Relative stereotypy of water-ingestive behavior induced by chronic alcohol injections in the rat

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Albino rats were maintained on a 23.5-h deprivation schedule and trained in CRF barpressing for water in a 30-min/day operant session. After responding had stabilized, animals were given either saline or 1.5-g/kg ethanol injections at 10 min, 15 min, or 20 min prior to the daily session on alternate days for a total of 12 days. Animals achieving tolerance to alcohol by Day 12 did not differ from controls in overall response rate, but displayed a lower variance of rate over the course of the session than controls. In addition, the sequence of barpressing and dipper approach responses was noted, and orders of serial dependency were used to obtain a measure of uncertainty (Frick & Miller, 1951). Average uncertainty of these responses was significantly less for the alcohol-tolerant animals than for controls.

Changes in variability, as distinctive behavioral phenomena, have been observed to occur as a result of various stimulus conditions, and they appear to be of adaptive significance (Kuo, 1922; Muenzinger, 1928; Skinner, 1938). Antonitis (1951) found response variability to be a function of the presence or absence of reinforcement, and these general results have been confirmed using a wide range of measures, including variation of force emission (Notterman, 1959), response duration (Hurwitz, 1954), lever displacement (Herrick & Bromberger, 1965), and orders of serial dependency of two separate responses (Frick & Miller, 1951). Frick and Miller (1951) developed a measure of uncertainty of response from the frequencies of occurrence of a barpress and approach to a feeder in a food-reinforced operant in the rat. Stereotypy was defined as $1 - \text{uncertainty}$.

An apparent lack of change in behavioral variability has been noted in studies of the effects of certain brain lesions (Pribram, 1960) in which perseverative errors in reversal problems with frontal monkeys were observed, and stereotypy has become a descriptive index of those behavioral changes induced by certain centrally acting drugs as a "continuous repetition of one or a few acts" (Randrup & Munkvad, 1974, p. 1).

Since alcohol is a centrally acting drug whose effects upon behavior are incompletely understood, the present study was undertaken to explore its effects upon response duration variability, barpressing rate variability, and the uncertainty index of Frick and Miller (1951), comparing these effects with those of brain lesions and drugs known to produce changes in variability of behavior.

EXPERIMENT 1

Method

Subjects. Twenty-four female albino rats from the Western

Washington University colony were used as subjects. The animals ranged in weight from 182 to 269 g.

Apparatus. The basic apparatus consisted of four bar-activated water-delivery operant boxes, each equipped to measure response rate and response duration.

Alcohol dosages. Alcohol was administered IP via a 23.75% (V/V) aqueous solution of 95% ethanol in an amount that was 1.5 g/kg. Isotonic saline was used for the control injections.

Procedure. All animals were adapted to a 23.5-h water-deprivation regimen and trained in CRF barpressing for water in daily 30-min sessions. After responding had stabilized, 16 of the animals were given 1.5 g/kg of alcohol 10 min prior to the daily session on alternate days for a total of 12 days. The remaining eight animals were given an equal volume of saline as controls. On the last treatment day, measures were made at 1-min intervals throughout the 30-min session of response rate and response duration (total number of responses and total time of bar depression).

Results and Discussion

Nine of the 16 experimental animals developed tolerance to the alcohol by Day 12; the remaining 7 animals did not reattain barpressing under alcohol by treatment Day 6 (D-6). The response rate under alcohol of the tolerant animals (3.33/min) was not significantly different from the controls (3.19/min), but the variance (σ^2) of the response rate in the alcohol group (5.92) differed significantly from that of the controls (15.56) by Mann-Whitney U test ($p = .001$). The variance of the response duration for the alcohol-treated animals (.05) was also less than that of the controls (.29) at the .05 confidence level, by U test. These data are summarized in Figure 1.

The results, that chronic alcohol treatments enhanced response duration stereotypy, are consistent with earlier reports (Crow, 1978; Crow, Westveer, & Kass, 1976). The present results, in addition, indicate an alcohol-induced rate stereotypy, and are, in some respects, strikingly similar to those effects on operant behavior noted after lesions of the frontal cortex in the rat (Crow & McWilliams, in press). The situations,

Figure 1. Mean response rate per minute over the course of the session for alcohol (or saline) injections given 10 min prior to the session on the 6th alcohol treatment day (D-6). Upper figure indicates mean response duration variance over the same session for the two groups.

behavioral changes as a result of brain lesions and those due to alcohol, of course, differ considerably. It is possible that the apparent stereotypy induced by alcohol is due, not to cortical depression *per se*, but to its diminishing effect over the course of the 30-min session. Experiment 2 was an attempt to control for the diminishing alcohol effect over the course of the session and address the question that the alcohol-induced stereotypy was an artifact of the time course of the alcohol effect.

EXPERIMENT 2

Method

Subjects. Eighteen female albino rats from the Western Washington University colony were used in Experiment 2. The animals ranged in weight from 138 to 212 g.

Apparatus. The water-delivery operant boxes of Experiment 1 were used.

Alcohol dosages. Alcohol dosages were the same as in Experiment 1 with the exception that injections were given at 15 or 20 min prior to the session, as opposed to the 10-min delay used in Experiment 1.

Procedure. The animals were trained as before to CRF barpressing for water 30 min/day, and treatments were carried out using 1.5 g/kg alcohol for nine of the animals and saline control injections for the remaining nine animals to D-6, at which time the same measures were made as in Experiment 1. Of those animals receiving alcohol, six were given their injections 15 min prior to the session, and the remaining three animals were given their injections at 20 min prior to the session. There were six controls for the 15-min delay and three controls for the 20-min delay groups.

After D-6 treatment measures were taken, an additional treatment day was carried out for eight of the nine experimental animals and eight of the controls. The measures taken on the additional treatment day consisted of noting the sequences of barpressing (B) and approach to the dipper (A) responses

throughout the 30-min session, in a procedure similar to that of Frick and Miller (1951). For the AB sequence measures, a 15-min injection-to-session delay was used for all animals.

Results and Discussion

For the response rate measure, there was no significant difference between the 15-min delay group's overall rate (2.62/min) and the 20-min delay group's overall rate (2.89/min), nor was there a significant difference between the 15-min delay group's rate variance (5.41) and the 20-min delay group's variance (5.34). Combining the two alcohol delay groups yielded no significant difference between the alcohol treatment overall rate (2.72) and controls (3.09), but a significant difference between the variance of rate for the combined alcohol grouping (5.38) and the controls (8.75) at the .05 confidence level.

For the response duration measure, there was no significant difference between the 15-min delay group's overall mean (.53 sec) and controls (.61 sec), but there was a significant difference between the 15-min delay group's response duration variance (.032) and controls (.147) at the .05 confidence level. There was no significant difference between the 20-min delay group's mean duration of response (.72) and controls (.60) or variance of response duration (.132 and .118, respectively).

In summary, the results of the 10-min delay conditions of Experiment 1 were replicated in terms of response rate variance for delays of both 15 and 20 min and for response duration variance for the delay period of 15 min, the response duration variance effect being absent with delays as long as 20 min. Since a displacement as great as 10 min (10-min vs. 20-min delay) does not appreciably alter the rate change reduction of alcohol, the variance changes associated with alcohol do not appear to be due to diminished levels of alcohol over the course of the session.

Supportive data for the general stereotypy interpretation (cf. Crow, 1977) of the above results was obtained in the analysis of AB sequences of behavior suggested by Frick and Miller (1951). Mean stereotypy for the alcohol group was .629 and, for the controls, .394, a difference significant by U test ($p = .001$). That is, the predictability of these behaviors was enhanced by alcohol.

A closer examination of the data reveals that, although there were no significant differences between the alcohol and control groups in $p(AA)$ or in $p(AB)$, there was a significant decrease in $p(BB)$ as a result of the alcohol ($p = .001$), and a significant increase in $p(BA)$ due to alcohol ($p = .019$). That is, alcohol diminished the tendency to barpress without going to the dipper, a behavioral sequence often noted in the sober state. Following Frick and Miller (1951), the AB sequence data were cast into a coordinate system of $p_A(A)$ vs. $p_B(B)$, where $p_A(A) = p(AA)/p(A)$. Figure 2 shows the nature of the isostereotypic contours of such

Figure 2. The resting point of operant responding frequencies of barpressing (B) and approach to dipper (A), as defined by Frick and Miller (1951) for saline and alcohol-treated animals after tolerance acquisition. Points represent the means of eight animals per group.

a plot, along with the data points for the saline and alcohol-treated groups. The alcohol displaced the resting point of these particular behaviors (Frick & Miller, 1951).

It is interesting to speculate on the displacement of this resting point that would be caused by other centrally acting drugs. Injections of d-amphetamine have been shown to induce barpressing behavior that would appear to be characterized by an enhanced $p_B(B)$ and a diminished $p_A(A)$ (Ellinwood & Kilbey, 1975). If this were the case, the resting point would be displaced to a different quadrant than that occasioned by alcohol, but it would, nonetheless, indicate an increased stereotypy as defined by Frick and Miller (1951).

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