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BRIEF COMMUNICATION

Stress Induced Suppression of Maintenance but not of Acquisition of Ethanol Consumption in Rats

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NG CHEONG TON, M. J., Z. BROWN, A. MICHALAKEAS AND Z. AMIT. *Stress-induced suppression of maintenance but not of acquisition of ethanol consumption in rats.* PHARMACOL BIOCHEM BEHAV **18**(1) 141–144, 1983.—Male Wistar rats were given a free-choice between water and increasing concentrations of ethanol from 3% to 11% (v/v) during the acquisition phase. Thereafter, animals were maintained on a choice between water and 11% ethanol for the balance of the experiment. For 5 days prior to and for periods during the acquisition and maintenance phases, the animals were exposed to electric footshock, restraint or no stress. The results showed no differences in ethanol drinking patterns among the groups during the acquisition phase. However, in the maintenance phase, both footshock and restraint suppressed the increase in ethanol intake seen in the no-stress control group.

Electric footshock   Restraint   Ethanol drinking   Stress-induced alcohol drinking

SINCE the work by Masserman and Yum [7] where it was reported that "neurotic" cats showed an increased preference for a cocktail mixture of milk and 5% alcohol to milk alone, numerous studies have been conducted to examine the relationship between stress and alcohol drinking [3,11]. Conger [5] hypothesized that the increase in alcohol preference or drinking reported in some studies [1, 4, 8, 9] may be due to alcohol's attenuating effect on tension. Tension-reduction would be positively reinforcing thereby strengthening the alcohol drinking behavior. However, the evidence for the tension-reduction hypothesis is still equivocal [3]. In fact, Pohorecky [11] argued that in humans alcohol usually increases anxiety with time during a drinking binge. In addition, assuming that alcohol does reduce anxiety or tension, Cappel and Herman [3] point out that it still remains to be demonstrated that organisms drink alcohol because of its tension-reduction effect.

The importance of these works has gained wider recognition in the recent years in part because of the possible implication of endogenous opioid peptides in mediation of stress [6,13]. Volpicelli (in press) has proposed a mechanism for stress-induced alcohol drinking. He suggested that the increase in alcohol intake compensates for the relative ACTH/β-endorphin deficiency that would occur when a chronic stressor is removed. This renewed interest calls for a reassessment of the phenomenon. Also, it is felt that the change in alcohol intake should be demonstrated with a variety of stressors in order to gain a better understanding of stress. We here report that chronic stress with electric footshock or restraint suppressed the increase in alcohol drinking seen in control animals during the maintenance phase but had no effect during the acquisition phase.

METHOD

Subjects

Twenty-four male Wistar rats (Canadian Breeding Laboratories Ltd.) were individually housed in stainless-steel cages. At the start of the experiment, the weight of the animals ranged from 260 to 280 g. Light in the housing room was on from 0800 hr to 2000 hr and temperature was regulated at 20°C. Food (rat chow from Charles River Laboratories Ltd.) and water were made available ad lib for a week prior the start of the alcohol presentation during which time animals were handled daily.

Apparatus

A wooden chamber (48×25.5×36 cm) was partitioned equally into four parts along its length, each compartment accommodating a single animal. The floor consisted of 0.32 cm stainless steel rods spaced 1.5 cm apart. Scrambled electric shock (Intensity—1 mA; Duration—1 sec) was delivered on a variable interval schedule of 5 sec to the grid floor from a shock generator (Granson-Stadler Co., Model 700, Lot. No. L6103). The restraint apparatus consisted of a Plexiglas "tunnel" which snugly fit an individual animal. Adequate ventilation was provided by means of holes along the side of the "tunnel" and at the head of the apparatus.

Procedure

Animals were randomly assigned to a footshock group (Fs), a restraint group (R), and a control group (C) (n=8 for each group). The experiment was divided into two phases:

TABLE 1

SCHEDULE OF ALCOHOL PRESENTATIONS AND STRESS SESSIONS

Phase	Days*	Number of Alcohol Presentations	Number of Stress Sessions
Acquisition	1–17	10	13
Maintenance			
Period 1	18–29	8	8
Period 2	30–57	18	0
Period 3	58–74	12	12
Period 4	75–87	8	0

*Beginning on the first day of alcohol presentation.

Acquisition phase and maintenance phase. Table 1 summarizes the experimental procedure.

Acquisition phase. The animals in the experimental groups (Fs and R) were subjected to a 30-min session of stress daily for 5 consecutive days. Thereafter, the stress schedule consisted of 2 consecutive days of stress followed by a no-stress day. Animals in the Fs group were placed four at a time in the footshock chamber and scrambled shock (1 mA, duration 1 sec) was delivered to the grid floor for 30 min on a variable interval of 5 sec. Animals in the restraint groups were placed in the restraint apparatus for 30 min. Control animals were handled and placed back into their homecages. Beginning on the fourth day of the stress treatment, the animals were given a choice between 3% (v/v) alcohol and water in Richter tubes in their homecages right after each stress treatment. On no-stress days, only water was made available. The concentration of alcohol was increased by 2% after every second alcohol presentation. The acquisition phase was arbitrarily ended following the second presentation of 11% ethanol.

Maintenance phase. This phase was subdivided into 4 periods. Period 1 began immediately following the acquisition phase and consisted of exposure to stress as previously described during 8 sessions over 12 days. Eleven percent ethanol and water were made available only on the stress days. Period 2 was a stress-free period of 28 days during which 11% ethanol was again presented in a free-choice with water. During period 3, the stressors were reinstated, in this case for 60-min rather than 30-min sessions for a total of 12 sessions over 17 days. Finally, Period 4 continued for :3 days of no-stress with presentation of ethanol and water as usual.

Throughout the whole experiment, ethanol and water intake were measured 24 hr after each stress sessions, and the weights of the animals were recorded. The positions of water and alcohol tubes were alternated after every alcohol presentation. These procedures adopted here are consistent with previous studies from the same laboratory, and thus allow for comparison. Stress sessions always took place between 9 a.m.–11 a.m. A split plot two-way ANOVA with one repeated measure (SPF—2.1 see Kirk, 1968) statistical design was used for analyzing the data.

RESULTS

The data for one animal in the control group were inadvertently lost. Analyses were conducted on data for the rest of the animals (n=7 for control group).

Acquisition phase. Figure 1 shows the mean absolute amount of alcohol consumed per kilogram of body weight for each group across the 10 days of alcohol presentation. An analysis of variance did not show any significant effect of stress on ethanol consumption F(2,20)=1,228, $p>0.05$. Although not significant, there was a slight tendency for animals in the Fs group to consume more alcohol than those in the two other groups particularly at the 5% and 7% alcohol concentrations.

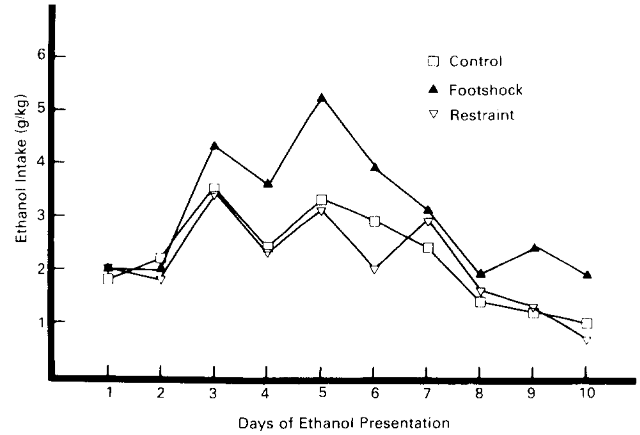

FIG. 1. Mean ethanol intake (g/kg) on each day of alcohol presentation during the acquisition phase for the 3 groups.

Maintenance phase. For ease of analysis and interpretation, the average daily alcohol consumption data for each period were used. Analyses of variance indicated significant stress × period interactions on both measures of alcohol consumption—percentage of alcohol intake (ml of alcohol as a ratio of ml of total fluid intake) and absolute alcohol intake in gram per kilogram of body weight—F(6,60)=3,073, $p<0.05$ and F(6,60)=2,371, $p<0.05$ respectively. Figure 2 shows the mean alcohol intake in grams per kilogram of body weight for each group across periods. Within-group paired-comparisons indicated significant increases in alcohol intake from Period 1 to Period 3, Period 1 to Period 4, and Period 2 to Period 4, $p<0.05$. Although there were increases in alcohol intake from stress periods (1,3) to non-stress periods (2,4) for both stress groups, these increases were not significant, $p>0.05$.

Furthermore, there was a gradual decrease in water intake in control animals, (see Table 2) but no change in total fluid consumed. In contrast, animals in the two stress groups showed slight non-significant increases in water intake ($p>0.05$) and significant increases in total fluid intake during non-stress periods ($p<0.05$). Animals in all the three groups showed normal weight gain across the successive periods. These observations suggest no stress-induced impairment of health of the animals.

DISCUSSION

The results indicated that both stressors, electric footshock and restraint, effectively suppressed the gradual increase in ethanol (11%) intake seen in control animals during the maintenance phase. However, no difference in the pattern of alcohol intake was observed between the two stress groups and the control group during the drinking acquisition phase. The schedule of increasing percentage of alcohol concentrations during the acquisition period could explain the absence of a major increase in alcohol intake in all three

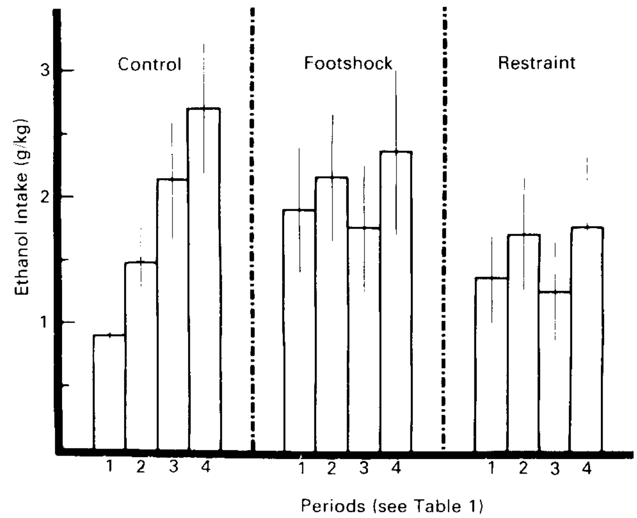

FIG. 2. Mean ethanol intake (g/kg) per day for each period during the maintenance period for the 3 groups.

groups of animals, particularly in control animals. On the other hand, when maintained at a certain percentage alcohol concentration for a long period (i.e., 11%), control animals showed a gradual increase in alcohol intake. This increase in alcohol intake was not observed in the two stress groups. Previous studies have not examined the possibility of a differential effect of stress on the acquisition and maintenance phases of alcohol drinking.

In a review of the literature, Pohorecky [11] indicated that the attempts to elevate alcohol intake using a physical stressor (usually electric footshock) have been disappointing. However, consistent with the present results, Powell *et al.* [12] have observed a similar suppression of the increase in alcohol preference following a period of forced alcohol intake in footshock animals. It is important to underscore the similar patterns in alcohol intake in the footshock and restraint animals in the present studies. The suppressive effect with restraint as a stressor indicated that the stress effect observed might be more psychological in nature rather than physical. One should note also that the increase in alcohol intake has also been consistently observed with the psychological stress of avoidance conditioning [11]. In addition, we have made earlier observations of this suppressive effect with a number of other stressors [10], including cold-water swim, hot-plate, and Formalin.

A change in alcohol intake can result from an adventitious punishment contingency with the preferred fluid [2]. There is no indication in the present study to suggest that the suppression of alcohol intake observed was related to the contingency between the stress treatment and the alcohol intake of the animals. The change in preference for alcohol (ml of alcohol intake per total fluid intake) during the acquisition from a maximum of about 90% to around 10% by the end of the phase was seen in all three groups of animals. This indicates that the change was mainly a function of the concentration of alcohol. During the maintenance phase, the percentage of alcohol intake never reached the 50% level. If the stressed animals perceived that they were being punished for their preference for water over alcohol, one would have expected an increase in alcohol intake in their animals during the two stress periods.

TABLE 2

Groups	Periods 1	2	3	4
Control, C	23.7	22.9	18.9	17.5
Footshock, FS	21.7	23.5	23.0	22.7
Restraint, R	21.8	26.9	22.6	25.6

Mean daily water intake during maintenance phase in ml.

One observation that could potentially reconcile the discrepant findings about the direction of stress on alcohol drinking could possibly be related to where alcohol is presented in relation to where the animals are being stressed. In the present study as well as in the study by Powell *et al.* [12], when animals were stressed outside of their homecages where they were presented with alcohol, the animals suppressed alcohol intake. In contrast, when animals were stressed in the same place where they were exposed to alcohol, their alcohol intake increased [4,8]. Mills and Bean [8] have shown that the consumption of alcohol increased immediately after the termination of the footshock treatment and lasted for about half an hour.

Recently, Volpicelli [14] has proposed a mechanism to explain the increase in alcohol intake after the termination of aversive events. He pointed out that both alcohol and aversive events can cause the release of ACTH and β-endorphin from the pituitary, and argued that termination of the aversive event would cause a relative deficiency in the levels of ACTH and/or β-endorphin. As such according to Volpicelli an increase in alcohol intake following the termination of the stressful events is part of a homeostatic response to restore the levels of ACTH and/or β-endorphin to the initial stress levels. However, one would predict that when animals presented with alcohol in their homecages—a less stressful situation than the shock box—they would have a lower level of ACTH/β-endorphin than they would have in the shock box and hence, they would be expected to drink more alcohol. The data presented here do not support this hypothesis. The results, however, suggest that a potential source for resolving the discrepant findings in the field of stress-induced alcohol drinking would be concerned with whether or not alcohol is presented within the actual boundaries of the stressful environment.

ACKNOWLEDGEMENTS

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