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Alcohol effects on operant-rate frequency spectra are schedule-dependent

LOWELL T. CROW
Western Washington University, Bellingham, Washington

Albino rats were trained in a two-bar lag reinforcement schedule in which previous response sequences could not be repeated, and were then switched to a fixed-ratio two-bar schedule of reinforcement in which previous response sequences could be repeated. The effects of i.p. injections of 0.5 g/kg alcohol were noted for each schedule of reinforcement. Fourier frequency spectra of response rates were dependent upon both the alcohol treatment and the reinforcement schedule.

Previous work has shown that alcohol reduces behavioral variability for some tasks (Crow, McWilliams, & Ley, 1979; Devenport & Merriman, 1983). The tasks for which alcohol reduces behavioral variability are traditional learning situations requiring the acquisition of a particular response or response series for reinforcement, a stereotypic behavior. It has recently been shown that behavioral variability itself may be brought under stimulus control (Page & Neuringer, 1985). By the use of "lag" reinforcement schedules requiring a different sequence of two-button response sequences for reinforcement, pigeons were able to acquire a virtually random behavioral pattern. In an analogous way, rats acquire highly variable behavioral patterns in a two-lever lag-reinforcement situation (Crow, 1988). Unlike the ordinary task requiring stereotypic behavior for which alcohol appears to reduce variability, variability-contingent reinforcement schedules do not appear to be affected by alcohol in the same way (Crow, 1988; Crow & McKinley, 1989; McKinley, Quevedo-Converse, & Crow, 1989). These studies of alcohol effects on variability-contingent reinforcement found that alcohol either had no effect or increased the behavioral variability.

The present work was undertaken to compare alcohol effects on the two kinds of tasks—stereotypic and variability-contingent reinforcement schedules—by using the same animals with the same alcohol dosage in one study, and, in addition to collecting traditional response-rate data, to make use of Fourier frequency analysis in assessing changes in response-rate patterns.

METHOD

Subjects

Six male albino Sprague-Dawley rats were used. They were experimentally naive and 120 days of age at the beginning of training. Their weights ranged from 300-359 g.

Correspondence may be addressed to Lowell T. Crow, Department of Psychology, Western Washington University, Bellingham, WA 98225.

Apparatus

Three two-bar operant chambers (Gerbrands), equipped for water reinforcement, were used. Reinforcements were controlled by three Atari XL personal computers, which computed rate data and saved the data on hard copy for each experimental session. Fourier analyses were done with the Turbo Pascal Numerical Methods Toolbox.

Alcohol Doses

Ten minutes prior to the alcohol sessions, the animals were injected i.p. with a 10% aqueous solution of 95% ethanol in the amount of 0.5 g/kg.

Procedure

The animals were put on a 23.5-h water-deprivation regimen for 2 days, then were trained daily in operant boxes in 20-min sessions or for the first 250 responses, after which free access to water was given for 30 min. Three animals were shaped manually and 3 were autoshaped to press both the left and the right levers, each lever providing water reinforcement. After approximately 1 week of shaping, LAG-1, followed by LAG-2, followed by LAG-5 reinforcement schedules were imposed. In LAG-1 schedules, four responses on the two levers in a sequence that differed from the last sequence of four responses was required for reinforcement; in LAG-2 schedules, a four-response sequence that differed from the last two four-response sequences was required for reinforcement; and in LAG-5, a four-response sequence that differed from the previous five four-response sequences was required. After a stable level of LAG-5 responding had been attained (as indicated by number of reinforcements), all animals were given alcohol treatments. At this point in the study (18 days after the beginning of water deprivation), all animals were put on a fixed-ratio (FR) schedule of reinforcement in which any sequence of four responses would be reinforced (referred to as FR-4). Then, after a stable number of reinforcements had been attained on this schedule (26 days after the first alcohol treatments), all animals were again given alcohol.

RESULTS

The data consisted of left and right leverpress uncertainty scores (Frick & Miller, 1951) for each daily session and the number of responses for each 30 sec during the daily operant session. For the uncertainty scores, there were no significant alcohol effects (relative to pretreatment days) for either LAG-5 performance [$F(1,4) = 3.05$] or FR-4 performance [$F(1,5) = 0.014$]. There were also no significant differences in the uncertainty scores for the control (pretreatment day) performances under the two schedules [$F(1,4) = 3.47$].

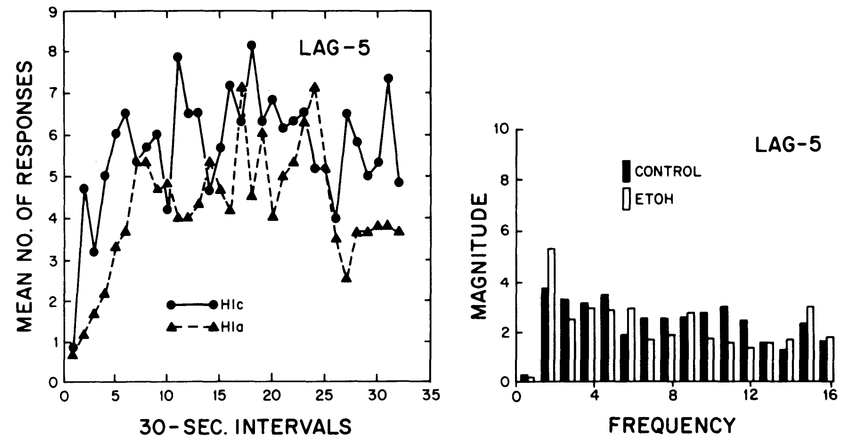

Figure 1. Lag reinforcement schedule. Left: Mean number of responses per 30 sec for the pretreatment (Hlc) and alcohol treatment (Hla) days. Right: Fourier frequency spectrum for data in the left panel.

The response-rate data were taken at 30-sec intervals throughout each experimental session, which was 20 min in duration or the first 250 responses, whichever occurred first. There was a significantly higher control response rate for the LAG-5 schedules than for the FR schedule [$F(1,31) = 28.40$] and, compared with the pretreatment days, response rates on the alcohol days were lower for each of the reinforcement schedules [LAG-5, $F(1,31) =$ 16.23; FR, $F(1,31) = 131.79$]. The mean rate data are plotted in the left panels of Figures 1 and 2.

Fast Fourier analyses were carried out for each animal's rate data on the pretreatment and alcohol treatment days for each reinforcement schedule. Since some animals arrived at the 250 response limit in less than 20 min, the data are based on the first 16 min, or 32 30-sec segments. The magnitude spectra for these data are shown in the right panels of Figures 1 and 2. It can be seen that alcohol affected each reinforcement schedule in a different way. Variance scores computed for each of the magnitudes for each animal reveal a greater variability for alcohol-treated animals in the LAG-5 schedules [$F(1,5) =$ 7.93], whereas the opposite was true for the FR data [$F(1,5) = 5.23$]. That is, alcohol increased the complexity of response-rate frequencies when given with lag reinforcement contingencies, but decreased the complexity of rate frequencies when given to animals engaged in FR reinforcement contingencies.

DISCUSSION

Although the uncertainty data revealed no alcohol effects on either reinforcement schedule with the present low alcohol dose, the frequency analysis suggests that behavioral variability in terms of response-rate changes was affected. The results from the Fourier analysis support previous work suggesting that alcohol tends to decrease the variability of response rates with traditional reinforcement schedules, but that alcohol may increase behavioral variability with variability-contingent rein-

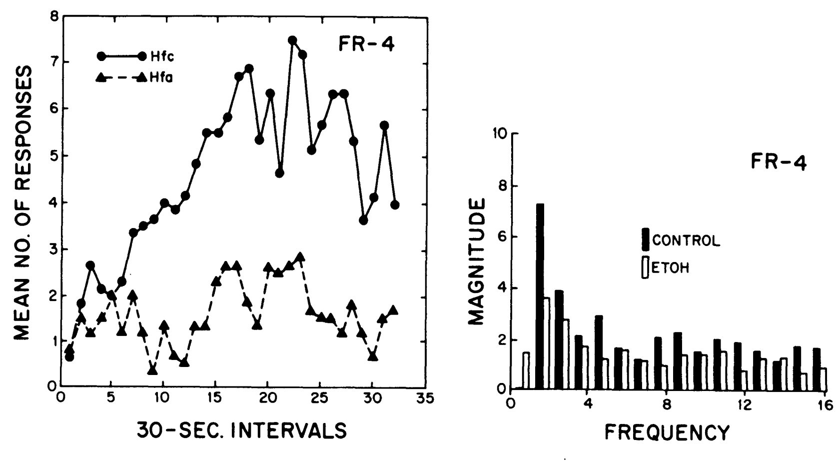

Figure 2. Fixed-ratio reinforcement schedule. Left: Mean number of responses per 30 sec for the pretreatment day (Hfc) and alcohol treatment (Hfa) days. Right: Fourier spectrum for data in the left panel.

forcement. For schedules that selectively reinforce variability of behavior, alcohol either has no effect (Crow & McKinley, 1989) or increases the response variability (Crow, 1988; McKinley et al., 1989), and for schedules that selectively reinforce a lack of response variability or stereotypy of responding, alcohol decreases variability.

The present findings imply that measures of behavioral variability based on response rates may be more sensitive to small changes than are measures based on probabalistic expectancies of specific response sequences—the uncertainty index. For the latter measure, variability is viewed as the tendency to approach random sequences, whereas for the former measure, variability is viewed as relative complexity in patterns of response-rate changes.

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