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BRIEF COMMUNICATION

Ethanol as a Positive Reinforcer via the Oral Route for Rhesus Monkeys: Maintenance of Fixed-Ratio Responding[1,2]

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HENNINGFIELD, J. E. AND R. A. MEISCH. *Ethanol as a positive reinforcer via the oral route for rhesus monkeys: maintenance of fixed-ratio responding.* PHARMAC. BIOCHEM. BEHAV. 4(4) 473–475, 1976. – Two rhesus monkeys were required to emit 1 to 16 responses (FR 1, 2, 4, 8, and 16) per 0.5 ml delivery of either 8% (w/v) ethanol or water. Ethanol had been established as an effective reinforcer via the oral route in an earlier experiment [4]. At FR 16, responding maintained by ethanol clearly exceeded responding maintained by water for both monkeys. The volume of ethanol intake per session remained nearly constant from FR 1 to FR 16, however, the volume of water consumed per session decreased when FR 16 was required.

Ethanol Ethanol reinforcement Fixed-ratio schedule

ETHANOL can serve as a positive reinforcer when self-administered via the oral route by rats [5,6] and by rhesus monkeys [4]. Meisch and coworkers [4] reported data from 2 rhesus monkeys in which schedule-induced polydipsia was used to establish ethanol as a reinforcer. Schedule-induced polydipsia is a phenomenon originally described by Falk [2] in which excessive liquid drinking is produced by a schedule of intermittent food presentation. In the Meisch *et al.* [4] study, after schedule-induced ethanol drinking had occurred, the polydipsia was eliminated by discontinuing the intermittent schedule of food presentation. Subsequently, the monkeys consistently drank ethanol in volumes exceeding water control levels, and they drank intoxicating amounts of ethanol (3 g/kg/hr). Over a period of several months, the volume of water consumed by one monkey, M-S, drifted upwards into the range of ethanol values. However, the temporal pattern of water drinking remained distinct from ethanol drinking: Most ethanol drinking occurred near the beginning of the session, whereas water drinking was more evenly distributed over the session. Since total water consumption frequently exceeded total ethanol consumption, a means of clearly establishing the reinforcing efficacy of ethanol, apart from its nonspecific liquid properties, was needed.

In the present study, the response requirement to obtain water or 8% (w/v) ethanol was increased to 16 responses per reinforcement. Reinforcement consisted of the delivery of approximately 0.5 ml of liquid. Under these conditions, 8% (w/v) ethanol maintained responding at rates far in excess of those maintained by water.

METHOD

Animals

Two adult male rhesus monkeys (*Macaca mulatta*) served as subjects. The monkeys were the same as those used in an earlier study in which schedule-induced polydipsia was employed to establish ethanol as a positive reinforcer [4]. At 80% of his free feeding weight, monkey M-P weighed 5.4 kg, and monkey M-S weighed 6.2 kg. The monkeys were individually housed in stainless steel primate cubicals (Labco, No. ME 1305) in a constantly lighted room at 25.5° C.

Apparatus

The primate cubicals served as experimental chambers. All liquid was available via a Plexiglas drinking spout which required 1 cm of the spout to be inside of a monkey's mouth for lip contact to operate a drinkometer circuit. The lip contact response was always paired with the illumination of a clear lensed 4.7 W stimulus light, which was

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mounted 5.5 cm above the drinking spout. A liquid reinforcement consisted of the operation of a solenoid liquid value, and each operation resulted in the delivery of approximately 0.5 ml of liquid. Water availability was signaled by the steady illumination of a green lensed stimulus light which was mounted 9.25 cm above the drinking spout. Ethanol availability was signaled by the flickering illumination (10 times per sec) of the same stimulus light.

Procedure

During daily 3 hr sessions either water or 8% (w/v) ethanol was available. The 8% solution was prepared at least 20 hr prior to use by adding 53.0 ml of 95% ethanol to a volumetric flask with sufficient tap water to make a total volume of 500 ml. Sessions were preceded and followed by 1 hr of stimulus blackout so that data could be recorded and solutions changed. Water was continuously available during the 19 hr intersession period via the drinking spout and the daily ration of food was available 1 hr following each session.

At a fixed-ration value of 1 (FR 1), 5 consecutive sessions in which responding showed no trend were obtained with 8% (w/v) ethanol. Next, 10 consecutive sessions were obtained with water. Finally, 5 consecutive sessions were again obtained with 8% (w/v) ethanol, and then the ratio manipulations for ethanol were begun. Five sessions were run at each of an increasing series of ratio values: 1, 2, 4, 8, and 16. A response consisted of lip contact with the liquid spout such that the drinkometer circuit was activated and the correlated clear lensed stimulus light was illuminated for the duration of lip contact. At FR 16, 5 stabilized sessions for 8% (w/v) ethanol, then 10 consecutive sessions for water, and finally, 5 consecutive sessions for 8% (w/v) ethanol were obtained.

RESULTS

Figure 1 shows that at FR 16, 8% (w/v) ethanol maintained substantially more responding by both monkeys than did water. At FR 1, monkey M-S increased his total response rate when water was available; accompanying this rate increase was an increase in the variability of responding. In contrast, at FR 1, monkey M-P decreased his total response rate when water was present. For monkey M-S, the number of ethanol reinforcements obtained was not significantly affected by the FR contingency, while for monkey M-P, more ethanol reinforcements were obtained at FR 16 than at FR 1.

Cumulative records for monkey M-S (Fig. 2) show that patterns and rates of responding maintained by ethanol and water were similar under the FR 1 contingency. However, when 16 responses per reinforcement (FR 16) were required, ethanol-maintained responding was clearly distinguished from water-maintained responding: Ethanol responding occurred at a greater rate and was characterized by a high rate of responding at the beginning of the session. For monkey M-P, cumulative records were similar except that responding seldom occurred when water was present. This temporal distribution of responses is similar to the fixed-ratio responding of rats reinforced by presentations of 8% ethanol [6], and it is distinct from the more irregularly-spaced pattern observed when water is present. The cumulative records also reveal that the fixed-ratio responding, when it occurred, is similar in pattern to that maintained by

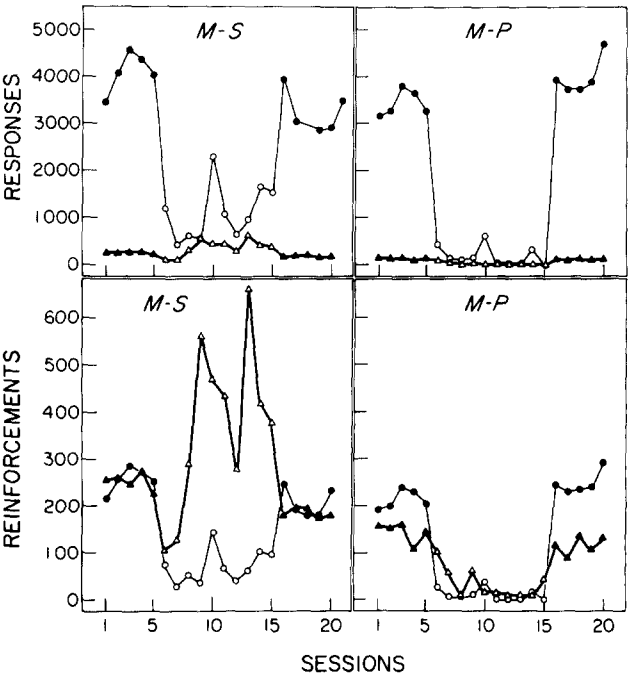

FIG. 1. Responses and reinforcements per 3 hr session. Triangles: FR 1; circles: FR 16. Filled circles and triangles represent 8% (w/v) ethanol sessions, and unfilled circles and triangles represent water sessions. Note that at FR 16 both monkeys responded more when 8% ethanol was present than when water was present, whereas at FR 1, monkey M-S emitted more water than ethanol-reinforced responses.

food reinforcement in pigeons [3] or by 8% (w/v) ethanol reinforcement in rats [6].

Monkey M-P usually obtained more than 0.50 g/kg/hr of ethanol (mean for 3 hr session) and more than 0.90 g/kg/hr during the first hr of the session. Monkey M-S also obtained more than 0.50 mg/kg/hr over the 3 hr session and more than 0.85 g/kg/hr during the first hr.

DISCUSSION

Under a FR 16 schedule, 8% ethanol maintained responding at higher rates than did water. These data confirm that 8% ethanol was functioning as a positive reinforcer and also demonstrate that response-contingent presentation of 8% ethanol will maintain intermittently reinforced responding by rhesus monkeys. When ethanol-reinforced fixed-ratio responding occurred, it was similar in pattern to that maintained by more commonly studied reinforcers, such as food. Differences in 2 dependent variables distinguished ethanol-reinforced responding from water-reinforced responding: First, the regular temporal pattern of responses that occurred at all FR values with 8% ethanol was in marked contrast to the irregularly spaced responses obtained with water, and second, the response rates at FR 16 maintained by ethanol exceeded the rates maintained by water. Although monkey M-S drank more water than ethanol when each response was reinforced (FR 1), 8% ethanol was clearly shown to be a positive reinforcer by the introduction of the FR 16 response requirement.

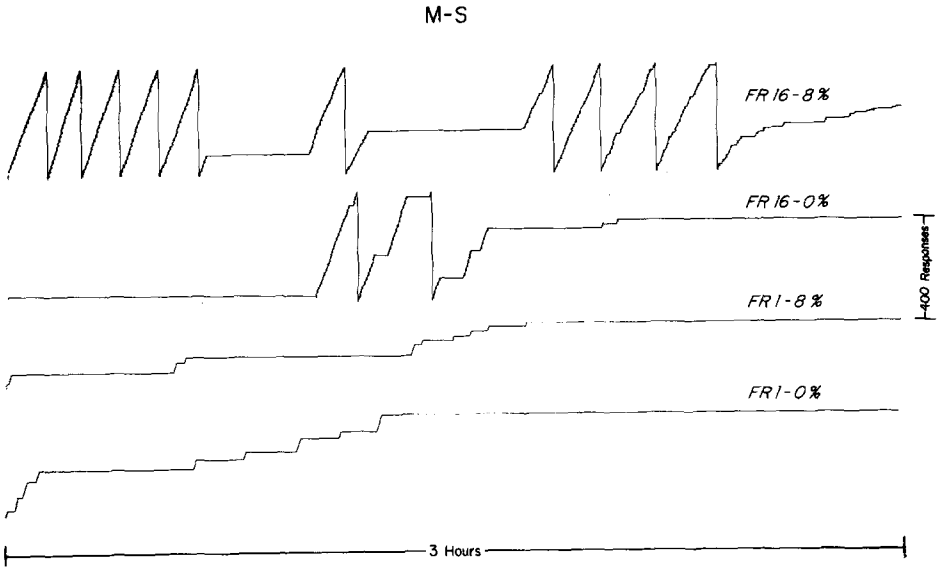

FIG. 2. Cumulative records of monkey M-S were chosen as most representative on the basis of being closest to the mean session data. Responses are cumulated on the ordinate, and time is indicated on the abscissa. The hatch marks at FR 16 indicate liquid reinforcements. The principal effect of the FR 16 contingency was to decrease the number of water reinforcers obtained.

These data extend the generality of findings obtained with rats (e.g., [1,6]) and with intravenously catheterized rhesus monkeys (e.g., [7]): Under certain conditions, ethanol can serve as a positive reinforcer and can maintain intermittently reinforced responding.

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