Pharmacology Biochemistry & Behavior, Vol. 7, pp. 393–399.

Attenuation of Ethanol Intake by Contingent Punishment of Food-Maintained Responding

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(Received 29 August 1977)

POLING, A. AND T. THOMPSON. *Attenuation of ethanol intake by contingent punishment of food-maintained responding.* PHARMAC. BIOCHEM. BEHAV. 7(4) 393–399, 1977. — Two food-deprived rats responded under a concurrent fixed-ratio 12 (food) fixed-ratio 1 (8% ethanol) reinforcement schedule in which a tone occurred during every second or every fourth interpellet interval. When ethanol-maintained lever presses during the presence of the tone shifted the food schedule to one in which electric shock punishment occurred, ethanol-maintained responding consistently decreased. The decrease in the frequency of ethanol-maintained responding varied directly with shock voltage from 25 to 100 V, and occurred during intervals with the tone present and absent. These results indicate that ethanol intake may be attenuated by contingent changes in a concurrent food schedule.

Ethanol Food Electric shock Lever press Punishment Concurrent schedule

BEHAVIORAL pharmacologists have long been interested in establishing consistent oral ethanol self-administration by non-human subjects [11]. In recent years, a number of techniques for engendering appreciable ethanol intake have been reported [7,11]. For example, food-deprived rats which intermittently receive dry food pellets regularly drink sufficient ethanol to show behavioral signs of intoxication [5, 6, 9, 11]. When food presentation within experimental sessions is stopped, these animals continue to drink more ethanol than tap water, demonstrating that the drug is serving as a reinforcer [7, 10, 12]. A decade ago, it was not clear whether ethanol could be established as a reinforcer for non-human species [11].

Perhaps due to the difficulties which met early attempts to establish orally-administered ethanol as a reinforcer, there have been few attempts to decrease the ethanol self-administration of non-human species with behavioral procedures. This stands in marked contrast to the multitude of studies which have attempted to attenuate the ethanol intake of non-humans with pharmacological interventions (e.g., [16]), and to reduce human ethanol consumption via behavioral manipulations (e.g., [4]).

Two studies [12,13] which used behavioral manipulations to attenuate the ethanol intake of rats demonstrated consistent reductions in ethanol-maintained lever pressing and ethanol intake when each ethanol-maintained lever press delayed concurrent food availability. The degree of reduction varied inversely with ethanol concentration and directly with delay length and did not result from changes in interpellet time alone. These data indicate that ethanol intake may be attenuated by contingent changes in a concurrent food schedule. The present study further examined the effects of altering a concurrent food schedule contingent on ethanol-maintained responding by determining the effects of punishing food-maintained lever pressing contingent on ethanol-maintained responding.

METHOD

Animals

Two male Sprague-Dawley rats, about 150 days old at the onset of experimentation, were individually housed in a constantly-lighted room with an ambient temperature of 24°C. Animals were maintained at 80% of free-feeding body weights, which were: R–7, 302 g; R–8, 300 g. Water was constantly available in home cages, except as noted below.

Apparatus

Each of two sound-attenuated Gerbrands operant conditioning chambers was equipped with two levers, a pellet dispenser, and a liquid dipper. A 7 W white magazine light and a 25 W white house light supplied constant illumination. A 7 W red light was located immediately above each lever. An exhaust fan provided ventilation and masking noise. Noyes food pellets (45 mg) were presented following designated presses of the left lever. The dipper (0.25 ml volume) was presented for four seconds contingent on designated presses of the right lever. A force of approxi-

[1]Currently at the University of South Carolina. This research was partially supported by grants AA 00299–06, DA 00884–03 and MH–08565. The assistance of Teresa Poling in preparing the manuscript is gratefully acknowledged.

mately 0.27 N was required to operate the levers. The chamber floor consisted of 0.2 cm diameter metal grids spaced 0.9 cm apart. Electric shock of specified intensity and duration could be delivered to the grids via an a.c. shock scrambler. Electromechanical programming and recording equipment was located in an adjacent room.

Ethanol solutions (v/v) were preparing using 95% ethanol in tap water. Solutions were prepared less than 48 hr before use and stored in sealed flasks at room temperature.

Procedure

Each animal was trained to press the left lever, with each press followed by presentation of a food pellet. Over a number of sessions, the food schedule was raised from fixed-ratio 1 (FR 1) to FR 12. Under the FR 12 schedule, every twelfth response produced food. Over the same period, animals were initially water deprived for 24 hr and trained to press the right lever, with each press followed by presentation of the dipper (FR 1), filled with tap water. Water deprivation was gradually reduced across sessions and finally abolished as consistent drinking developed. At that time, 4% (v/v) ethanol solution was substituted for tap water for three sessions, after which 8% (v/v) ethanol solution replaced the 4% solution. Daily sessions terminated after 100 food pellet presentations.

After five sessions of exposure to the concurrent FR 12 (food) FR 1 (8% ethanol) schedule, a tone was presented during every second interpellet interval. No changes in programmed contingencies were associated with the tone at this time. This procedure remained in effect until the rate of food-maintained lever pressing showed no obvious upward or downward trend across five consecutive sessions.

At that time, a procedure was instituted in which any ethanol-maintained lever press during the presence of the tone shifted the FR 12 food schedule to one in which each food-maintained lever press was followed by a brief (200 msec), 25 V electrical shock delivered to the chamber floor. This punishment contingency remained in effect until a food pellet was earned, at which time both tone and punishment terminated. During the time that punishment was programmed, a light located above the left lever was illuminated. This procedure remained in effect until the number of interpellet intervals with the tone present in which at least one ethanol-maintained lever press occurred showed no obvious upward or downward trend over five consecutive sessions. At that time, shock intensity was raised to 50 V. Animals were run at this intensity until the above criterion was met, at which time shock intensity was

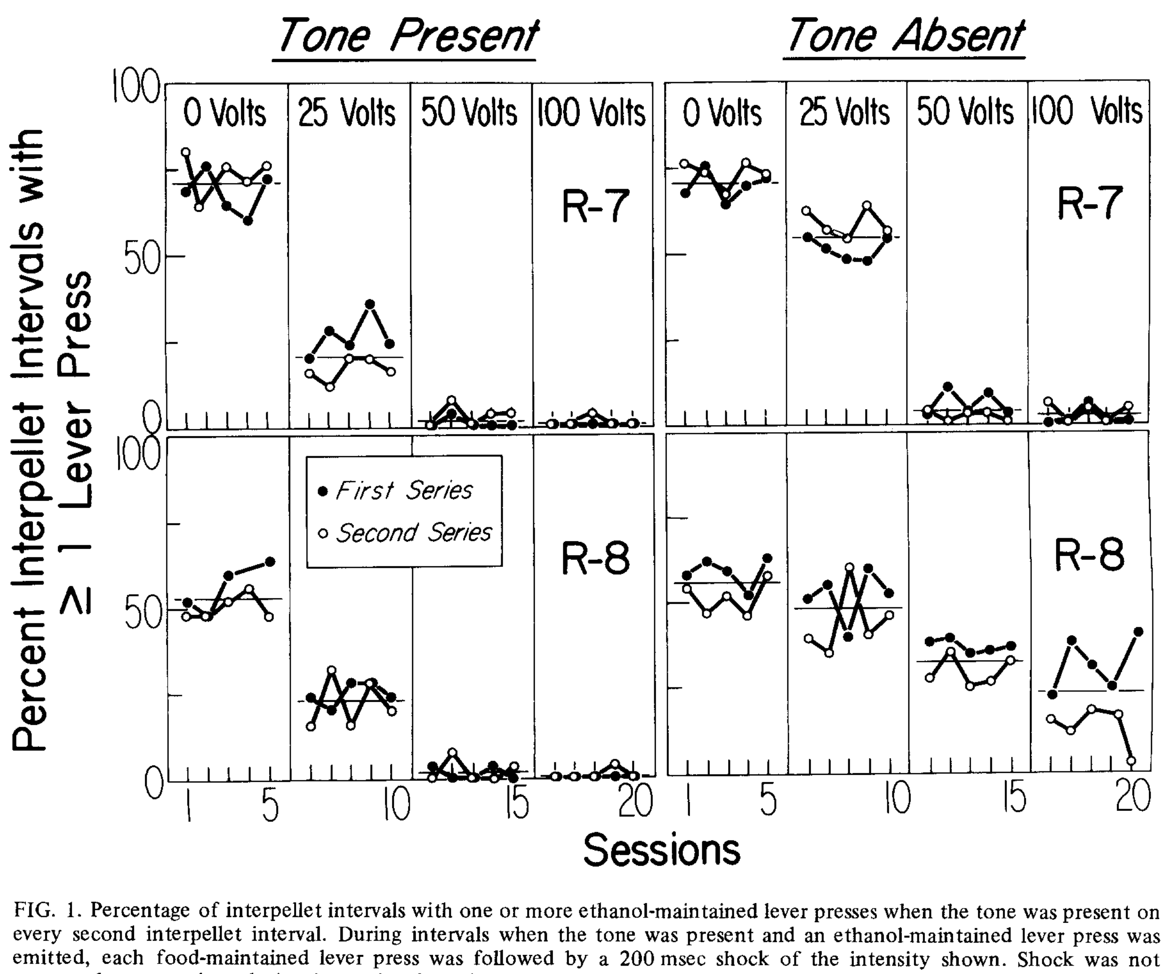

FIG. 1. Percentage of interpellet intervals with one or more ethanol-maintained lever presses when the tone was present on every second interpellet interval. During intervals when the tone was present and an ethanol-maintained lever press was emitted, each food-maintained lever press was followed by a 200 msec shock of the intensity shown. Shock was not presented at any time during intervals when the tone was not present. During the first series, shock intensities were presented in ascending order, while a descending order was employed in the second series. The horizontal lines through the data points represent the mean of both series.

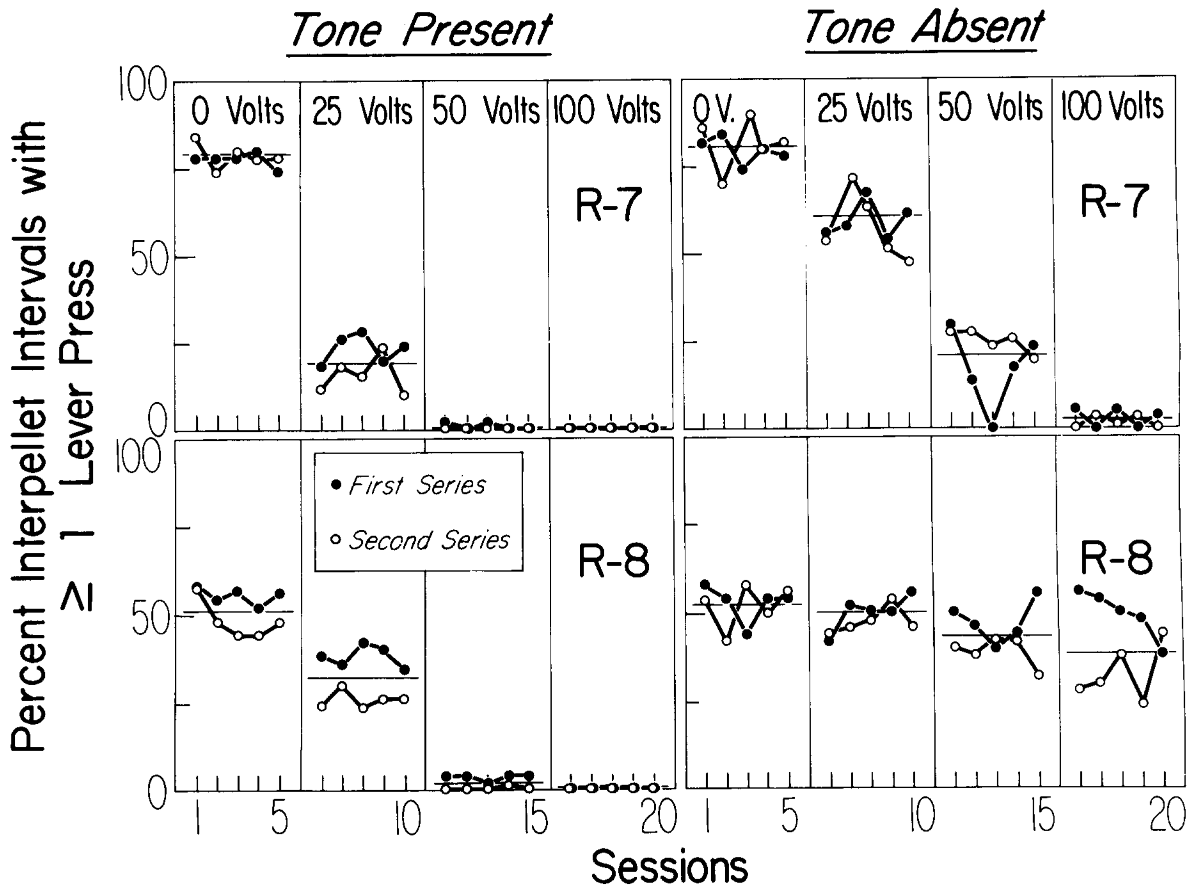

FIG. 2. Percentage of interpellet intervals with one or more ethanol-maintained lever presses when the tone was present on every fourth interpellet interval. During intervals when the tone was present and an ethanol-maintained lever press was emitted, each food-maintained lever press was followed by a 200 msec shock of the intensity shown. Shock was not presented at any time during intervals when the tone was not present. During the first series, shock intensities were presented in ascending order, while a descending order was employed in the second series. The horizontal lines through the data points represent the mean of both series.

raised to 100 V and the animals were again run to criterion. This concluded the first (ascending) series of shock intensities. A second (descending) series, like the ascending series in all respects except for a reversed ordering of shock intensities, was then instituted.

Following the final session of the ascending series, a series of manipulations similar to that described above was performed with the tone (and potential punishment) present on every fourth interpellet interval.

During each session, number of ethanol-maintained lever presses during each interpellet interval was recorded, as were rate of food-maintained lever pressing and milliliters of solution consumed. Consumption was corrected for evaporation as described by Meisch and Beardsley [8]. Only data collected during the final five sessions of each experimental condition are reported below.

RESULTS

During initial sessions when punishment was not programmed, both animals emitted at least one ethanol-maintained lever press during over half of the interpellet intervals with the tone present and absent. When shock was programmed, the percentage of interpellet intervals with at least one ethanol-maintained lever press decreased progressively as shock voltage increased (Fig. 1). This decrease was evident during both the presence and absence of the tone, although ethanol-maintained responding decreased more during interpellet intervals with the tone present than during intervals with the tone absent. The percentage of interpellet intervals with at least one ethanol-maintained lever press was similar for the first (ascending) and second (descending) series of shock intensities. When the tone was present on every fourth interpellet interval (Fig. 2), the relation between shock intensity and the percentage of interpellet intervals with at least one ethanol-maintained lever press was similar to that described above. Examination of cumulative records indicated that throughout the study ethanol-maintained lever presses typically occurred immediately after a food pellet was received, just before food-maintained responding was initiated. During all conditions, more than one ethanol-maintained lever press rarely occurred during any interpellet interval.

Like ethanol-maintained responding, mean volume of solution and mean milligrams ethanol (per 100 g body weight) consumed per session decreased progressively with increasing shock intensity, both when the tone was present during every second (Fig. 3) and every fourth (Fig. 4) interpellet interval.

Food-maintained responding occurred at a high rate

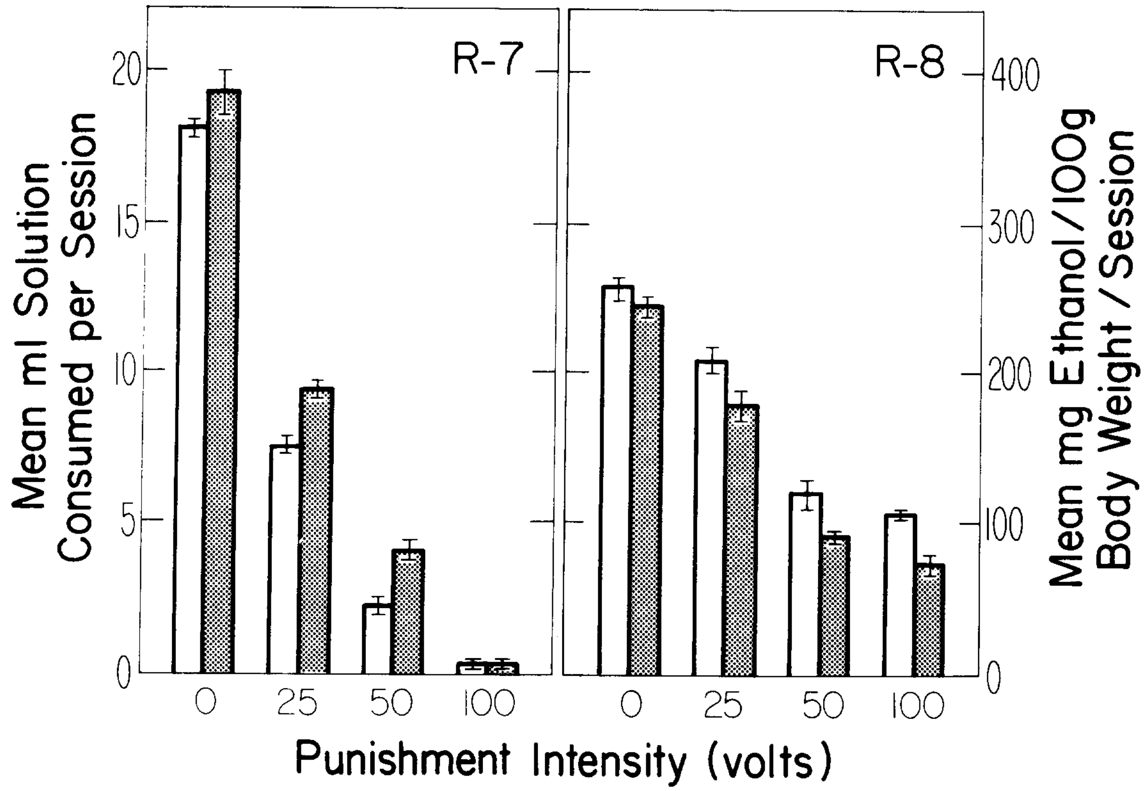

FIG. 3. Mean volume of solution and milligrams ethanol (per 100 g body weight) consumed per session under all conditions when the tone was present on every second interpellet interval. Conditions are labelled according to the intensity of shock which followed each food-maintained lever press during interpellet intervals when the tone was present and an ethanol-maintained lever press occurred. The first bar under each condition represents consumption during the first (ascending) series of shock intensities, the second bar represents consumption during the second (descending) series of shock intensities. The area within brackets represents ± 1 standard error.

when punishment was not programmed and the tone was present during every second (Fig. 5) or every fourth (Fig.. 6) interpellet interval. Rates of food-maintained lever pressing during all interpellet intervals in which ethanol-maintained responding occurred were slightly lower than rates when no such responding occurred, while rates during interpellet intervals when shock was delivered were appreciably lower than rates during other interpellet intervals. The relative decrease in the rate of food-maintained responding associated with shock delivery varied directly with shock voltage.

DISCUSSION

The present results parallel previous findings [5, 6, 9, 10, 12, 13], demonstrating that rats which intermittently receive food pellets may consume appreciable quantities of ethanol. These data also indicate that ethanol-maintained responding and ethanol consumption can be decreased by punishing food-maintained responding contingent on ethanol-maintained lever pressing. Although the effects of such a procedure have not been reported previously, earlier studies have indicated that drug-maintained behavior can be attenuated by manipulation of its consequences: Conventional punishment procedures suppress behavior maintained by codeine, morphine, and amphetamine [15,18], and ethanol-maintained responding can be reliably decreased by contingent postponement of food availability [12,13].

Contingent interactions within concurrent reinforcement schedules have been given little experimental attention (for a review of research on concurrent schedules see [3]). However, recent findings suggest that altering a food schedule contingent on ethanol-maintained responding may attenuate such responding when the alteration consists of the addition of shock punishment, as in the present study, or the postponement of food availability, as in earlier studies [12,13]. In the present study, the magnitude of the decrease in ethanol-maintained responding was directly related to the voltage of the shock punishment added to the food schedule. Such a direct relation between shock voltage and response suppression generally occurs when a single operant response is punished [1,2], and was evident when food-maintained responding was punished in the present study.

Since rates of food-maintained responding invariably decreased during intervals when shock was programmed, the procedure used in the present study functionally delayed food availability when ethanol-maintained responding occurred during interpellet intervals with the tone present. Whether such delays in food presentation are required to attenuate ethanol-maintained responding is not clear: Previous research [12,13] has indicated that such

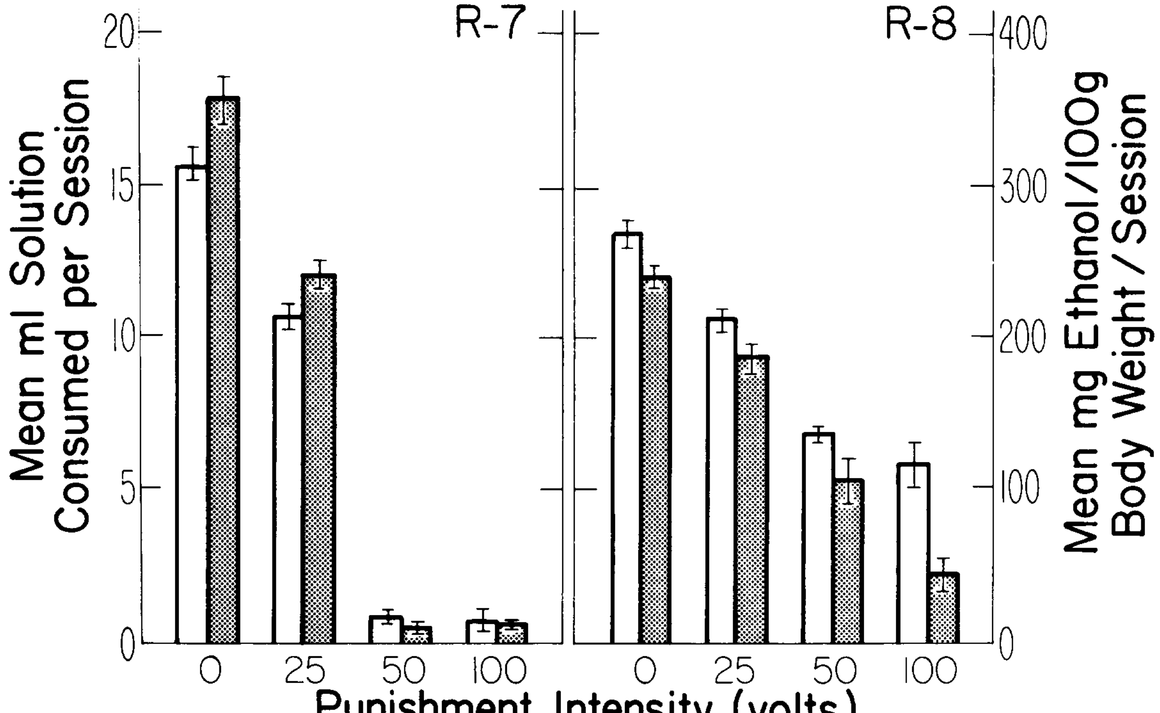

FIG. 4. Mean volume of solution and milligrams ethanol (per 100 g body weight) consumed per session under all conditions when the tone was present on every fourth interpellet interval. Conditions are labelled according to the intensity of shock which followed each food-maintained lever press during interpellet intervals when the tone was present and an ethanol-maintained lever press occurred. The first bar under each condition represents consumption during the first (ascending) series of shock intensities, the second bar represents consumption during the second (descending) series of shock intensities. The area within brackets represents ± 1 standard error.

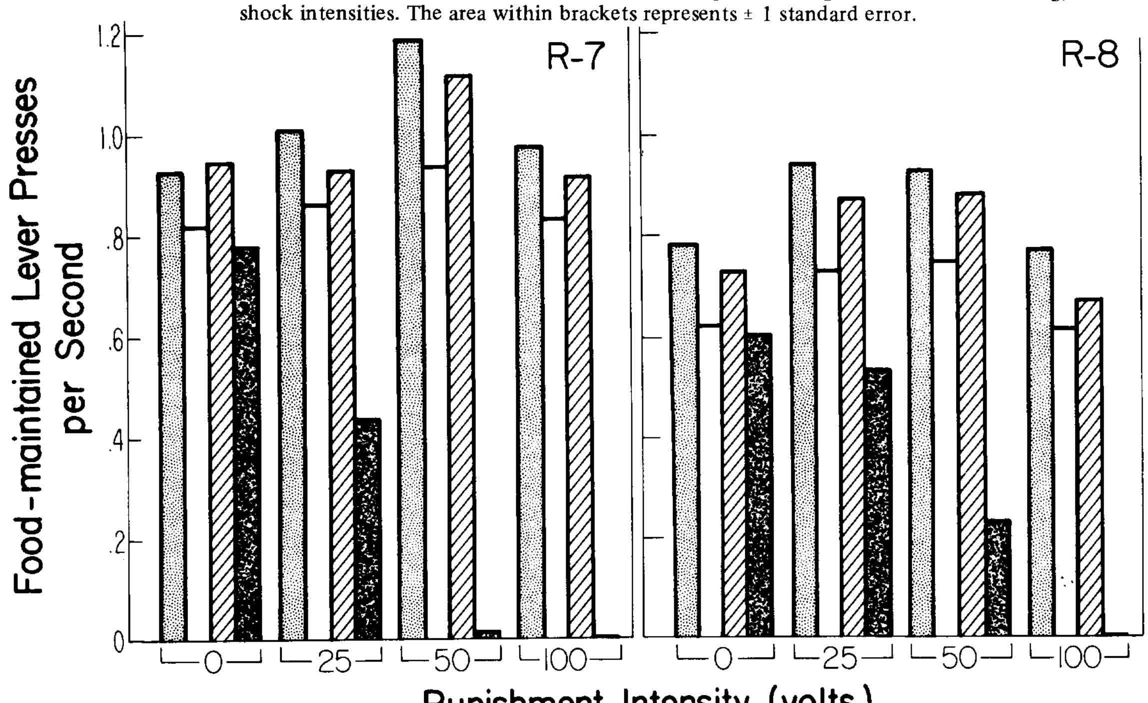

FIG. 5. Rates of food-maintained lever pressing under all experimental conditions when the tone was present on every second interpellet interval. Conditions are labelled as in Fig. 3. The first bar under each condition represents response rate during interpellet intervals when the tone was not present and ethanol-maintained lever pressing did not occur. The second bar represents intervals with the tone absent and one or more ethanol-maintained lever presses. The third bar represents tone present, no ethanol-maintained lever presses, while the fourth bar represents intervals with the tone present and ethanol-maintained lever pressing (i.e., interpellet intervals when shock of the listed intensity followed each food-maintained lever press). Rates are calculated across the first (ascending) and second (descending) series of shock intensities.

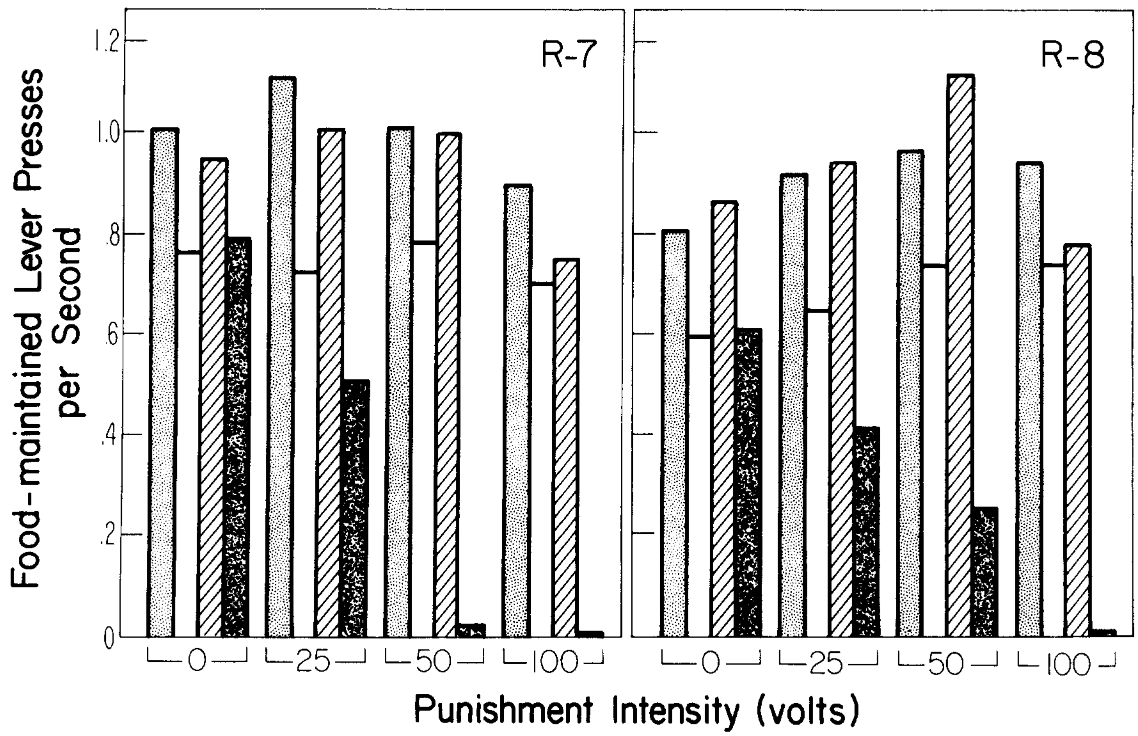

FIG. 6. Rates of food-maintained lever pressing under all experimental conditions when the tone was present on every fourth interpellet interval. Conditions are labelled as in Fig. 3. The first bar under each condition represents response rate during interpellet intervals when the tone was not present and ethanol-maintained lever pressing did not occur The second bar represents intervals with the tone absent and one or more ethanol-maintained lever presses. The third bar represents tone present, no ethanol-maintained lever presses, while the fourth bar represents intervals with the tone present and ethanol-maintained lever pressing (i.e., interpellet intervals when shock of the listed intensity followed each food-maintained lever press). Rates are calculated across the first (ascending) and second (descending) series of shock intensities.

delays alone may be sufficient to attenuate ethanol-maintained responding, but their necessity remains to be empirically evaluated.

Although food-maintained lever pressing in the present study was punished contingent on ethanol-maintained lever pressing only during particular interpellet intervals, which were signalled by a tone, ethanol-maintained lever pressing decreased relative to initial sessions during intervals with the tone present and absent. The magnitude of this decrease varied directly with shock intensity during intervals with the tone present and absent, although the decrease at a given shock intensity was typically greater during interpellet intervals with the tone present. Ethanol consumption also decreased directly with shock intensity. These data suggest that the suppressive effects of adding a punishment contingency to the food schedule during intervals with the tone present generalized to intervals when the tone was not present. Having repeatedly presented the tone without consequence during baseline sessions may have contributed to this generalization, although this possibility was not tested.

Whether the present data relate in any meaningful way to human drug abuse problems is doubtful. Non-human models of ethanol intake have been justly criticized as ignoring the multiple causation and complex conditioning factors probably involved in human drug abuse [14,17], and model procedures for attenuating ethanol intake are subject to these same criticisms. Further, even if these criticisms are countered, ethical and practical considerations would surely limit the practical therapeutic value of a procedure directly analogous to that used in the present study, although not necessarily that of other, similar procedures based on concurrent schedule interactions.

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