Reinforcement of ethanol consumption in rats by an increase in the frequency of food-pellet delivery*

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An increase in the frequency of food-pellet delivery to four food-deprived rats was made contingent upon drinking either distilled water or a 9% (v/v) ethanol solution. In spite of the contingency of a minimum interval of 3 sec between drinking the reinforced liquid and pellet delivery, an increase in the frequency of pellet delivery from one per 120 sec to one per 15 sec on the average acted as a positive reinforcer for drinking that liquid associated with the greater pellet frequency.

"There are two psychological paradigms of dependence: stimulus-organism-response and stimulus-response-reinforcement ... 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 [Keehn & Coulson, 1970, p. 283]."

In an experiment by Keehn & Coulson (1970), food-deprived rats could increase the probability of pellet delivery from one per 120 sec to one per 15 sec on the average by drinking an initially nonpreferred 9% (v/v) ethanol solution. This contingency, referred to as a differential probability of reinforcement (dpr) schedule, produced a marked increase in alcohol consumption in four out of four Ss. However, in that experiment, a pellet could, and often did, immediately follow a lick on the alcohol tube, allowing for the interpretation that alcohol consumption was maintained by adventitious reinforcement. The present experiment was designed to eliminate this possibility by requiring that Ss not drink the reinforced liquid for at least 3 sec before pellet delivery.

In addition, we examined the conditions under which drinking responses established under a dpr schedule could be changed.

SUBJECTS

Four experimentally naive 90-day-old male Holtzman rats of the Sprague-Dawley strain were Ss. During the first 7 days prior to magazine training they were food deprived to 80% of their free-feeding weights and maintained at this level with corrections for normal growth. Ss were housed in individual cages with water freely available.

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APPARATUS

The experimental space (Keehn & Coulson, 1970) 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 on the side wall to the right of the food receptacle. The first was 76 mm from the corner, the second, 76 mm from the first. Delivery of standard formula 45-mg Noyes food pellets was controlled by two tape programmers, and each pellet delivery was accompanied by a brief buzz from a buzzer mounted outside the experimental space close to the food receptacle. Drinking was monitored by a solid-state capacitance-operated drinkometer.

The experimental chamber was inside a sound-attenuating outer shell which was ventilated by fans which also provided masking noise. Electromechanical control and recording equipment was housed in an adjacent room. Ss were monitored via a closed-circuit television system.

PROCEDURE

During the first two sessions, Ss were magazine trained, with neither alcohol nor water available. For the first 10 min of the first session, which lasted 70 min, four pellets were in the foodcup, and no additional pellets were delivered. Thereafter, pellets were delivered every 30 sec on the average. During the second session, which lasted 120 min, pellets were delivered every 120 sec on the average. At the end of the two magazine training sessions, each S ate the food pellets as they were delivered. During the third session, two bottles, one containing distilled water and one with a 9% (v/v) solution of ethanol in distilled water, were placed on the side of the chamber. Bottle position was randomized from day to day, with the restriction that a bottle could not be on one side any more than 3 days in a row. Consecutive sessions were run on

consecutive days; each session after magazine training lasted for 1 h or until 100 pellets had been delivered, whichever came first.

Licking one of the two bottles was defined as the operant that changed pellet densities. A lick on the reinforced bottle started a tape programmer, which ran for 12 sec on the average, sensed a hole in the tape, and stopped and started a 3-sec timer. Licks when the 12-sec tape programmer was running had no effect. Licks on the reinforced bottle when the 3-sec timer was running reset the timer. When the 3-sec timer timed out, a pellet was delivered. This schedule is called tandem (tand) variable interval of delay (VID) 12 sec; differential reinforcement for other behavior (DRO) 3 sec. If neither the VID 12-sec nor the DRO 3-sec timer were running, another tape programmer delivered pellets every 120 sec on the average. This is called the free variable interval (FVI) 120-sec schedule. This pair of schedules was in effect during all sessions after magazine training.

During the first phase of the experiment for P-1 and P-2, licking the alcohol tube produced an increase in pellet frequency. For P-3 and P-4, licking the water tube had the same effect. During the second phase, the reinforced liquid was switched to water for P-1 and P-2 and to alcohol for P-3 and P-4. Since P-1 drank little water during the second phase, only water was present during the third phase, and water drinking was reinforced for 14 sessions. During the fourth phase, both water and alcohol were present, and water drinking was reinforced.

RESULTS

Session duration varied from 29 to 60 min, depending on how much of the reinforced liquid was consumed. Table 1 shows the mean session length for the last five sessions in each phase for individual Ss.

Licks during the DRO component were frequent, ranging from 10 to 46/min, except for P-1 during Phase 2, when the reinforced liquid was not consumed. In general, licks during the DRO component were directly proportional to the amount of the reinforced liquid consumed.

Table 1
Mean Session Lengths in Minutes for Individual Ss for the Last Five Sessions of Each Phase

Phase	SP1	SP2	SP3	SP4
1	33	60	50	40
2	60	48	60	37
3	35			
4	37

Fig. 1. Rates of liquid consumption for each S averaged over two sessions. The triangles and circles represent alcohol and water, respectively. Filled symbols are for the reinforced liquid, and open symbols are for the nonreinforced liquid.

Figure 1 shows the average fluid intake in milliliters per minute, averaged over two sessions for individual Ss as a function of session number and contingency.

The development of a strong preference for alcohol under the dpr schedule employed in this experiment is seen most clearly in the drinking pattern for P-1. During Phase 2, when the reinforced liquid was changed from alcohol to water, P-1 continued to drink alcohol almost exclusively. When only water was available as the reinforced liquid for 14 sessions, the amount of water consumed by P-1 increased and was maintained upon the subsequent reintroduction of the alcohol bottle.

The consummatory behavior of P-2 was under control of the dpr schedule; water drinking increased and alcohol drinking decreased when the reinforced liquid was switched from alcohol to water. P-3 and P-4 both exhibited a strong preference for water, even in the absence of reinforcement for water drinking. However, they both increased their alcohol consumption when alcohol drinking was reinforced.

Schedule control in the White-Necked Raven, *Corvus cryptoleucus**

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Five White-Necked ravens were run to behavioral stability on each of three moderate schedules of positive reinforcement: FR 50, FI 4 min, and RI 2.5 min. The sequence of schedule exposure for any one raven was different from that for any other raven. Temporal variations in rates emitted by the raven under these schedules were characteristic of those emitted by other species more typically used in operant conditioning studies.

Behavior theorists generally assume that the major effects of positive

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DISCUSSION
The main point of the present experiment is that alcohol consumption was increased by reinforcing it with an increase in the frequency of pellet delivery under the dpr contingency, even when a pellet could not follow alcohol drinking by less than 3 sec. These results decrease the probability that the increased alcohol consumption observed by Keehn & Coulson (1970) was due to adventitious reinforcement.

The observation that three of the four Ss drank more water than alcohol, even when alcohol was the reinforced liquid, suggests a preference for water; a similar preference for water was noted by Keehn and Coulson. In spite of this preference, the drinking pattern of the aberrant S, P-1, indicates that, in some cases, it might be necessary to take special steps, such as reinforcing water drinking in the absence of alcohol, in order to reverse a preference for alcohol induced by a dpr schedule of reinforcement.

REFERENCE
KEEHN, J. D., & COULSON, G. E. Ethanol consumption by rats on a differential probability of reinforcement schedule. *Psychonomic Science*, 1970, 19, 283-284.

reinforcement schedules are species independent. Indeed, a number of studies (e.g., Skinner, 1961) have shown that species membership is perhaps one of the least important determinants of schedule performance. However, it is standard practice to test this assumption when one first applies operant conditioning methods to a new species.

Since ancient times (cf. I Kings 17:6), man has considered members of