Ethanol consumption by rats on a differential probability of reinforcement schedule

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Four white rats were trained to drink 9% (v/v) ethanol by programming drinking to change the frequency of food pellet delivery from once every 2 min to once every 15 sec on the average. When water and ethanol were both available and only ethanol drinking changed the frequency of pellet delivery, the animals switched from drinking water on the preferred side to drinking ethanol on the nonpreferred side.

There are two psychological paradigms of dependence: stimulus-organism response and stimulus-response reinforcement (Keehn, 1969a). Most theories of human dependence on alcohol stem from the first of these paradigms, but it is the second that has generated procedures for controlling alcohol consumption by animals. One of these procedures involves scheduling food reinforcement at intervals for hungry rats, whereupon they normally drink after eating (Falk, 1961), thereby imbibing large quantities of fluid, including ethanol (Holman & Myers, 1968; Lester, 1961). Drinking in this case is known as schedule-induced behavior, as it is not a specified requirement of the reinforcement schedule.

A second procedure also necessitates scheduling food reinforcement for hungry animals, but in this case drinking is the specified operant for producing the reinforcer. With this procedure, too, rats ingest large amounts of normally unpalatable ethanol (Keehn, 1969b). When response-contingent reinforcers are scheduled it is usual to insist on immediate reinforcement of the specified response (Reynolds, 1968; Skinner, 1938). A recent publication by Herrnstein & Hineline (1966), however, suggests that a schedule-specified response may be conditioned when immediate reinforcement is not a programmed consequence of that response.

Herrnstein and Hineline arranged a two-level schedule of shock delivery in which a specified response temporarily changed the probability of shock from a higher to a lower level, but did not affect the delivery of shocks programmed at the lower level when it was in effect. This corresponds, in the case of positive reinforcement, to a two-level schedule of free food delivery in which a specified response is followed by a temporary change from a less to a more frequent delivery of reinforcers, but not necessarily by immediate reinforcement. The present experiment was concerned with the acquisition and maintenance of ethanol drinking by rats under such a differential probability of reinforcement (dpr) schedule. Specifically, free food pellets (standard 45-mg Noyes pellets) were delivered to hungry rats once every 2 min, on the average, unless they drank from a tube containing 9% (v/v) ethanol in distilled water. Each drink raised the probability of the next pellet from one per 2 min to one per 15 sec, and the next pellet delivery returned the probability back to the lower level.

SUBJECTS

Four 120-day-old male Holtzman Sprague-Dawley rats were used. They had previously been exposed to saccharin-sweetened alcohol in the apparatus. They were housed individually, with freely available water, and were maintained at 80% of free-feeding weights at 90 days of age. Actual weights during the experiment were between 300 and 312 g.

APPARATUS

The experimental space was a chamber .3 x .3 x .35 m with a food receptacle in the center of one wall 50 mm above floor level. There were two openings for drinking tubes 62 mm above floor level in the wall to the right of that containing the food receptacle. The first was 76 mm from the corner, the second 76 mm from the first. Delivery of reinforcers (45-mg Noyes pellets) was programmed by punched tape and each reinforcer was accompanied by a brief buzz. Drinking was monitored with a Grason-Stadler drinkometer.

The experimental chamber was housed in a lightproof sound-attenuating shell which was ventilated by fans that also provided masking noise. Electromechanical control and recording equipment was housed in an adjacent room. Ss were observed via closed-circuit TV.

PROCEDURE

The experiment was conducted in four phases. In Phase 1, baseline ethanol intakes with only ethanol available were measured during three 28-min sessions in each of which the empty pellet dispenser was operated 100 times at irregular intervals.

In Phase 2, pellet deliveries were programmed by two tapes, one of which delivered a pellet every 2 min on the average, the other of which delivered a pellet every 15 sec on the average. One drinking tube, containing ethanol, was available. In the absence of drinking, the 2-min tape was in effect, but contact with the drinking tube stopped this tape and started the 15-sec tape. Regardless of a S's behavior, the 15-sec tape ran until a food pellet was delivered, whereupon this tape stopped and the 2-min tape ran again until the next drink, and so on. This phase lasted for 11 to 15 sessions during most of which 100 pellets were delivered.

In Phase 3, ethanol was replaced by water in the single drinking tube and pellets were scheduled at the same rate as in the final session of Phase 2 regardless of

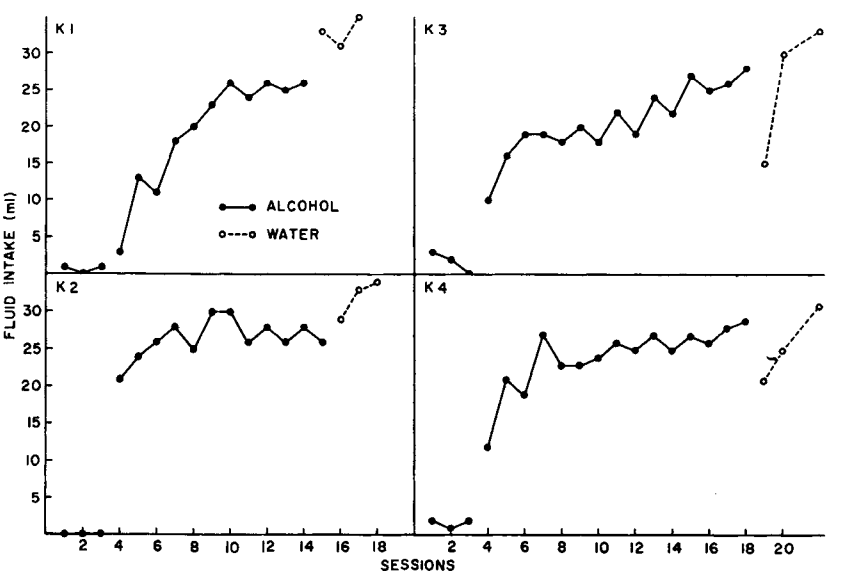

Fig. 1. Ethanol and water intakes during Phases 1, 2, and 3. See text for details.

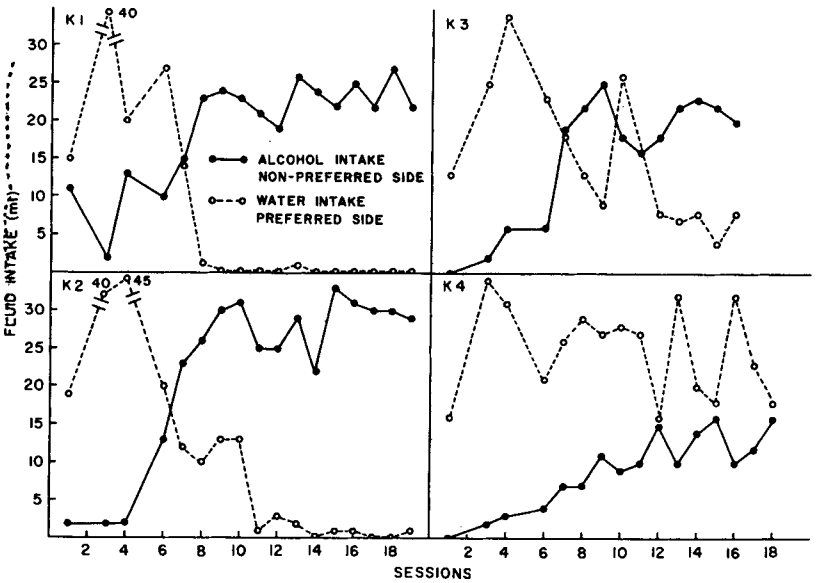

Fig. 2. Ethanol and water intakes during Phase 4. See text for details.

the animals' drinking behavior. This phase lasted for three sessions.

Phase 4 was initiated because it was not possible to tell whether ethanol consumption in Phase 2 was maintained because drinking was schedule-specified or because it was schedule-induced. In this phase, two drinking tubes were provided, one containing ethanol, the other containing water. Tube positions were varied in Sessions 1-5 (ethanol position:RLRRL), after which ethanol was always in the nonpreferred (R) position and water was always in the preferred (L) position, the position occupied by the single drinking tube in Phases 1, 2, and 3. Contacts with the ethanol tube continued to differentially affect reinforcement probability as in Phase 2; contacts with the water tube had no programmed effects. There were 16 to 19 sessions in this phase, in each of which 100 pellets were delivered.

RESULTS AND DISCUSSION

Figure 1 shows, for each S, baseline ethanol intake, ethanol intake when each drink changed the frequency of food delivery from once every 2 min to once every 15 sec, on the average, and water consumption when food was delivered at the same rate as under the dpr schedule but in the absence of a drinking-response requirement.

The dpr schedule of reinforcement generated substantial increments in ethanol intake above baseline levels, but water consumption, even without the dpr contingency, was higher still. This last result indicates the animals' preference for water over 9% ethanol but also suggests that ethanol drinking occurred as a schedule-induced phenomenon (Falk, 1961) rather than as a schedule-specified response under the control of the dpr schedule of reinforcement.

Data on this possibility appear in Fig. 2. The figure shows, for each S, the amount of water and ethanol consumed over several sessions in which both fluids were available but only ethanol-drinking increased the frequency of food-pellet delivery. During these sessions, ethanol was in the tube in the nonpreferred position, where this position was determined by the amount of fluid consumed from each tube during the first five sessions. All animals drank more from the left-hand (L) tube during these sessions regardless of whether it contained ethanol or water; the data in Fig. 2 are consumptions with water in the L tube and ethanol in the R tube. All animals increased their ethanol intakes and decreased their water intakes, three of them drinking ethanol almost entirely by the end of the experiment. These animals were consuming about 7 mg ethanol per gram of body weight in about 30 min at this time.

Observation by closed-circuit TV showed that as the position preference was overcome a typical sequence of behavior developed: eat pellet, drink water from L tube, drink ethanol from R tube, wait at pellet dispenser, and so on. For K1 and K2, water drinking eventually ceased, but for K3 and K4 the total sequence persisted to the end of the experiment. Inasmuch as schedule-induced drinking could have been entirely confined to the preferred fluid (water) from the preferred side (the L tube) consumption of ethanol was maintained, at least in part, by the effects of the dpr program of reinforcement.

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