SUPPRESSION OF ETHANOL-REINFORCED LEVER PRESSING BY DELAYING FOOD AVAILABILITY

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When food was initially available to rats under a fixed-interval 26-second schedule and each liquid-reinforced lever press delayed food availability 8 seconds, suppression of liquid-reinforced lever pressing and liquid consumption occurred when the liquid presented was 4, 8, 16, 32, and 0% ethanol. Suppression did not occur in yoked-control animals, which received food coincidentally with experimental animals but were not directly exposed to the delay dependency. After exposure to the food schedule, each ethanol solution served as a reinforcer in the absence of food presentation. Delaying food availability for increasingly long periods (8 to 2048 seconds) suppressed ethanol-reinforced lever pressing and consumption relative to baseline levels, with the maximum decrease being below the level maintained in the absence of food. However, degree of suppression did not increase monotonically with delay length. Liquid-reinforced performance of yoked-control animals indicated that suppression did not result from changes in the sequencing of food presentation alone.

Key words: ethanol, food delay, suppression, lever press, rats

If food-deprived rats have access to either water or an ethanol solution, and also intermittently receive food pellets, they consume large amounts of the liquid (Falk, 1961, 1966, 1967; Meisch and Thompson, 1972a). Such schedule-induced drinking persists over many sessions (Falk, 1966) and is largely confined to the immediate postpellet period (Falk, 1961; Stein, 1964; Segal and Holloway, 1963), although its temporal location can be modified by limiting access to the liquid. Previous experiments have shown that consumption of water during schedule-induced drinking is largely determined by body weight, the number of food pellets presented, and the frequency of food presentation (Falk, 1967, 1971), and that schedule-induced ethanol drinking is determined in addition by the concentration of ethanol (Meisch and Thompson, 1972a). However, less is known about conditions under which drinking is suppressed. Under some con-

ditions, lick-produced postponement of food presentation does not suppress water consumption (Falk, 1964; Segal and Oden, 1969), but under other conditions, it does (Flory and Lickfett, 1974). Also, even though the amount of schedule-induced water drinking can sometimes be decreased by lick-produced postponement of food presentation, it is not known whether drinking of ethanol solutions can be similarly decreased. With no water deprivation, little water is consumed in the absence of food presentation (Falk, 1961; Stein, 1964; Segal and Oden, 1963), although considerable ethanol can be consumed under the same conditions (Meisch and Thompson, 1974). Similar differences might also occur for water drinking and ethanol drinking, with respect to sensitivity to suppression by response-dependent delays in food presentation. The present experiment studied whether responding maintained by access to ethanol could be directly suppressed when each response postponed the concurrent availability of food.

METHOD

Subjects

Six male albino Sprague-Dawley rats, about 150 days old at the onset of experimentation, were individually housed in a constantly illu-

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minated room with an ambient temperature of 24° C. Animals were maintained at 80% of free-feeding weights, which were: S-1, 300 g; S-2, 285 g; S-3, 305 g; S-4, 313 g; S-5, 299 g; S-6, 301 g. Water was constantly available in home cages, except as noted below.

Apparatus

Each of two sound-attenuated operant conditioning test chambers (R. Gerbrands Co.) was equipped with two levers, a pellet dispenser, and a liquid dipper (0.25 ml volume). A 7-W white light located at the rear of the chamber and a 7-W white light located in the dipper opening supplied constant illumination. An exhaust fan provided ventilation and masking noise. Noyes food pellets (45 mg, rat formula) were presented following designated presses of the left lever. The dipper was presented for 4 sec following designated presses of the right lever. A force of approximately 0.27 N was required to operate the levers. Electromechanical control and programming equipment was located in an adjacent room.

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

Procedure

The initial manipulations determined the effects of an 8-sec delay of food availability imposed dependent on lever presses maintained by each of a number of ethanol concentrations. During preliminary training, each subject was trained to lever press under a concurrent fixed-interval 26-sec (food) fixed-ratio 1 (4% ethanol) schedule. Under this schedule, ethanol solution was presented following each right-lever press, while a food pellet was presented following the first left-lever press emitted after 26 sec had elapsed since receipt of the preceding pellet. The procedures employed in preliminary training are shown in Table 1. After preliminary training, daily sessions were 1 hr in length and were held seven days a week, at about the same time each day.

After two sessions of exposure to the concurrent FI 26-sec (food) FR 1 (4% ethanol) schedule, three subjects were arbitrarily designated as experimental animals (S-1, S-2, S-5), three as yoked-control animals (S-4 yoked to S-1, S-3 yoked to S-2, S-6 yoked to S-5). The yoking procedure was such that food became available for a yoked-control subject immediately after it was earned by its experimental

Table 1

Procedures employed during initial training. All sessions before Day 10 were 2 hr in length, while subsequent sessions were 1 hr. During those sessions where "maintenance food in chamber" appears in the food schedule column, animals received their daily ration of Purina Rat Chow in the operant chamber at session onset. Under the VT 4-min liquid schedule, liquid was presented once every 4 min, on the average, without regard to the subject's behavior. Under the FT 1-min food schedule, a pellet was presented at 1-min intervals without regard to the subject's behavior. Fixed-ratio (FR) and fixed-interval (FI) schedules are described in the text.

Day	Liquid Deprivation	Liquid Schedule and Ethanol Concentration	Food Schedule
1	36 hr	Concurrent VT 4-min FR 1 (0%)	Maintenance food in chamber
2	24 hr	Concurrent VT 4-min FR 1 (0%)	Maintenance food in chamber
3-5	12 hr decreased to 0 hr	Concurrent VT 4-min FR 1 (2% increased to 4%)	Maintenance food in chamber
6-9	0 hr	FR 1 (4%)	Maintenance food in chamber
10-12	0 hr	FR 1 (4%)	Concurrent FT 1-min FR 1
13-16	0 hr	FR 1 (4%)	FR 1
17-24	0 hr	FR 1 (4%)	FI 5-sec lengthened to FI 26-sec
25-26	0 hr	FR 1 (4%)	FI 26-sec

partner. Food presentation for all animals was always dependent on lever pressing. For yoked-control animals, food availability, not presentation, was controlled by the behavior of their partners. Yoked-control animals were included to evaluate changes in liquid intake due to alterations in the temporal distribution of pellet deliveries *per se* resulting from imposition of the delay dependency.

After yoking, the baseline concurrent FI 26-sec (food) FR 1 (4% ethanol) schedule remained in effect until the rate of ethanol-reinforced lever pressing showed no obvious trend across seven consecutive sessions. At that time, a delay procedure was instituted in which each ethanol-reinforced lever press by an experimental subject postponed food availability 8 sec. For all subjects, each response on the ethanol lever during the delay procedure was followed by a 1-sec tone. The FR 1 (4% ethanol) schedule was not altered for either experimental or yoked-control animals; each right-lever press was followed by dipper presentation. As in previous sessions, presses of the ethanol lever by yoked-control subjects did not affect scheduled food availability. The delay procedure was in effect for seven sessions, after which the baseline concurrent FI 26-sec (food) FR 1 (4% ethanol) schedule was reinstated for 10 sessions. Following the tenth baseline session, a sequence of manipulations like that described above was instituted with ethanol concentrations of 8%, 16%, 32%, and 0%.

Following determination of the effects of delaying food availability dependent on lever presses maintained by a number of ethanol concentrations, the rate of liquid-maintained responding and the consumption maintained by several ethanol concentrations (0 to 32%, v/v) was determined in the absence of the concurrent food schedule. This condition provided a means of determining the role of the food schedule in engendering liquid consumption. The food levers were covered during sessions in which an FR 1 schedule reinforced with ethanol concentrations of 4%, 8%, 16%, 32%, 0%, or 8% (v/v) was in effect for right-lever presses. Each concentration was presented to each subject during seven consecutive sessions, in the above order. No yoking procedure was involved in these sessions, since food was never presented.

After ethanol-maintained responding and

ethanol consumption in the absence of food was evaluated, the effects of postponing food availability for increasingly long intervals (8 to 2048 sec) following each lever press maintained by a single ethanol concentration (8%) were determined. This determination involved the same procedure used earlier to evaluate the effects of an 8-sec delay. Experimental subjects (S-1, S-2, S-5) lever pressed under a concurrent FI 26-sec (food) FR 1 (8% ethanol) schedule. Subjects S-4, S-3, and S-6 served as yoked-control animals as described earlier. After ethanol-reinforced lever pressing rates showed no obvious trend across seven consecutive sessions, a delay dependency was instituted in which each ethanol-reinforced lever press by an experimental animal delayed food availability 8 sec. Ethanol-reinforced lever presses by all subjects produced a 1-sec tone during delay sessions. This condition remained in effect for seven sessions, after which delay length was progressively lengthened to 32, 128, 512, and 2048 sec. Each delay length was in effect for seven consecutive sessions. After the final delay session, the baseline FI 26-sec (food) FR 1 (8% ethanol) schedule was reinstated for 10 sessions. Ethanol concentration remained at 8% (v/v) throughout this series of manipulations.

During each session, number of liquid-reinforced lever presses was recorded, as were liquid reinforcers presented and volume of solution consumed. Consumption was monitored and corrected for evaporation as described by Meisch and Beardsley (1975). During sessions when food was available, number of food-reinforced lever presses and number of food reinforcers presented were also recorded.

RESULTS

Across all experimental conditions, number of liquid-reinforced lever presses per session and volume of solution consumed in that session were highly correlated. For all animals, the correlation (Pearson r) between these measures was $+0.86$ ($df = 1282$, $p < 0.01$). Correlations for individual subjects ranged from $+0.74$ to $+0.94$ ($df = 212$, $p < 0.01$). Experimental manipulations generally affected liquid-reinforced lever pressing and liquid consumption similarly.

Figure 1 shows the mean number of liquid-reinforced lever presses per session during the initial experimental conditions when food was concurrently available and each lever press reinforced by 0 to 32% ethanol solution delayed food availability 0 or 8 sec. Increasing ethanol concentration from 4% to 32% generally decreased liquid-reinforced lever pressing when such presses did not delay food availability. Exposure to tap water (0%) resulted in

increased lever pressing relative to the 32% concentration.

At all concentrations, the 8-sec delay decreased liquid-reinforced lever pressing by experimental animals. The magnitude of this decrease was inversely related to ethanol concentration from 4% to 32%. With tap water (0%), mean lever presses by S-1 decreased slightly during the delay condition, while liquid-reinforced lever pressing by S-2 and S-5

Fig. 1. Mean number of liquid-reinforced responses (lever presses) per 1-hr session during the initial experimental conditions when food was concurrently available and each lever press reinforced by 0 to 32% ethanol solution delayed food availability 0 or 8 sec. Ethanol concentration was varied across conditions in the order listed. Yoked pairs are grouped horizontally. The first (stippled) bar under each concentration represents responding during seven baseline (no delay) sessions, the second (white) bar represents responding during seven 8-sec delay sessions, and the third (gray) bar represents responding during 10 sessions following return to baseline. The area within brackets is ± 1 standard error. Conditions and the yoking procedure are explained in text.

decreased more substantially. During the 8-sec delay condition at all concentrations, mean liquid-reinforced lever presses per session by yoked-control animals typically increased. The magnitude of this increase was not systematically related to ethanol concentration.

Figure 2 shows the mean number of liquid-reinforced lever presses per session during each experimental condition when food was not concurrently available. Ethanol concentrations of 4 to 32% engendered appreciable lever pressing across seven sessions, while tap water (0%) did not. The amount of liquid-reinforced lever pressing was inversely related

to ethanol concentration from 4% to 32% for four subjects, while 8% engendered the most responding by S-1 and S-2. At all ethanol concentrations, the number of liquid-reinforced lever presses per session by each animal was invariably lower than that obtained when food was concurrently available and ethanol-reinforced lever pressing did not delay food availability, and typically lower than that obtained when such presses delayed food availability 8 sec.

Figure 3 shows liquid-reinforced lever presses per session when food was concurrently available and each lever press maintained by

Fig. 2. Mean number of liquid-reinforced responses (lever presses) per session during each experimental condition when food was not concurrently available. During each condition, liquid was available on an FR 1 schedule during seven consecutive sessions. Ethanol concentration was varied across conditions in the order listed. The area within brackets is ± 1 standard error.

8% ethanol solution delayed food availability 0 to 2048 sec. During sessions when ethanol-reinforced responses did not delay food availability, each subject emitted more liquid-reinforced lever presses than were maintained by the 8% concentration when food was not available. However, all subjects except S-1 emitted fewer liquid-reinforced responses than during the previous sessions when food was concurrently available and lever presses maintained by 8% ethanol solution did not delay food availability.

The 8- and 32-sec delays progressively decreased ethanol-reinforced lever pressing by experimental animals, while generally increasing ethanol-reinforced lever pressing by yoked-control animals. Increasing the delay to 128 sec increased ethanol-reinforced lever pressing by experimental animals. Further increases in

delay length decreased ethanol-reinforced lever pressing by experimental animals relative to 128-sec delay sessions, although responding across sessions by S-2 and S-5 increased in variability.

During 2048-sec delay sessions, ethanol-reinforced lever pressing by yoked-control animal S-4 occurred at a lower rate than during pre-delay and postdelay sessions. At all other delay intervals, ethanol-reinforced lever pressing by yoked-control animals occurred at a rate at least equal to or higher than during baseline sessions.

During 512-sec and 2048-sec delay sessions, temporal distribution of ethanol-reinforced lever pressing within sessions by S-2 and S-5 changed relative to baseline and shorter delay sessions. During baseline and 8-, 32-, and 128-sec delay sessions, most ethanol-reinforced

Fig. 3. Liquid-reinforced responses (lever presses) per session when food was concurrently available and each lever press reinforced by an 8% ethanol solution delayed food availability 0 to 2048 sec. Each ethanol-reinforced lever press by an experimental animal delayed food availability by the number of seconds listed at the bottom of the figure. The baseline schedule of food availability was FI 26-sec and all sessions were 1 hr in length. See text for further explanation of conditions and the yoking procedure.

lever pressing occurred early in the session. This pattern was characteristic of all subjects. At delay lengths of 512 and 2048 sec, S-2 and S-5 often made no ethanol-reinforced responses during the first 30 to 45 min of the session. Rather, such responding began late in the session and persisted at a high rate until the session terminated. This change in temporal dis-

tribution of lever pressing is evident in Figure 4, which shows a representative cumulative record of lever pressing by S-5 during a baseline, 32-, and 512-sec delay session. Note that the pattern of delayed responding by S-2 and S-5 alternated irregularly with a pattern in which no ethanol-reinforced lever presses were emitted. Experimental animal S-1 did not show

Fig. 4. Representative cumulative records of lever pressing by experimental animal S-5 during the baseline, 32-sec delay, and 512-sec delay conditions of the final series of experimental manipulations. The upper track of each record was stepped by presses on the food lever; pellet presentation is signalled by a diagonal pip. Lever presses reinforced by 8% ethanol solution are indicated by diagonal pips on the lower track. Food was initially available on an FI 26-sec schedule as explained in text. Each record represents a single 1-hr session.

a pattern of delayed lever pressing at any time, nor did yoked-control animals.

An effect of delaying ethanol-reinforced lever pressing until late in the 1-hr session was to increase the number of food presentations that could be attained with a given number of ethanol-reinforced lever presses. This is evident in Table 2, which shows mean number of food pellets presented to each subject during sessions in which each lever press maintained by 8% ethanol solution postponed food availability 0 to 2048 sec. Rats S-2 and S-5 (and their yoked partners) were presented with 90 to 120 food pellets per session during 512- and 2048-sec delay sessions, while S-1, which did not show the pattern of delayed responding (and its yoked partner), received fewer than five pellets per session under the same conditions.

Figure 5 shows the mean milliliters of solution consumed per session by each subject across all experimental conditions. During the first sequence of manipulations, when each lever press reinforced by 0 to 32% ethanol solution did not delay food availability, increasing ethanol concentration decreased liquid consumption. However, each doubling of

concentration reduced consumption by less than 50%. Therefore, absolute ethanol consumption varied directly with ethanol concentration. The initial 8-sec delay condition reduced consumption by experimental animals relative to baseline levels at all ethanol concentrations. Consumption by yoked-control animals rose or remained unchanged during these delay sessions. For experimental animals, degree of intake reduction was inversely related to concentration from 4 to 32%, while the reduction at 0% was to intermediate magnitude.

Deletion of the food schedule resulted in decreased consumption at ethanol concentrations of 0 to 32%. In the absence of food presentation, the mean volume of solution consumed by each animal decreased as ethanol concentration was increased from 4% to 32%. As in previous sessions when food was available, each doubling of ethanol concentration decreased consumption by less than 50%, so that absolute ethanol consumption varied directly with concentration.

Re-instatement of the food schedule with 8% ethanol available resulted in increased consumption of this solution relative to intake in the absence of food. However, consumption did not typically increase to the levels maintained during the initial exposure to 8% ethanol with food available. Delays of 8 and 32 sec progressively decreased consumption by experimental subjects relative to baseline levels. The 128-sec delay increased consumption by experimental subjects relative to the 32-sec delay condition, while delays of 512 and 2048 sec produced further decreases in consumption. At delays of 512 and 2048 sec, mean consumption by all experimental animals was lower than that which occurred in the absence of food. Return to the baseline condition resulted in increased consumption by all experimental subjects. However, postdelay mean consumption was lower than predelay mean consumption for all experimental animals.

These delay conditions inconsistently affected consumption by yoked-control animals. In no case did consumption by a yoked-control animal fall below the level that occurred in the absence of food. However, mean consumption by S-4 during 512- and 2048-sec delay sessions was less than the consumption maintained during both predelay and postdelay baseline sessions.

Table 2

Mean ($\bar{X}$) and standard error (S.E.) for number of food pellets presented per session during sessions in which each lever press reinforced by 8% ethanol solution delayed food availability 0 to 2048 sec. Conditions are labelled according to the time by which an ethanol-reinforced lever press by an experimental subject delayed food availability. Subjects S-1, S-2, and S-5 were experimental animals, S-4, S-3, and S-6 were yoked-control animals, as explained in text. Conditions were in effect for seven sessions except for the final 0-sec delay condition, which was in effect for 10 sessions.

Subject		Length of Delay (seconds)						
		0	8	32	128	512	2048	0
S-1	$\bar{X}$	136	109	68	25	4	1	135
	S.E.	0.9	3.5	7.7	1.1	2.9	0.0	0.5
S-4	$\bar{X}$	136	108	66	24	4	1	134
	S.E.	1.0	3.4	6.9	1.2	2.9	0.0	0.9
S-2	$\bar{X}$	134	123	112	92	105	132	131
	S.E.	0.6	2.4	3.8	10.5	14.6	0.9	1.6
S-3	$\bar{X}$	132	121	111	90	104	131	130
	S.E.	0.9	2.1	3.6	10.2	14.4	0.8	1.6
S-5	$\bar{X}$	134	120	109	101	104	91	132
	S.E.	0.9	2.8	5.7	5.5	11.4	21.0	2.3
S-6	$\bar{X}$	132	118	108	99	103	90	130
	S.E.	2.1	2.5	5.7	5.5	11.4	20.5	3.2

Fig. 5. Mean milliliters of solution consumed per session by each subject across all experimental conditions. Conditions are listed in order of presentation and are labelled according to ethanol concentration and the interval by which each ethanol-reinforced lever press by an experimental subject postponed food availability. Food was initially available under a fixed-interval 26-sec schedule during all sessions except those labelled "No Food", in which food was never presented. Yoked pairs are grouped horizontally in the figure. The area within brackets is ± 1 standard error.

Typically, food-reinforced responding varied similarly across conditions for each experimental animal and its yoked partner. This is evident in Figure 6, which shows mean food-reinforced responses per session during the final series of manipulations when 8% ethanol was available and each ethanol-reinforced lever press delayed food availability 0 to 2048 sec.

Within all baseline sessions, pattern of food-reinforced lever pressing by all subjects approximated the "scaloping" characteristically generated by short fixed-interval schedules (Ferster and Skinner, 1957). During delay sessions, this pattern predominated during intervals when no ethanol-reinforced lever presses occurred and food became available 26 sec after

receipt of the preceding pellet. When food availability was delayed for a relatively short time (*i.e.*, less than 128 sec), the high local rate of responding characteristic of the terminal segment of a fixed interval persisted until food was presented. With delays of 512 and 2048 sec, food-reinforced lever pressing often developed a pattern similar to that seen during extinction following exposure to a fixed-interval schedule (Ferster and Skinner, 1957).

DISCUSSION

As previously demonstrated (Meisch and Thompson, 1972a; Poling and Thompson, 1977), the amount of lever pressing and the consumption maintained by 0 to 32% ethanol

Fig. 6. Mean food-reinforced responses (lever presses) per session during the final series of manipulations when 8% ethanol was available and each ethanol-reinforced response by an experimental animal delayed food availability 0 to 2048 sec. The area within brackets is ± 1 standard error. Conditions are explained in Figure 3.

concentrations in the presence of concurrent food delivery decreased as ethanol concentration increased, while absolute ethanol consumed varied directly with concentration. Ethanol served as a reinforcer following discontinuation of the food schedule, as Freed, Carpenter, and Hymowitz (1970) and Meisch and Thompson (1974) have reported. Intake of ethanol solution in the absence of the food schedule decreased as ethanol concentration increased, while absolute ethanol consumed was directly related to concentration. A similar

relation was reported by Meisch and Thompson, 1972b. The reinforcing efficacy of ethanol in the absence of food delivery was not primarily due to the vehicle alone, as indicated by the low rates of lever pressing and small intake resulting from exposure to tap water (0% ethanol).

The delay dependency suppressed lever pressing maintained by ethanol, and ethanol consumption, at all concentrations tested. This suppression was not due to variations in the schedule of food presentation alone, since the

liquid-reinforced responding and liquid consumption of yoked-control animals were not similarly suppressed. The reliable differences between the performances of yoked-control and experimental animals is consistent with a number of studies that have reported differences in the behavioral effects of response-dependent and response-independent events of various sorts (*e.g.*, Wesp, Lattal, and Poling, 1977; Zeiler, 1977).

When delay length was varied with ethanol concentration held at 8%, relative suppression increased when the delay interval was raised from 8 to 32 sec. However, increasing delay length did not result in further suppression. A possible explanation for this effect involves the alteration in interpellet times resulting from this delay interval. The relation between interpellet time and water intake is well established (Falk, 1967, 1971; Wuttke and Innis, 1972). Water intake typically increases as the interpellet interval is increased from about 30 to 120 sec (Wuttke and Innis, 1972). The relation between interpellet interval and ethanol intake has not been systematically explored. However, the increases in ethanol-maintained responding and ethanol consumption typically shown by yoked-control animals during delay sessions of the present study, when the mean interpellet interval increased, suggest a similar relation may obtain. In addition, the effects of varying the temporal distribution of interpellet intervals given a fixed mean interpellet time have not been explored. The 128-sec delay condition altered both the mean interpellet interval and the distribution of intervals relative to preceding sessions. Apparently, this alteration largely overrode the suppressive effects of the delay dependency.

Consumption of ethanol in the food-availability conditions of the present study may involve two potentially separable kinds of drinking: that which occurs in the "normal" consumption of a liquid reinforcer, and that which is food-induced, or "adjunctive" (Falk, 1971). Consumption during the first series of manipulations, when food was present and lever presses reinforced by 0 to 32% ethanol concentrations postponed food availability by 0 or 8 sec, seemed to have been considerably elevated by the concurrent food presentation. The 8-sec delay reliably decreased ethanol-maintained responding and ethanol consumption relative to food-present, but not food-

absent, baselines during this condition, although longer delays were not evaluated. When the effects of longer delays were evaluated at a single ethanol concentration (8%), consumption during baseline (no delay) sessions was only slightly above the levels maintained in the absence of food. Apparently, once ethanol maintains responding and consumption in the absence of food, its intake may be controlled by variables such that drinking engendered by a concurrent food schedule is not copious. The nature of these variables remains to be determined. However, even though responding and consumption were being maintained at little more than food-absent levels, the delay dependency consistently resulted in decreased ethanol-maintained responding and ethanol consumption. In fact, delay lengths of 512 and 2048 sec regularly suppressed lever pressing and consumption maintained by 8% ethanol below the levels that occurred in the absence of food. Long response-dependent delays seemingly suppressed drinking not only below the food-induced level, but also below the level maintained in the "normal" (*i.e.*, food absent) consumption of a liquid reinforcer. Whether such a degree of suppression could be attained under conditions where higher levels of food-induced drinking were maintained is an interesting question as yet unanswered.

The present data generally parallel those of Flory and Lickfett (1974), who demonstrated consistent suppression of schedule-induced water intake when each lick of a water-filled drinking tube was followed by a timeout from the concurrent food schedule. However, Flory and Lickfett examined the effects of an event delivered dependent on drinking, while the present study examined the effects of an event delivered dependent on a response maintained by the opportunity to drink a liquid. Since the two kinds of responses might well differ with respect to sensitivity to experimental manipulations, direct comparisons between the studies is difficult. Further, Flory and Lickfett, like others who have examined lick-produced postponement of food presentation (Falk, 1964; Segal and Oden, 1969), were clearly concerned with schedule-induced drinking; this was not the case in the present study.

The delay procedure did resemble a timeout, in that responses on the ethanol lever increased the interval between potential rein-

forcer deliveries, and such increases were signalled by an exteroceptive stimulus. In fact, the present procedure bears a closer paradigmatic resemblance to timeout, generally considered as a punishment procedure, than to traditional delay-of-reinforcement procedures, in which the delay between the terminal response and reinforcer delivery is typically manipulated (e.g., Ferster and Hammer, 1965; Pierce, Hanford, and Zimmerman, 1972). The behavioral effects of the response-dependent delay were surely punishing: responding invariably decreased. Thus, the delay procedure is perhaps best considered as a kind of punishment manipulation, much like timeout (see also Poling and Thompson, 1977). Few studies have punished the drug-reinforced responding of nonhuman subjects. Smith and Davis (1974) demonstrated that response-dependent electric shock decreases rats' intake of morphine and amphetamine, while Goldberg, Hoffmeister, and Schlichting (1972) and Woods, Downs, and Carney (1975) reported that response-dependent delivery of narcotic antagonists suppresses the morphine-maintained responding of monkeys. The present study extends these findings by demonstrating another condition under which drug-maintained responding is reduced by manipulation of its consequences.

The pattern of delaying ethanol-reinforced responding until late in the session that was manifested by two experimental subjects during some 512- and 2048-sec delay sessions represents an interesting, and seemingly efficacious, sensitivity to scheduled contingencies, insofar as about the baseline number of ethanol reinforcers, along with a large proportion of the maximum possible number of food pellets, were received during sessions in which this pattern occurred. However, ethanol consumption during such sessions was less than during food-present baseline sessions. Apparently, this pattern of responding presented ethanol in a pattern unsuited to maximal consumption. During the 512- and 2048-sec delay conditions, ethanol-maintained responding by experimental animal S-1 did not show the change in temporal distribution evidenced by the other experimental animals. Instead, this animal responded early in the session and consequently received few food pellets. Consumption by S-1 and its yoked partner fell during these sessions. This suppression seemingly differed from that shown by experimental animals S-2 and S-5,

which revealed suppression despite the receipt of sufficient food pellets to maintain the consumption and ethanol-reinforced responding of their yoked partners at above the baseline level. The factors accounting for this difference in the performance of experimental animals are unclear. Subject S-1 emitted more lever presses and consumed more 8% ethanol than S-2 or S-5 during baseline sessions of the final series of manipulations, suggesting that the reinforcing value of 8% ethanol may have been greater for S-1 than for S-2 or S-5. Such a difference in reinforcing efficacy may have resulted in the differential sensitivity to the 512- and 2048-sec delay intervals evidenced by S-1 compared to S-2 and S-5.

The similarity between yoked pairs in the effects of the various conditions on food-reinforced lever pressing suggests that the pattern of pellet presentations largely determined rate of food-reinforced responding.

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