is that alcohol consumption is directly related to stress. We expect then that when the electric shock is present, the rats will show a change in the physiological measures and increase their consumption of alcohol. Upon termination of the electric shock we would expect a further increase of both alcohol intake and stress.

The first measure of stress is heart rate. In animal studies the heart rate seems to decrease at the onset of a stressing stimulus (Brady, 1970; Katcher et al., 1969; Satinger, 1970). This is followed by an increase which is significantly higher than baseline. Studies dealing with electric shock (Ducharme et al., 1961), water deprivation (Belanger, 1962; Goldstein, 1970; Granger, 1969), food deprivation (Goldstein, 1970) as well as open field situations (Candland et al., 1967) have shown the heart rate acceleration

The second measure of stress used was random activity as indicated by shifts in the baseline of the heart rate recordings as described in the Method section. Although this measure of random activity has not previously been reported in the literature, there is support for the hypothesis that random activity increases when the animal is subjected to stress. Both water deprivation and food deprivation have been shown to increase mobility (Campbell and Sheffield, 1953; Campbell, 1960; Campbell et al., 1961).

Defecation, the third measure of stress, has been shown to increase at the onset of a stressful situation (Candland et al., 1967; Lebo, 1953). As in heart rate, the response seems to change and, as the animals continue to be exposed to the aversive situation, the number of feces decreases when compared to baseline levels (Candland et al., 1967; Newell, 1969; Snowden et al., 1964).

Method

Subjects

Thirty two male Sprague Dawley rats, implanted for the recording of heart rate, were used in this experiment. Their weight ranged from 322 to 440 grams at the begining of the experiment.

Apparatus

Twelve modified Skinner boxes, having a grid floor through which electric shock could be delivered, and four pigeon cages housed the animals. The Skinner boxes were modified by: (a) opening a hole on top for the heart rate cable, (b) dismounting both the lever and the food dispenser so that the animals could not avoid shock by clinging to them, (c) suspending a wire mesh food box, about four inches in volume, from the upper edge of the cage in such a way that the animal could not cling to it, and (d) providing for two bottles were necessary.

Scrambled electric shock was delivered to the grid floors of the cages by two Grason and Stadler shock generators (Model E1064GS). Each of these generators delivered shock to four cages. The generator was activated by a BRS relay (Model RY204) which also activated a counter that recorded the total amount of shocks administered (Grason and Stadler, Model 3700). The relay, in turn, was closed by a punched tape reader system (BRS, Model TRS-3). The tapes fed into the reader were made according to a probability table that distributed the occurrence of the electric shocks around an average of one shock every ten minutes. Two electronic timers (Grason and Stadler, E1100H), connected in series, advanced the tape every ninety seconds. The shock used was 1.5 volts and variable current, delivered through the scrambling device to the floor grids for 1.5 seconds.

The hear rate signals were taken from a plug on top of the cage and sent through a low level amplifier (Tektronix Inc., Model 122). The high frequency noise was removed by means of a filter (A.P. Cincuit Co., Model APS-1). This signal was then fed to a Grass Model 5 polygraph.

Procedure

Sixteen rats were implanted with electrodes to measure heart rate and assigned at random to one of four groups. They were presented with a fifteen percent solution by volume of alcohol in distilled water as their only available liquid, together with Purina Lab Chow block food ad lib for one week.

At the end of the first week differential treatment started. An illustration of the different groups in the design can be found in Table 2. The first group of rats, designated the "Shock-Choice" group, had two identical drinking tubes available. One bottle contained the 15% alcohol solution, the other contained distilled water. The position of the bottles

Table 1. Illustration of the four different groups present in the design.

	CHOICE (Alcohol and water)	NO-CHOICE (only water)
SHOCK	Group No.1 "Shock-Choice group"	Group No.2 "Shock-No-Choice group"
NO-SHOCK	Group No.3 "No-Shock-Choice group"	Group No.4 "No-Shock-No-Choice group"

was counterbalanced for the group but was always the same for a given animal. The animals in this group were also subjected to four-day periods of electric shock intermittent with similar periods of no shock. The first four-day period was a no-shock period. There were four no-shock periods and four shock periods in the experiment.

The second group was the "Shock-No-Choice" group. The rats in this group were subjected to the same treatment given to the "Shock-Choice" group but had only water available and, therefore, no choice.

The third group was the "No-Shock-Choice" group. The animals had two bottles with water and alcohol as in the first group but did not receive electric shocks.

The four remaining rats had only water available and did not receive shocks. These rats constituted the "No-Shock-No-Choice" group.

Heart rate readings were taken twice daily, at 9:00 A.M. and 4:00 P.M. Each rat was sequentially connected to the equipment through the plug on top of its cage and the heart rate was recorded for a period of 2.5 minutes. The rat was not able to see this operation and every effort was made to keep this procedure as silent as possible. The order in which the readings were taken was counterbalanced. During the shock periods the heart rate recording was taken five minutes after a shock was administered.

After the morning recording of the heart rate, alcohol and water consumption were measured, feces were counted and the food receptacles were refilled. The animals were weighed on the second day of every four-day period.

When these animals were finished the same procedure was repeated with sixteen more subjects.

Surgical Procedure

For the implantation of the electrodes the animal was anesthetized using Nembutal (Sodium Pentobarbital). Whenever necessary, Ether was also used to reinforce the sedation. Two loops of multistrand, stainless steel wire were subcutaneously sewn less than three inches appart, into the middle of the animal's back. Each of these electrodes was connected to a single pole, multistrand, insulated electrical cable. The cable was covered by a flexible spring in order to avoid having the animals chewing on the wires. Three inch adhesive tape was used then to cover the implantation.

The wire spring went first through the hole on top of the cage and then the center hole of a strip of thin metal about two inches long. The wires were then connected to a plug. When perpendiculat to the spring, the strip of metal made it impossible for the plug to slip back through the hole in the cage. Due to the flexibility of the spring, this strip of metal could be held vertically enough to be pulled back inside the cage when the rat had to be taken out. This procedure also allowed the animals to move freely inside the cage without breaking the wires.

With some frequency one of the wires from the electrodes to the plugs would break. When this occurred, the wire was fixed as soon as possible. In most cases this was done by cutting the tape that covered the implantation, soldering the wire and retaping, without ever taking the old tape off. This procedure was quick and apparently painless. There were, however, some exceptions in which the animals had to be anesthetized and completely re-implanted.

Scoring

The water and alcohol intake and the number of feces were divided daily by the weight of the rat in that particular four-day period and multiplied by a hundred. In this manner a daily weighted score in terms of milliliters or fecal units per hundred grams was obtained for these variables taking into consideration the size of the animal.

The author observed that some of the heart rate records had more baseline shifts than others. It was felt that the rats that were being shocked were more likely to produce a preponderance of this shift which was thought to be a muscle artifact coming from movement in the animal. A system was then devised to measure this shift objectively. A piece of paper, 2.5 by 25 millimeters in size, was marked longitudinally so as to divide it into ten equal segments of 2.5 millimeters each. This paper was placed over the heart rate recordings on the second page of the rat's graph. The second page was always recorded with a standardized setting on the polygraph since the sensitivity of the apparatus alters the amount of the shift. Any segment 2.5 millimeters long that would have a part of the graph showing when the paper was placed over the recording was counted as "movement". The movement score of one reading was added to the other reading taken on that date. A rat had a daily movement score, then, that ranged from 0 to 20.

Results

The total number of units of movement in each four-day period are shown for each animal in Table 4 in the Appendix. There was a significant difference between the Choice and the No-Choice groups during the period prior to the onset of the electric shocks (days 1-4). This would indicate that these groups were different from the begining and would preclude any comparison between them. Meaningful comparisons can be made, however, between the two Choice groups which showed no significant differences prior to the onset of the stress.

Figure 5 shows the pattern of random movement of these two groups. Analysis of variance showed a significant difference ($p < .05$) between the Shock-Choice and the No-Shock-Choice conditions. The rats in the Shock-Choice condition moved significantly more during the shock periods when these were compared to the no-shock periods ($p < .01$). There was a tendency in both groups for the amount of movement to decrease as the experiment proceeded ($p < .01$). This tendency also appeared within periods so that at the begining of, for example shock periods, the shock rats showed significantly more movement than at the end ($p < .01$).

The average heart rate of each rat in the Choice groups for each four-day period is given in Table 5 in the Appendix. Figure 6 shows the average heart rate pattern for the two

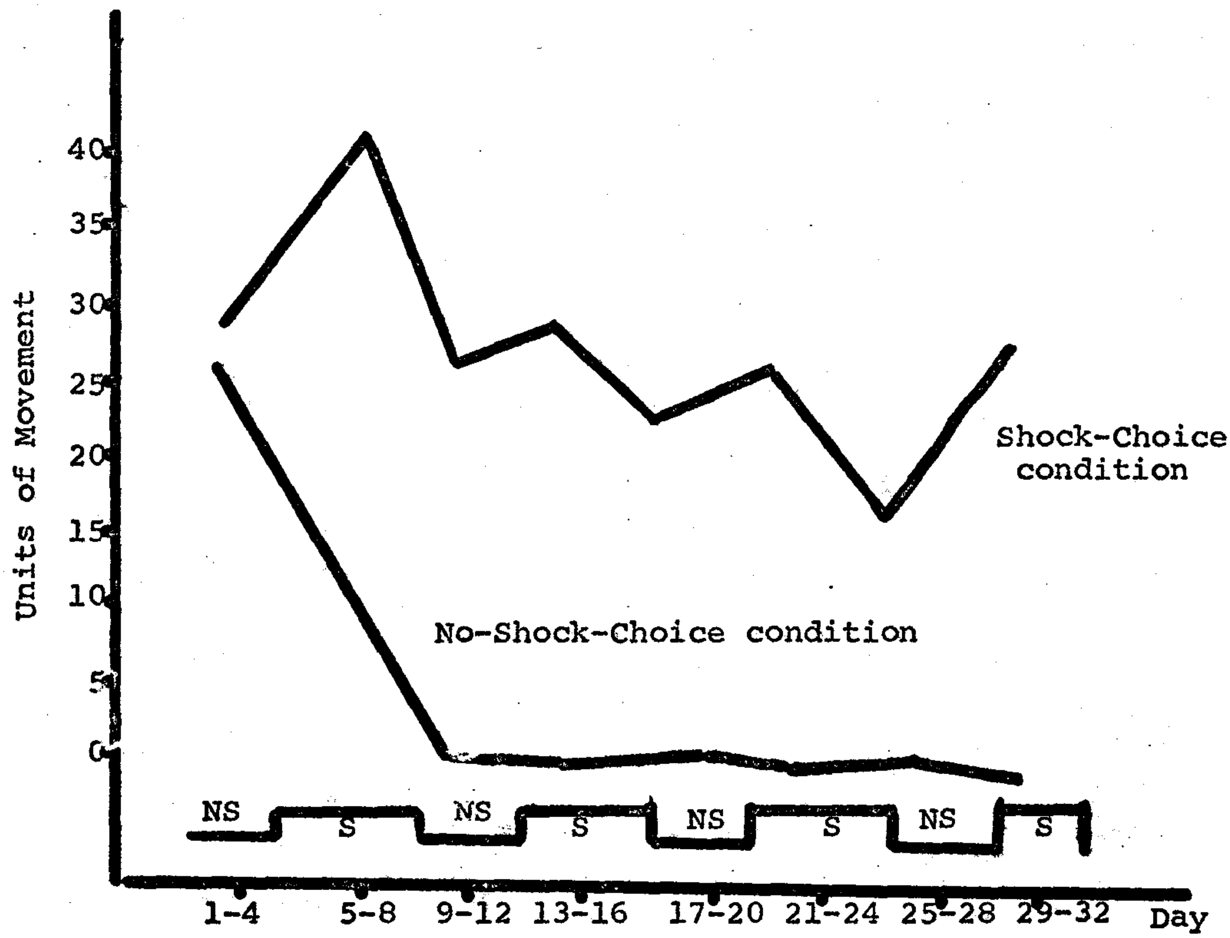

Figure 5: Average amount of random movement in each four-day period. Shocks apply only to the Shock-Choice condition.

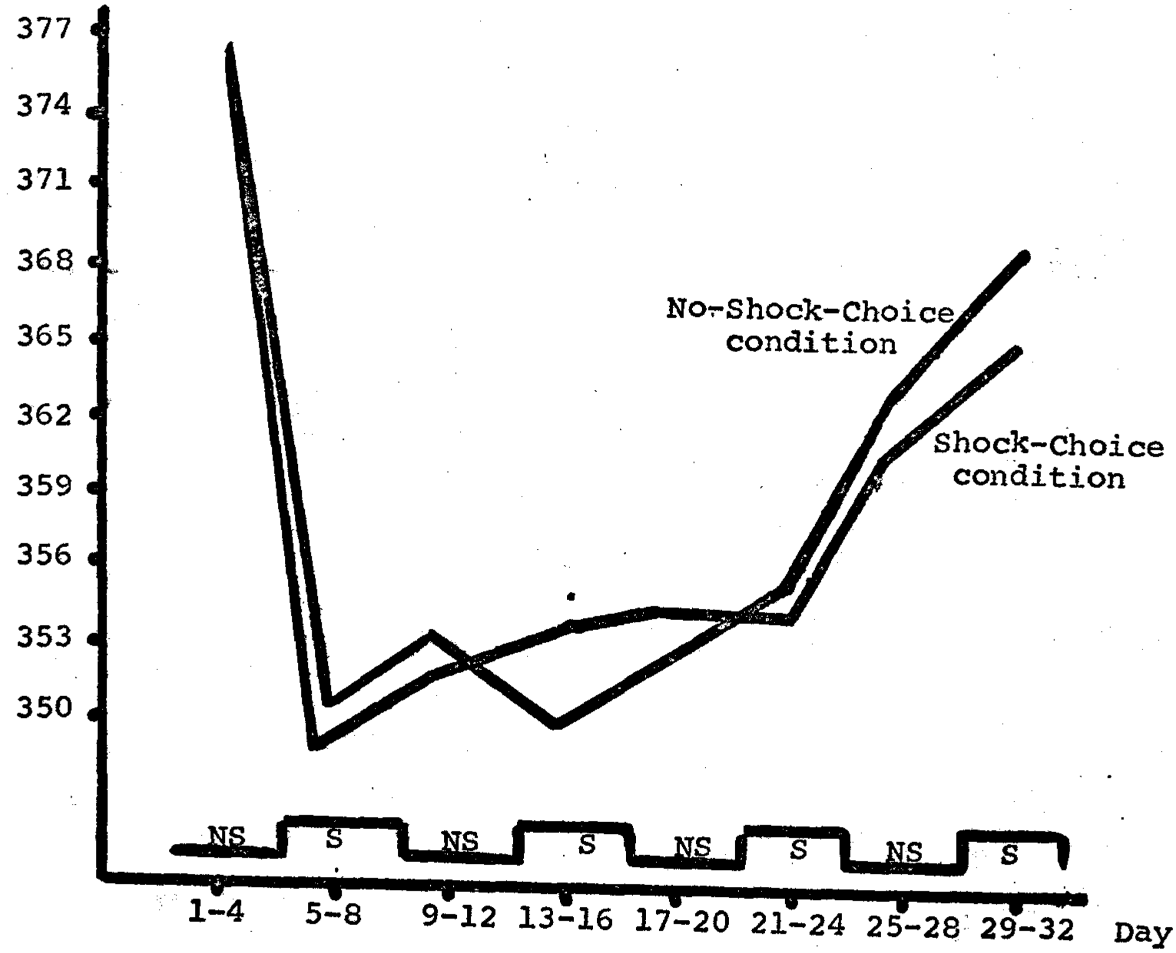

Figure 6: Average heart rate in each four-day period for the two Choice groups. Shocks apply only to the Shock-Choice condition.

Choice groups. The analysis of variance indicated no difference between the two groups. The heart rate of the Shock group during the shock periods, furthermore, was not significantly different from the heart rate of the no-shock periods.

Table 6 in the Appendix shows the total amount of feces per rat in each four-day period. There was a tendency for the number of feces to decrease as the experiment proceeded. This tendency was significant within periods ($p < .05$) as well as across the thirty-two days ($p < .01$). There was no significant difference between the Shock-Choice and the No-Shock-Choice groups as can be seen in Figure 7.

The total amount in millimeters of alcohol solution consumed each four-day period per hundred grams of body weight is shown in Table 2 for each rat of the Choice groups. Figure 8 represents the alcohol intake for both of the Choice groups. The analysis of variance showed no significant results. Examination of the data would suggest that what raised the alcohol intake of the Shock-Choice group were single individuals that drabk much higher amounts of the ethanol solution. However, an F Test showed that the difference in variability was not significant and a second analysis of variance done after a transgeneration designed to reduce variability ($\log_{10}(x+1)$) also failed to attain significance.

Table 3 gives the total number of millimeters of water intake in each four-day period per hundred grams of body

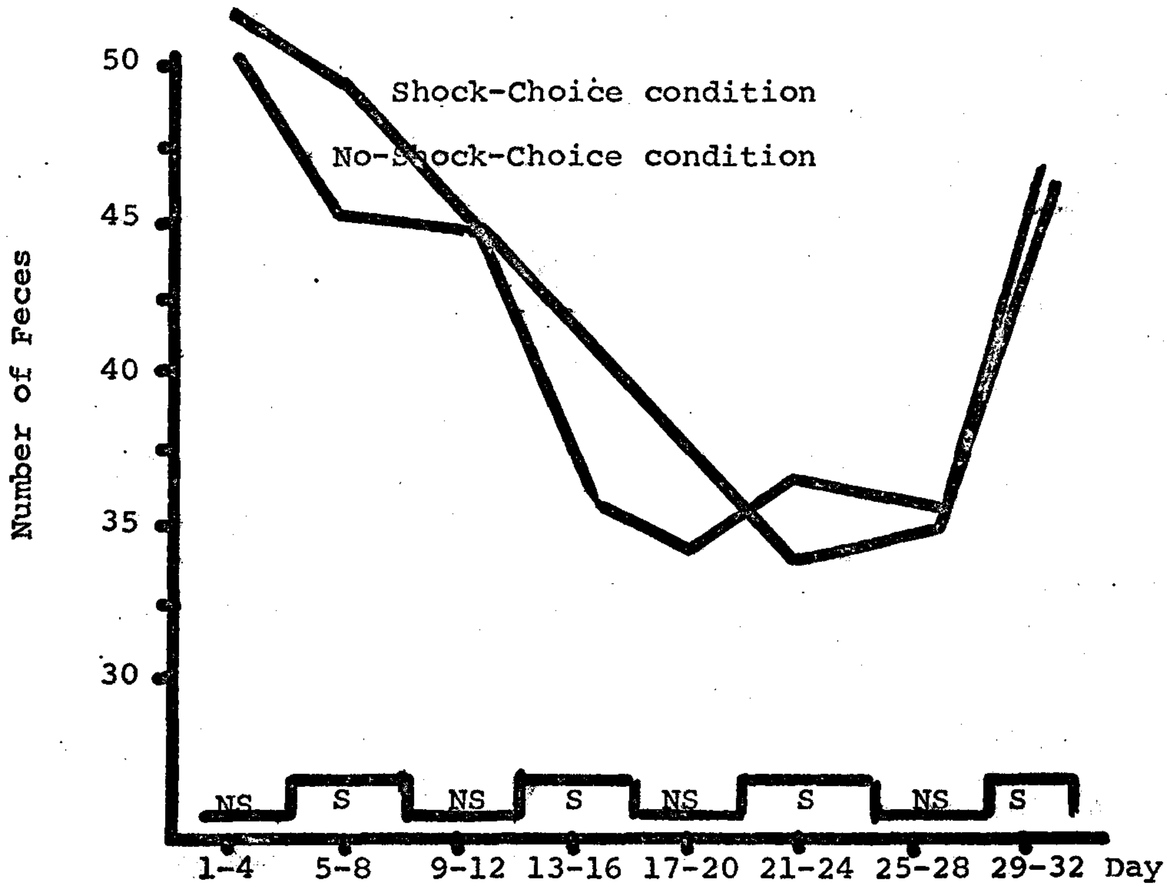

Figure 7: Number of feces per hundred grams of body weight in each four-day period. Shocks apply only to the Shock-Choice group.

Table 2. Total number of millimeters of alcohol solution consumed in each four-day period per hundred grams of body weight. Underlining of the days comprising the period indicates the presence of shock. Administration of shock is only applicable to the Shock-Choice group.

GROUP	RAT DAYS:	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32
	21	17.3	4.3	2.7	6.6	9.2	11.6	9.1	8.3
	22	1.8	1.8	1.3	1.5	1.4	1.9	2.3	6.2
No-	23	8.7	4.8	7.3	14.2	5.4	8.5	14.7	4.4
Shock-	24	1.5	1.7	.9	1.6	1.4	1.2	.9	1.1
Choice	31	2.5	1.9	3.9	2.5	2.0	1.8	1.5	2.2
	32	2.5	2.0	2.1	1.9	1.4	3.1	1.9	1.6
	33	2.1	3.1	2.7	3.4	1.9	3.1	3.4	5.7
	34	11.4	2.3	1.7	1.2	1.6	3.4	1.8	4.6
	Average	6.0	2.7	2.8	4.1	3.1	4.3	4.4	4.3
	25	2.6	1.5	2.4	2.2	1.7	1.5	1.4	1.2
	26	4.8	7.5	16.6	20.1	32.2	28.5	37.9	5.3
	27	1.9	2.1	.7	2.4	1.4	1.3	1.3	1.2
Shock-	28	3.2	12.7	3.0	11.9	6.0	10.3	6.3	7.8
Choice	35	2.7	2.4	2.4	2.2	2.0	1.9	1.7	2.4
	36	2.3	2.2	1.3	1.8	2.0	2.0	1.0	1.2
	37	2.8	2.2	1.0	3.1	6.4	5.4	11.7	12.1
	38	3.1	11.3	3.6	5.1	1.7	19.8	40.4	19.9
	Average	2.9	5.2	3.9	6.1	6.7	8.8	12.7	6.4

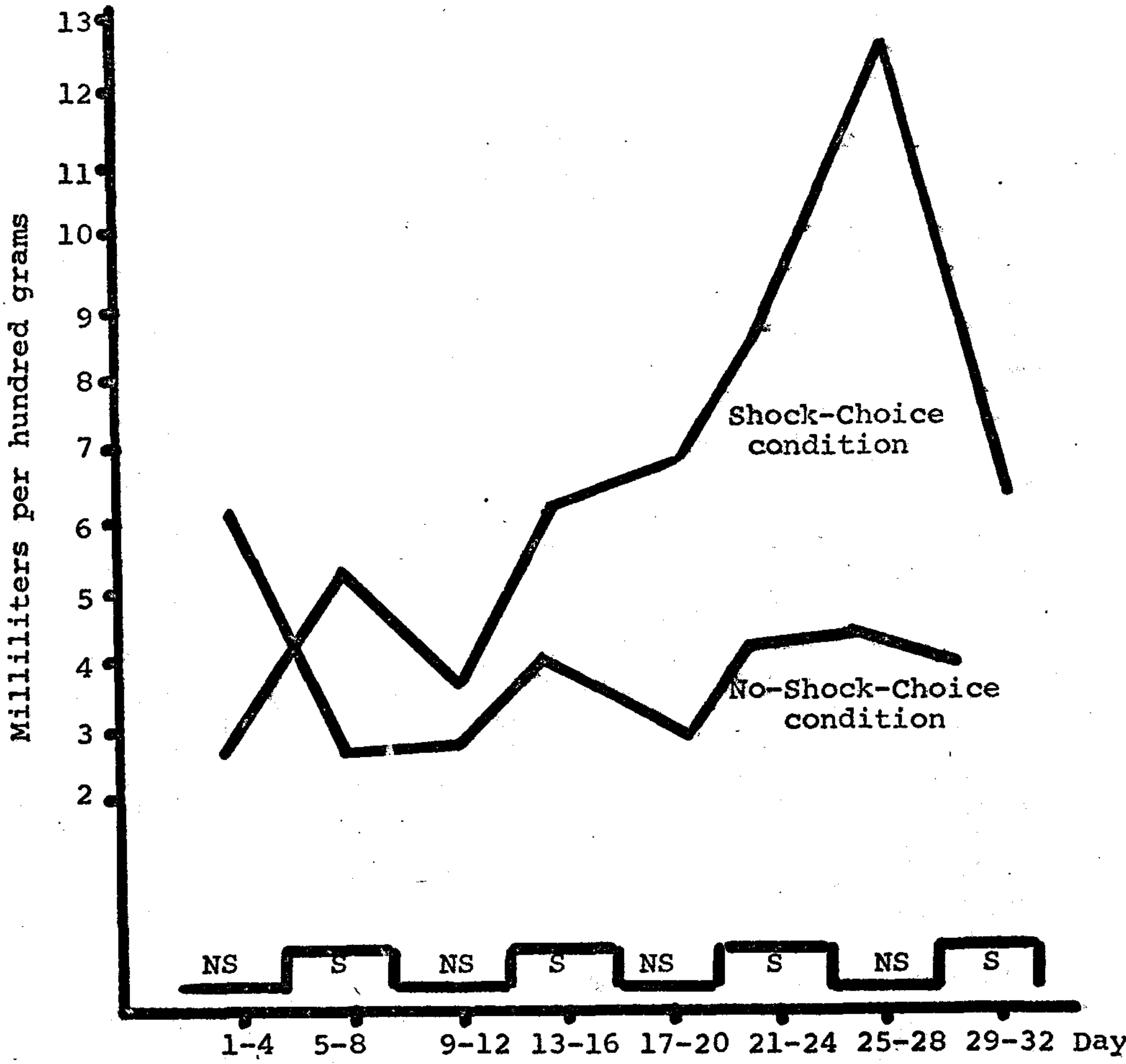

Figure 8: Milliliters of the ethanol solution per hundred grams of body weight consumed during each four-day period. Shocks apply only to the Shock-Choice condition.

Table 3. Total number of milliliters of water intake in each four-day period per hundred grams of body weight for each animal in the Choice conditions. Underlining of the days comprising the period indicates the presence of shock. Administration of shock is only applicable to the Shock-Choice group.

GROUP	RAT	DAYS: 1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32
	21	25.5	42.7	38.5	29.5	26.7	18.7	26.2	23.9
	22	57.5	71.1	49.7	46.3	46.5	46.3	43.3	52.6
No-	23	46.2	56.0	44.1	51.9	32.2	34.2	43.3	45.1
Shock-	24	39.8	40.7	35.0	31.4	32.9	31.9	26.6	32.3
Choice	31	41.2	39.8	34.7	28.0	34.0	35.4	31.9	30.2
	32	51.3	39.3	42.4	39.4	42.5	40.8	43.3	45.6
	33	44.3	44.2	29.8	30.4	31.3	31.9	35.4	31.0
	34	41.1	40.9	33.3	32.8	32.2	34.9	38.2	31.7
	Average	43.4	46.8	38.4	36.2	34.8	34.3	36.0	36.5
	25	38.3	42.2	41.0	31.6	29.3	29.6	36.5	36.1
	26	39.0	21.2	32.3	27.5	35.0	29.9	41.7	43.8
	27	47.3	39.1	39.6	24.1	28.5	27.0	31.3	37.2
Shock-	28	41.9	37.6	37.3	29.5	42.5	40.7	46.1	50.9
Choice	35	39.3	38.7	31.1	30.2	45.2	38.0	34.5	30.1
	36	47.5	48.6	52.0	32.9	31.9	30.8	34.7	35.0
	37	39.2	34.4	31.2	26.8	21.9	26.3	17.5	20.5
	38	40.6	33.4	33.0	31.9	47.3	35.3	32.7	37.0
	Average	41.7	36.9	37.2	29.3	35.2	32.2	34.4	36.3

weight for each animal in the choice conditions. Water consumption levels are illustrated in Figure 9. The analysis indicated that there was a significant tendency for the animals to drink less water as the experiment proceeded. This tendency was significant within periods ($p < .05$) and across the length of the experiment ($p < .01$).

A correlational analysis was undertaken in an attempt to determine if any of the stress measures could predict changes in the consumption of alcohol or water. None of the stress measures showed a significant correlation demonstrating that no single measure could significantly predict the changes obtained in the alcohol and water intake. A multiple regression analysis was then tried in order to judge if a collective consideration of more than one of the variables was capable of significant prediction. This analysis was also non-significant.

Although neither correlation nor multiple regression analysis testified to significant relationships, it seemed possible that a relationship still existed if this relationship changed to its opposite during the experiment. It was possible, for example, that there was a strong postive relationship between random activity and alcohol intake during the shock periods if this relationship was strongly negative during the no-shock periods. If this was the case, the two relationships would balance out and the total coefficient would be low. Because of this possibility, a day-

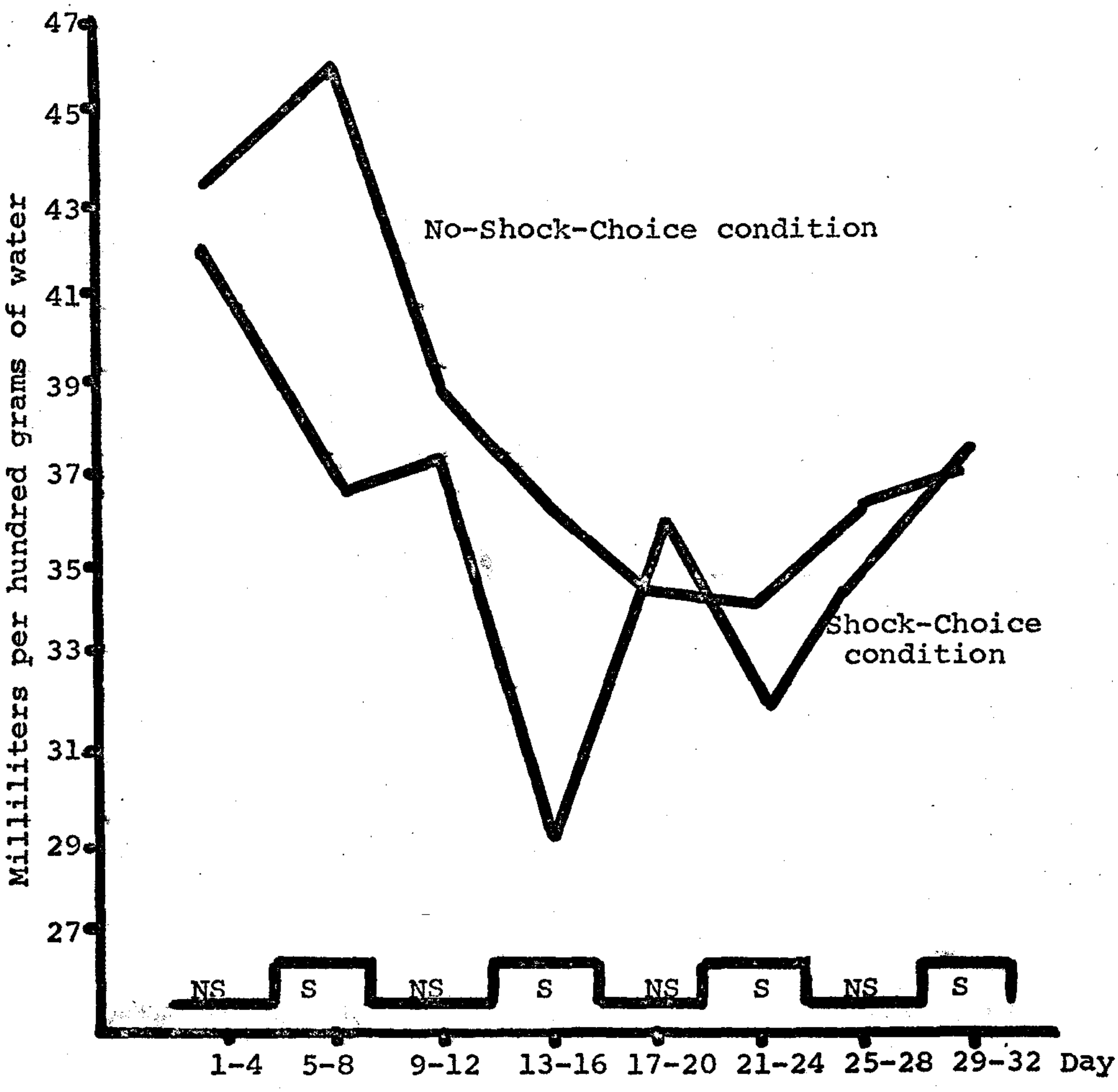

Figure 9: Milliliters of water per hundred grams of body weight consumed during each four-day period. Shocks only apply to the Shock-Choice condition.

by-day correlation and multiple regression analyses were carried out. Neither of them, however, demonstrated significant relationships.

Discussion

A four group design was used in the present experiment in an attempt to show that animals experiencing a subjectively stressful situation demonstrated by physiological measures, would increase their alcohol consumption. The two No-Choice (control) groups showed a significant difference from the Choice groups prior to the experimental treatment in one of the physiological measures, random movement. The factors producing this significant difference are not readily apparent. One of these groups, the No-Shock-No-Choice group, was housed in a somewhat different cage. It might be suggested that perhaps these cages were more similar to their pre-experimental cages so that the resulting low movement was produced by a lack of exploratory behavior. This appears to be an unlikely explanation since the first readings were taken eight days after the animals were introduced to the experimental cage and the exploratory behavior tends to reach satiation sooner (Berlyne, 1954). Furthermore, this explanation can not be applied to the Shock-No-Choice group which showed a significantly higher -instead of lower- movement level and was housed in the regular cages. Other hypotheses like differential animal weights, seem similarly unlikely.

The difference in random movement at the onset of the experiment made it unfeasible to take the No-Choice groups into consideration. It was impossible, as a result, to determine the effects on the stress measures of the passage of time and the effect of electric shock in the absence of alcohol. This obvious setback might be prevented in future experiments by matching the subjects instead of assigning them randomly.

Not taking into consideration the unpredicted difference found at the onset of the experiment, the results on random movement support our hypothesis. More than any other stress measure the random movement level followed the following expectations: (1) The random movement of the Shock group should be higher than the movement of the No-Shock group, (2) there should be higher movement levels for the shock periods when compared to the no-shock periods, and (3) movement should decrease as the animal adapts to the experimental situation. It seems that this procedure represents an accurate and practical way to measure the effect of electric shock.

The literature reviewed showed that heart rate decreases at the onset of the stressing stimulii but tends to increase above the baseline if the stress continues. This could be viewed in terms of behavior: when the animal is shocked there is a "freezing" period during which the animal is inactive and which might coincide with the lowered heart rate. After a brief period, the animal becomes hyperactive which might account for the heart rate increase. The heart rate readings used in this experiment were mostly taken after the hyperactivity had relinquished. The increased mobility that was found apparently did not necessitate a significantly higher heart rate. It seems, therefore, that heart rate is only an effective measure of stress during a brief period following the stressing stimulus.

It is possible that the same consideration discussed regarding heart rate changes applies to feces. There is support for the use of feces during brief periods of stress. Our data indicates that when used for longer periods of time, this measure is no longer effective.

A factor that might apply to heart rate but most especially to fecal production is the question of the length of time that an animal can support an extreme biological state. An increased heart rate could be something that the animal can produce only momentarily. In the case of the feces, there is a ceiling on the amount of waist material that the animal can yield. It might be that studies that deal with brief periods after the stress are considering the time at which the animal defecates. In the present study the observations were more likely to deal with the amount of defecation since feces were counted only once in twenty-four hours. It seems likely that how much the animal defecates is not as subject to variation as when the feces are produced.

The main hypothesis of the present experiment stated that animals showing higher levels of stress in the physiological measures would show higher alcohol intake. Although our data suggests that some animals increased drinking, there is no support for the hypothesis. At least one animal in the No-Shock group showed a higher level of alcohol intake and all attempts to obtain a correlation or a significant difference between the Shock and the No-Shock groups resulted in failure. There is the possibility that if more subjects were included in a study of this kind, it could be shown that significantly more rats in the Shock-Choice group ingest higher amounts of alcohol. This would imply the existance of an "alcoholic propensity" which produces a tendency to drink in some rats. Our data seems to suggest that this particular kind of stress has an influence in the alcohol consumption of some but not all animals.

Turning to the water consumption, we indicated that there was a tendency for the animals to drink less water as the experiment proceeded. This phenomena is probably due to the unavailability of water during the seven-day preparatory period, at least in part. It seems likely that after this forced abstention the animals would be overly eager to drink water, accounting for a high level of water consumption at the onset of the experiment. As the experiment proceeded, their eagerness tended to diminish.

Summary

Physiological measures of stress were used in an attempt to show that stress leads to increased alcohol consumption in rats. A significant difference in random movement at the onset of the experiment made it unfeasible to consider the two control groups that had no alcohol available. Of the physiological measures of stress, random movement measured through shifts in the heart rate recordings proved to be the most sensitive since it was (1) significantly higher for the Shock group, (2) significantly higher in the shock periods and (3) significantly lowered by the adaptation of the animal to the stress. The number of feces excreted also decreased as the animals adapted. The third measure of stress, heart rate, did not demonstrate any of the expectations listed above.

Although the Shock group had a higher level of alcohol intake, this difference was not significant. There was also a non-significant difference between the alcohol consumption of the shock periods when compared to the consumption of the no-shock periods. Correlational and multiple regressional analyses between the stress measures and the alcohol and water intakes were non-significant. The possibility that stress increases alcohol intake only in some animals was discussed.

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Appendix

Table 4. Total number of units of movement in each four-day period for each rat. Underlining of the days comprising the period indicates the presence of shock. Administration of shock is only applicable to the Shock groups.

GROUP	RAT DAYS:	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32
	21	45	12	0	1	6	6	0	0
	22	60	14	0	0	4	0	0	0
No-	23	43	14	0	1	0	0	0	0
Shock-	24	34	28	2	4	1	0	0	3
Choice	31	0	0	0	0	0	0	0	0
	32	1	0	1	0	0	0	8	0
	33	0	2	0	0	0	0	0	0
	34	0	6	1	0	0	0	0	0
	Average	22	10	1	.75	1.38	.75	1	.38
	25	30	43	27	38	19	19	60	48
	26	45	46	21	32	17	33	10	42
	27	47	60	43	48	29	40	22	32
Shock-	28	45	61	32	20	20	27	7	17
Choice	35	15	15	6	0	13	17	0	2
	36	20	26	5	21	12	9	7	21
	37	5	24	23	28	28	33	14	36
	38	5	20	19	9	15	6	14	8
	Average	26	37	22	24.5	19.1	23	16.7	25.7
	29	56	47	36	31	28	21	12	17
	210	27	55	63	53	56	29	15	21
Shock-	211	66	20	5	28	20	28	10	11
NO-	212	45	45	25	14	21	21	16	0
Choice	39	died							
	310	29	8	25	3	30	36	47	38
	311	15	23	9	17	22	32	15	21
	312	40	27	1	21	16	8	11	45
	Average	39.7	32.1	23.4	23.9	27.6	25	18	21.9
	213	10	8	0	0	0	0	0	0
	214	16	0	0	5	6	1	2	1
No-	215	6	3	0	1	0	0	1	1
Shock-	216	1	2	0	2	4	0	0	6
NO-	313	0	2	1	0	0	1	0	0
Choice	314	0	0	0	0	0	0	3	0
	315	0	0	0	0	0	0	2	0
	316	0	0	1	0	0	0	6	0
	Average	4	2	0	1	1.2	.25	1.75	1

Table 5. Average heart rate of each rat in the Choice groups in each four-day period. Underlining of the days comprising the period indicates the presence of shock. Administration of shock is only applicable to the Shock-Choice group.

GROUP	RAT	DAYS: 1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32
	21	357	317	355	361	350	345	337	359
	22	351	336	363	353	363	364	368	401
No-	23	331	334	354	343	338	335	351	369
Shock-	24	359	350	367	347	346	346	354	371
Choice	31	437	402	368	373	379	374	380	364
	32	399	375	351	336	350	370	398	372
	33	394	362	337	353	329	352	360	360
	34	388	355	346	349	382	370	376	378
	average	377	354	355	352	355	357	366	371
	25	369	310	339	347	350	369	338	367
	26	337	358	354	345	353	348	348	375
	27	352	329	357	356	333	365	348	360
Shock-	28	335	329	372	351	384	368	366	388
Choice	35	401	350	334	334	349	341	356	346
	36	441	380	350	370	378	348	379	388
	37	393	368	348	376	370	360	382	361
	38	386	375	355	348	340	341	367	347
	average	377	350	352	355	356	356	361	366

Table 6. Total amount of feces of each rat in the Choice groups in each four-day period. Underlining of the days comprising the period indicates the presence of shock. Administration of shock is only applicable to the Shock-Choice group.

GROUP	RAT DAYS:	1-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32
	21	49.2	46.7	40.7	29.3	35.7	31.5	30.4	30.5
	22	45.2	52.1	50.1	29.6	27.9	29.9	37.7	40.8
No-	23	40.9	39.0	37.7	34.4	30.8	27.4	31.5	31.9
Shock-	24	36.4	38.9	36.4	29.4	28.9	32.6	27.7	31.2
Choice	31	55.9	55.2	55.1	52.7	40.9	63.8	46.1	50.0
	32	42.3	39.3	40.0	39.2	35.9	37.0	36.6	40.2
	33	65.5	46.6	62.1	40.4	33.3	34.7	37.6	38.0
	34	66.1	45.1	39.2	36.6	37.5	39.2	37.3	33.4
	Average	50.2	45.4	45.2	36.4	33.9	37.0	35.6	47.0
	25	36.6	38.1	35.4	27.0	27.9	26.1	32.2	32.9
	26	32.3	31.5	44.6	40.1	29.5	28.7	30.8	32.0
	27	41.5	61.5	42.3	35.6	29.7	29.0	33.8	35.1
Shock-	28	37.6	33.3	37.8	35.1	32.1	35.8	35.6	34.6
Choice	35	52.8	51.6	39.6	38.5	40.5	38.3	37.6	38.1
	36	74.2	73.5	77.7	53.8	39.5	39.4	40.8	47.0
	37	107.	48 4	40.4	40.8	33.2	38.4	36.5	33.3
	38	42.7	50.7	39.9	40.3	36.5	37.3	35.2	35.5
	Average	53.1	48.6	44.7	38.9	33.6	34.1	35.3	46.1

APPROVAL SHEET

The dissertation submitted by Mr. James P. Choca has been read and approved by members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

4/28/72
Date

Signature of Advisor