EFFECTS OF LICK-CONTINGENT TIMEOUT ON SCHEDULE-INDUCED POLYDIPSIA¹

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Rats bar pressing on a 1-min fixed-interval schedule for 45-mg food pellets became polydipsic when water was concurrently available. They were then exposed to conditions in which each lick on the drinking tube produced a timeout period during which the food-schedule lever was retracted and the fixed-interval timer either did or did not continue to operate. Licks occurring within a timeout period extended its duration. As the duration of the lick-initiated timeout period was increased logarithmically through four values from 10 sec to 80 sec, lick rates as well as water intake rates generally decreased for all three subjects. As timeout duration was progressively increased, the rate of licks occurring in the absence of, but producing, timeouts decreased for all three rats, whereas the rate of licks occurring in the presence of timeout periods remained essentially constant. Water-intake rates and, with one exception, lick rates were suppressed more by timeout periods during which the fixed-interval timer did not continue to operate. These results indicate that lick-contingent timeout from positive reinforcement reduces schedule-induced drinking, and this suppressive effect is greater when the timeout period necessarily increases the interreinforcement interval beyond its minimum duration than when it does not.

Schedule-induced polydipsia was first reported by Falk (1961). He found that food-deprived rats, bar pressing for 45-mg food pellets on a variable-interval 1-min schedule, drank after each pellet to the point of consuming in a 3.2-hr session three to four times their normal 24-hr intake. Schedule-induced polydipsia, which has been observed in mice (Palfai, Kutscher, and Symons, 1971), in monkeys (Schuster and Woods, 1966), in the pigeon (Shanab and Peterson, 1969) as well as in rats, is characterized by a period of drinking that occurs shortly after the ingestion of a food pellet. This typical drinking pattern is observed with fixed or variable schedules whether or not food deliveries are contingent upon the emission of a specific operant response (Falk, 1969, 1971).

Although it appears to be physiologically maladaptive (Falk, 1971), schedule-induced polydipsia is a relatively strong behavioral phenomenon. Falk (1966a) observed that polydipsia occurred adjunctive to a 60-sec variable-interval food schedule even when water was concurrently available in 0.1-ml portions contingent on responding under a fixed-ratio schedule requiring as many as 50 responses. These results indicate that schedule-induced drinking is not simply a mediating or collateral behavior, but rather is an activity that is sufficiently reinforcing to sustain scheduled behavior. Further indication of the strength of adjunctive drinking behavior was provided by Flory and O'Boyle (1972), who reported that rats, bar pressing for food pellets on a 60-sec fixed-interval schedule, became polydipsic when 0.1-ml portions of water were concurrently available via a second lever on a fixed-ratio 1 basis. The session water intakes of each rat remained at polydipsic levels even when 15-sec periods of water unavailability were inserted into various portions of the 60-sec fixed-interval food schedule.

Because schedule-induced polydipsia appears to be a relatively strong behavior, it seems reasonable to predict that such behavior might be difficult to suppress or eliminate

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through the use of punishment contingencies. Although no research has been directed toward such an investigation, information does exist concerning the effectiveness of one type of punishment procedure in suppressing adjunctive attack behavior (Flory, 1972). In this study, fixed-ratio schedule-induced biting attack by monkeys against a rubber tube (*cf.* Hutchinson, Azrin, and Hake, 1966; Hutchinson, Azrin, and Hunt, 1968) was suppressed when each bite response produced a timeout period during which the opportunity to obtain food pellets was removed. The use of relatively long (*i.e.*, 30-sec and 60-sec) timeout periods resulted in a temporary facilitation of biting before this behavior was eventually suppressed.

Several studies have indicated that a response-contingent period of timeout from positive reinforcement can effectively suppress ongoing behavior in a number of different organisms (see general review by Coughlin, 1972). Timeout periods, for example, have been used to suppress stuttering (Haroldson, Martin, and Starr, 1968) and aggressive behavior (Allison and Allison, 1971; Bostow and Bailey, 1969; Pendergrass, 1971) in human subjects and to suppress responding maintained by variable-interval (McMillan, 1967; Thomas, 1968), fixed-ratio (Kaufman and Baron, 1968), and differential-reinforcement-of-low-rate (Kramer and Rilling, 1969) schedules of food reinforcement in animal subjects. These results support Leitenberg's (1965) conclusion that timeout from positive reinforcement is aversive and suppresses the behavior that produces it.

Because schedule-induced aggression and polydipsia occur under similar conditions and have a number of characteristics in common (Brown and Flory, 1972; Falk, 1971), it might be expected that the effects of punishment on polydipsic drinking would be similar to those observed for adjunctive attack. The present study investigated the effectiveness of lick-contingent timeout from positive reinforcement in suppressing schedule-induced polydipsia.

METHOD

Subjects

Three, female, 120-day-old Sprague-Dawley rats were used. Each experimentally naive

subject was housed individually in a temperature and humidity controlled room with constant illumination. Water was freely available throughout the study.

Apparatus

The experimental space was a Lehigh Valley Model 1417 test cage enclosed within a Model 1417C sound-attenuating cubicle. The intelligence panel was replaced by one that contained a retractable lever requiring 5 g (0.05 N) for operation and 1.9 sec for retraction, a pellet dish, and a drinking tube. A 7-W houselight provided general illumination during experimental sessions. Mounted 0.7 cm behind the intelligence panel was a stainless-steel drinking tube attached to a 100-ml calibrated reservoir. The tip of the drinking tube was accessible to the rat's tongue through a 0.8-cm by 1.2-cm oval hole placed vertically 6.4 cm above the grid floor. The lever was located 2.5 cm above the grid floor and 16.1 cm from the tip of the drinking tube. Thus, the rats could see the lever retract while they were drinking. Digital counters and a Gerbrands four-channel event recorder (1 mm/sec) recorded responses, while standard electromechanical apparatus arranged experimental events. Licks were monitored by a Lehigh Valley Model 221-05 contact relay. White noise and an exhaust fan served partially to mask extraneous noise.

Procedure

Each rat was food deprived to 80% of its free-feeding body weight and maintained at this level throughout the experiment. The 80% body weights of Rats R31, R32, and R33 were 247, 272, and 264 g, respectively. When body weights showed little variability around their 80% levels, a 2-hr, home cage, water-intake baseline was determined for each rat. This home cage baseline was obtained by giving each subject 90, 45-mg Noyes lab rat food pellets and measuring 2 hr later the water consumed from 100-ml animal drinking tubes. When this water intake showed little variability over five sessions, each rat was magazine trained. The lever-press response was then shaped, and each subject was exposed to increasing fixed-interval (FI) food-schedule values until stable responding was obtained for

each rat at FI 60-sec. This schedule remained in effect throughout the study. Experimental sessions consisted of the delivery of 90 food pellets and were conducted daily. Throughout the study, schedule-induced drinking behavior was considered stable when little or no systematic increases or decreases over five consecutive sessions were observed for water intake and licking rates.

After drinking behavior stabilized at the FI 60-sec schedule, each rat was exposed to a condition in which each lick on the drinking tube was followed by retraction of the food-schedule lever, that is, by a period of timeout from positive reinforcement. During the first phase of the experiment, the minimum timeout duration was 10 sec. Thus, if no further licks followed the lick that initiated the timeout period, the response lever was reintroduced 10 sec after its retraction. If, however, additional licks occurred during the timeout, the lever remained retracted until a 10-sec period of no drinking had elapsed. This punishment contingency, then, was one that differentially reinforced behavior other than drinking (DRO: Reynolds, 1961). During the occurrence of this 10-sec timeout period, the fixed-interval timer continued to operate. When drinking behavior in this 10-sec punishment condition was stable, the baseline fixed-interval, no-punishment food schedule was reinstated. After water intake and drinking rates stabilized in the no-punishment condition, a second 10-sec timeout contingency was imposed. In this punishment condition, however, each lick on the drinking tube was followed by a 10-sec timeout period during which the food-schedule lever was retracted and the fixed-interval timer did not continue to operate. When stable drinking behavior in this punishment condition was obtained, the baseline condition was reinstated, completing Phase I of the experiment. Phases II, III, and IV were essentially similar to Phase I, except that the timeout durations in the latter phases were 20, 40, and 80 sec, respectively. (See Table 1 for a summary of the procedure.)

As Falk (1969) pointed out, there are several criteria for determining the degree of schedule-induced polydipsia. In the present study, drinking was defined as polydipsic when the ratio of session intake to the 2-hr, home-cage intake was greater than 1.0.

RESULTS

Table 1 shows the sequence of experimental conditions, lever, press rates, session times, and number of sessions devoted to each condition. Response rates and session times are means from the final five sessions of each condition. Table 1 indicates that as the experiment progressed, lever-press rate generally increased for Rat R31, decreased slightly for Rat R32, and remained relatively constant for Rat R33. Furthermore, Table 1 shows that the response rate of Rat R31 was considerably higher than that of either Rat R32 or Rat R33 at each experimental condition.

Figure 1 shows for each subject the rate of water intake at each baseline and timeout condition. Water intake is presented in terms of rate rather than absolute amount per session because the duration of sessions varied across timeout conditions.

For each subject, water intake rate across the four timeout conditions during which the fixed-interval timer continued to operate (*i.e.*, 10+, 20+, 40+, and 80+) was a decreasing function of increasing timeout duration. Figure 1 shows, however, that exposure to the 10+ timeout condition slightly facilitated intake rate for all three subjects. That is, the water-intake rate of each rat was higher during the 10+ timeout condition than during the preceding and subsequent no-punishment baselines. The 20+, 40+, and 80+ timeout conditions suppressed, except for Rats R32 and R33 at the 20+ condition, water-intake rates below those observed for the preceding and subsequent baselines. At the 20+ timeout condition, the intake rate of Rat R32 as well as that of Rat R33 was greater than the rate observed for the preceding baseline but less than that observed for the subsequent no-punishment condition. With the exception of Rat R33 at the 80+ timeout condition, the intake rate of each subject during each of the timer-on timeout conditions was at least twice that observed for the home-cage control condition.

As Figure 1 shows, the drinking rate of each subject was less during timeout conditions when the fixed-interval timer did not continue to operate (*i.e.*, 10-, 20-, 40-, and 80-) than during conditions of corresponding timeout duration when the fixed-interval timer continued to operate. For Rat R31, water in-

Table 1

Sequence of experimental conditions, lever-press rates, session times, and numbers of sessions devoted to each condition. Response rates and session times are means based on the last five sessions of each condition.

Condition	Rat	Resp/Min	Session Time (sec)	Sessions
2-hr Home-Cage Control	R31	—	7200	11
	R32	—	7200	13
	R33	—	7200	13
Baseline (no timeout)	R31	21.2	5408	28
	R32	13.0	5410	33
	R33	10.1	5547	25
10-sec Timeout (FI timer on)	R31	20.9	5610	7
	R32	6.4	5446	5
	R33	9.3	5520	12
Baseline (no timeout)	R31	22.3	5478	7
	R32	13.9	5488	5
	R33	7.3	5670	6
10-sec Timeout (FI timer off)	R31	21.8	8158	15
	R32	4.3	7332	14
	R33	8.5	7976	5
Baseline (no timeout)	R31	15.4	5566	6
	R32	4.2	6054	9
	R33	8.5	5517	5
20-sec Timeout (FI timer on)	R31	21.9	5950	10
	R32	4.3	5810	17
	R33	6.5	5565	5
Baseline (no timeout)	R31	28.0	5584	5
	R32	5.4	5692	5
	R33	6.7	5536	5
20-sec Timeout (FI timer off)	R31	36.8	9543	7
	R32	3.5	6807	8
	R33	7.0	9137	5
Baseline (no timeout)	R31	82.5	5539	5
	R32	6.0	5547	8
	R33	5.3	5524	5
40-sec Timeout (FI timer on)	R31	42.4	7769	14
	R32	2.8	6115	5
	R33	2.3	5922	5
Baseline (no timeout)	R31	50.1	5666	5
	R32	5.4	5549	6
	R33	6.5	5528	6
40-sec Timeout (FI timer off)	R31	72.3	7833	6
	R32	3.4	6357	13
	R33	9.6	7339	10
Baseline (no timeout)	R31	78.3	5805	12
	R32	5.1	5517	11
	R33	6.4	5462	22
80-sec Timeout (FI timer on)	R31	79.7	7154	5
	R32	3.1	6688	8
	R33	6.5	6451	5
Baseline (no timeout)	R31	76.4	5832	5
	R32	4.3	5508	6
	R33	7.6	5475	12
80-sec Timeout (FI timer off)	R31	96.5	7287	7
	R32	3.2	7142	5
	R33	9.4	6620	7
Baseline (no timeout)	R31	86.5	5647	7
	R32	3.2	5530	5
	R33	8.3	5505	5

take during the timer-off timeout conditions decreased monotonically with increasing timeout duration. The rate of water intake for Rat R32, however, was nearly constant in each of the four timeout conditions during which the fixed-interval timer did not continue to operate. For Rat R33, intake rate was a bitonic function of increasing timeout

Fig. 1. Water intake (ml) per hour for 2-hr, home cage control conditions, for conditions in which each lick on the water tube was followed by a timeout period during which the food-schedule lever was retracted, and for baseline conditions during which licks were not followed by timeout periods. The numbers 10, 20, 40, and 80 along the horizontal axis indicate duration of timeout periods, while the plus (+) and minus (−) signs following each of these numbers indicate, respectively, whether the FI food-schedule timer did or did not continue to operate during timeout periods. Each vertical bar represents the mean of the last five sessions.

duration, with the greatest rate occurring at the 20- condition. During the timer-off timeout conditions, water intake per hour of each rat was, with the exception of the 40- and 80- conditions for Rat R33, at least twice the rate that occurred during the respective home cage control. The 80- timeout condition for Rat R33 was the only instance during which session water-intake rate was suppressed below the home cage baseline.

For each subject, water intake during baseline conditions tended to decrease near the end of the experiment. Figure 1 shows this attenuation during the last three baseline conditions for Rats R31 and R32 and during the last two baseline conditions for Rat R33.

Figure 2 shows for each subject the rate of licking at each baseline and timeout condition. A comparison of Figures 1 and 2 reveals that for Rats R32 and R33, the effects of the four timer-on timeout conditions were similar for rates of water intake and licking. Water-intake rate as well as rate of licking for these two subjects was a decreasing function of increasing timeout duration. Furthermore, rates of water intake and licking relative to the rates observed for preceding and subsequent baseline conditions were essentially similar for Rats R32 and R33 at each of the four timer-on timeout conditions. For Rat R31, however, a comparison of Figures 1 and 2 reveals that the effect of timer-on timeout conditions on water-intake rate was somewhat different than the effect of this condition on rate of licking. Whereas the water-intake rate of this subject progressively decreased across the 10+, 20+, 40+, and 80+ timeout conditions, rate of licking across these four conditions did not systematically decrease. As Figure 2 shows, the lick rate of Rat R31 was higher at the 40+ than at the 20+ timeout condition. A comparison of Figures 1 and 2 reveals that, with the exception of the 10+ timeout condition, the rates of water intake and licking relative to the rates observed for preceding and subsequent baseline conditions were essentially similar for Rat R31 at each of the timer-on timeout conditions.

Figure 2 shows that, with the exception of Rat R31 at the 20- condition, the licking rate of each subject was less during the timeout conditions when the fixed-interval timer did not continue to operate than during conditions of corresponding timeout duration

Fig. 2. Lick rate for each condition during which the 60-sec fixed-interval food schedule was in effect. The numbers 10, 20, 40, and 80 along the horizontal axis indicate duration of timeout periods, while the plus (+) and minus (-) signs following these numbers indicate, respectively, whether the FI timer did or did not continue to operate during timeout periods. During baseline conditions, licks were not followed by timeout periods. Each vertical bar represents the mean based on the last five sessions.

when the fixed-interval timer continued to operate. For Rats R31 and R33, rate of licking during the timer-off timeout condition was a bitonic function of increasing timeout duration, with the greatest rate occurring at the 20- condition. For Rat R32, lick rate remained relatively constant across timer-off timeout conditions. Thus, with the exception of the 20- condition for Rat R31, changes in lick and water-intake rates across the four timer-off timeout conditions were similar for each subject.

A comparison of Figures 1 and 2 further reveals that rates of water intake and licking showed similar variability across baseline conditions for Rats R32 and R33. For Rat R31,

however, licking rates during the second, third, and fourth baseline conditions were relatively low as compared with water intake rates at each of these conditions.

Figure 3 shows for each subject the average interreinforcement time for each experimental condition. During the four timer-on timeout conditions, interreinforcement time approximated a monotonically increasing function of increasing timeout duration for Rats R32 and R33, and was for Rat R31 a bitonic function of timeout duration, with the maximum interreinforcement time of 86.3 sec occurring at the 40+ condition. For those timeout conditions during which the fixed-interval timer did not continue to operate, the interreinforcement times for Rats R31 and R33 increased to a maximum at the 20- condition and then decreased. For Rat R32, interreinforcement time was a shallow U-shaped function of increasing timeout duration with the minimum of this function occurring at the 40- condition. With the exception of Rat R32 at the third baseline condition, the interreinforcement times observed during no-punishment baselines generally approximated the scheduled fixed-interval duration of 60 sec.

In order to determine quantitatively the temporal locus of drinking and lever pressing between reinforcements, fixed intervals were divided into quarters. Licks or lever presses that occurred after reinforcement had become available were included in the fourth quarter. From these data, the Index of Curvature (Fry, Kelleher, and Cook, 1960) was computed for both responses. The Index of Curvature has a value approaching -0.750 when responding is most frequent during the first quarter of an interreinforcement interval, a value of 0.0 when responding is equal in all four quarters, and a value approaching $+0.750$ when responding is most frequent during the fourth quarter. Mean Indices of Curvature based on the last five sessions of each experimental condition indicated that the drinking behavior of each subject occurred predominantly after rather than before pellet deliveries. Mean indices for licking ranged from $+0.387$ to -0.603 for Rat R31, from -0.147 to -0.750 for Rat R32, and from -0.349 to -0.749 for Rat R33. Of the 17 mean licking indices calculated for Rat R31, 10 were negative and seven were positive. Mean indices also indicated that the lever-pressing behavior of Rats

Fig. 3. Interreinforcement duration (sec) for each condition during which the 60-sec fixed-interval food schedule was in effect. The numbers 10, 20, 40, and 80 along the horizontal axis indicate duration of timeout periods, while the plus (+) and minus (-) signs following these numbers indicate, respectively, whether the FI timer did or did not continue to operate during timeout periods. During baseline conditions, licks were not followed by timeout periods. Each vertical bar represents the mean based on the last five sessions.

R32 and R33 showed the positively accelerated or "scaloped" pattern characteristic of fixed-interval responding (Ferster and Skinner, 1957). Mean Indices of Curvature for lever pressing ranged from $+0.430$ to $+0.674$ for

Rat R32 and from +0.440 to +0.654 for Rat R33. For Rat R31, however, Index of Curvature calculations indicated that the positively accelerated lever pressing observed during the 10+ timeout condition and the first two baseline conditions was disrupted when this subject was exposed to the subsequent 10– timeout condition. Whereas mean Indices of Curvature during the first baseline, 10+ timeout, and second baseline conditions were, respectively, +0.633, +0.627, and +0.633, mean indices during exposure of Rat R31 to the remaining 13 conditions of the study never exceeded +0.475 and were often considerably lower, although never negative. Mean indices for lever pressing ranged from +0.171 to +0.633, for Rat R31. Visual observation during the 10– timeout condition revealed that this subject began to gnaw on the response lever rather than pressing with a paw in a more typical manner. Subsequent observation revealed that this gnawing behavior continued throughout the remainder of the study.

Fig. 4. Number of fixed-interval components in which at least one water-tube lick occurred. The numbers 10, 20, 40, and 80 along the horizontal axis indicate duration of timeout periods, while the plus (+) and minus (–) signs following these numbers indicate, respectively, whether the FI timer did or did not continue to operate during timeout periods. During baseline conditions, licks were not followed by timeout periods. Each vertical bar represents the mean based on the last five sessions.

Figure 4 shows the mean number of fixed-interval components in which at least one lick occurred. For Rat R31 and R32, the number of intervals with licks generally decreased with increasing timeout duration, whether or not the fixed-interval timer continued to operate during timeout periods. For Rat R33, however, the number of intervals with licks remained at or near the maximum of 90 until the 40– timeout condition. For all three subjects, the number of intervals with licks during baseline conditions also tended to decrease as the study progressed. Figure 4 shows an attenuation in the frequency of licking intervals during the last three baseline conditions for Rat R31, the last seven baseline conditions for Rat R32, and the last two baseline conditions for Rat R33.

When mean number of timeout periods per session was plotted as a function of timeout duration, functions similar to those observed for timeout conditions in Figure 4 were obtained for all subjects. Although multiple bursts of licking occasionally occurred during the 10-sec and 20-sec timeout conditions, subjects predominantly exhibited only one drinking episode per fixed-interval component. Thus, the mean number of timeout periods per session was slightly higher than the mean number of licking intervals only for those timeout conditions in which multiple licking bursts occurred.

Figure 5 shows the rate of licking at each baseline condition and the lick rate within lick-initiated timeout periods at each timeout condition. During timeout periods, a lick-initiated DRO contingency arranged that a timeout of N sec remained in effect until N sec of no licking had elapsed. Thus, as the duration of timeout periods was increased, progressively longer periods of no licking had to elapse before a timeout could terminate. To avoid the biasing of within-timeout lick rates toward progressively lower values with progressive increases in timeout duration, rates of licking in the presence of timeout are based upon the amount of time spent within timeout minus the no-licking period required to elapse before a timeout period could terminate. As Figure 5 shows, within-timeout lick rates across all timeout conditions were, for each rat, considerably higher than baseline lick rates. Furthermore, lick rates in the presence of timeout periods showed essentially no

Fig. 5. Lick rate within timeout periods at each timeout condition, and lick rate at each baseline condition. Rates of licking in the presence of timeout are based upon the amount of time spent within timeout minus the no-licking period required to elapse before a timeout period could terminate. The numbers 10, 20, 40, and 80 along the horizontal axis indicate duration of timeout periods, while the plus (+) and minus (−) signs following these numbers indicate, respectively, whether the FI timer did or did not continue to operate during timeout periods. During baseline conditions, licks were not followed by timeout periods. Each vertical bar represents the mean based on the last five sessions.

systematic increase or decrease as timeout duration was increased from 10 sec through 80 sec, whether or not the fixed-interval timer continued to operate during timeout periods. Figure 6 shows at each timeout condition the rate of licks occurring in the absence of, but producing, timeout periods. Thus, this figure shows the rate of timeout initiations per

Fig. 6. Rate of licks occurring in the absence of, but producing, timeout periods. Data are plotted separately for timeouts during which the FI timer did (solid line) and did not (broken line) continue to operate. Each point represents the mean based on the last five sessions.

session for timeout conditions during which the fixed-interval timer continued to operate (solid line) and for timeout conditions during which the timer did not continue to operate (broken line). Comparative lick rates during baseline conditions are not presented in this figure because such rates are based upon total

session licks and total elapsed session time, whereas the rates presented in Figure 6 are based only upon the single lick initiating each timeout period and only upon that portion of session time that elapsed in the absence of timeouts. Thus, the overall lick rates during baselines are not directly comparable to the local lick rates presented in Figure 6. For each subject, the rate of licks occurring in the absence of timeout periods and, therefore, the rate of timeout initiations generally decreased as timeout duration was increased. Similar functions were obtained when number of licks occurring in the absence of timeouts was plotted as a function of timeout duration.

DISCUSSION

In the present study, all three subjects became polydipsic when exposed to a 60-sec fixed-interval schedule of food reinforcement with water concurrently available. As the duration of lick-contingent timeout periods was increased logarithmically through four values from 10 sec to 80 sec, rates of water intake and licking generally decreased across conditions in which the fixed-interval timer continued to operate during timeout periods and also decreased, for Rats R31 and R33, across conditions in which the fixed-interval timer stopped during timeout periods. Thus, with the exception of Rat R32 during the four timer-off timeout conditions, the effectiveness of timeout periods in suppressing schedule-induced drinking was systematically related to the duration of timeouts. Similar relations between timeout duration and effectiveness of timeout as a punisher have been reported for behavior maintained by a ratio schedule of reinforcement (Kaufman and Baron, 1968) and for matching-to-sample errors (Ferster and Appel, 1961; Zimmerman and Ferster, 1963).

Although the longer timeout periods employed in the present study generally reduced schedule-induced drinking for all subjects, water intake rates were not suppressed below home cage control levels in seven of the eight timeout conditions investigated. Only when (a) timeout duration was 80 sec, or 20 sec greater than the FI 60-sec food schedule, and (b) the fixed-interval timer did not continue to operate during this 80-sec timeout, did the session water-intake rate of one subject, Rat R33, fall below the home cage control rate.

These results suggest that schedule-induced drinking is somewhat resistant to the suppressive effects of lick-contingent timeout. Additional research is needed to determine the relative resistance of other classes of adjunctive behavior to punishment operations.

The results of several recent studies indicate that degree of schedule-induced polydipsia is related to food delivery rate by an inverted-U or bitonic function. This relation was observed when food pellets were delivered on response-noncontingent fixed-time and variable-time schedules (Hawkins, Schrot, Githens, and Everett, 1972; Segal, Oden, and Deadwyler, 1965), fixed-interval schedules (Falk, 1966*b*; 1969; Flory, 1971; Hawkins *et al.*, 1972), and variable-interval schedules (Hawkins *et al.*, 1972). Taken together, the results of these studies indicate that schedule-induced drinking increases to a maximum level as the average or actual interpellet interval is progressively increased from that inducing threshold polydipsia (*e.g.*, 15 sec) up to values of approximately 90 to 180 sec. When interpellet interval is further increased, the degree of polydipsia progressively decreases to lower values. Based upon these observations, it is possible that schedule-induced drinking in the present study was reduced by lick-contingent timeouts because the occurrence of timeout periods increased the interreinforcement interval up to a value that fell along the descending limb of the bitonic function relating degree of polydipsia and pellet delivery rate. According to this explanation, drinking could be expected to decrease if the actual interreinforcement interval was increased beyond approximately 90 to 180 sec. Such an account might explain, at least in part, the reduction of polydipsia during the 10- timeout condition for Rats R31 and R33 and during the 20- condition for Rat R33, since actual interreinforcement times during these conditions were somewhat greater than 90 sec. It is also possible, however, that the increases in interreinforcement intervals during these conditions did not result in reduced drinking, since such intervals could have fallen within the effective range of pellet delivery rates found to induce maximal polydipsia. The actual interreinforcement intervals during the 40-sec and 80-sec timeout conditions, those conditions resulting in the greatest suppression of drinking, never exceeded 90 sec. Thus, it is reasonable

to conclude that the effectiveness of these timeout periods in suppressing polydipsia was not due to an increase of the actual interreinforcement interval beyond that found to induce maximal drinking.

Drinking was slightly facilitated by 10-sec timeout periods during which the fixed-interval timer continued to operate (see Figure 1). Similar facilitation effects have been observed for schedule-induced biting when each bite initiated a relatively short timeout period (Flory, 1972). The observations that adjunctive drinking and biting increase in rate when these responses produce a relatively short period of timeout from positive reinforcement may be related to the observations that various organisms, responding on intermittent food schedules, will engage in a second response that produces escape periods during which extinction and a correlated S^a stimulus are in effect (Appel, 1963; Azrin, 1961; Brown and Flory, 1972; Thomas and Sherman, 1965; Thompson, 1964, 1965; Zimmerman and Ferster, 1964). Escape responding is most likely during those portions of the schedule in which reinforcement is not immediately available. Thus, it is possible that adjunctive drinking and biting were negatively reinforced because they terminated, for a short time, the stimuli correlated with the relatively aversive post-reinforcement period of the fixed-ratio food schedule in the Flory (1972) study and the fixed-interval food schedule in the present study.

Session water-intake rate, lick rate, and number of intervals with licks tended to decrease during no-punishment baseline conditions near the end of the experiment. It is possible that baseline drinking was somewhat attenuated because it was slow to recover from the suppressive effects of preceding timeout conditions. Thus, if the stability criterion employed in the present study had required more than five sessions of exposure to each condition investigated, drinking during the final baseline conditions might have recovered to somewhat higher levels.

In the present study, two distinctly different punishment contingencies were in effect during timeout conditions. In one of these contingencies, each lick occurring in the absence of timeout resulted in lever retraction and, therefore, in a timeout of specified duration. As a result of this contingency, session drink-

ing episodes and, therefore, timeout initiations progressively decreased in frequency and rate as the duration of timeout periods was increased. The other punishment contingency in effect during timeout conditions arranged that each lick occurring within a timeout period would extend the duration of that period. That is, a timeout of N sec would not terminate until N sec of no licking had elapsed. Even at the longer timeout durations, this DRO contingency did not reduce the relatively high rate of licking that occurred within timeout periods. These results support previous observations that lick-dependent delays of pellet delivery do not substantially reduce schedule-induced polydipsia (Falk, 1964; Hawkins *et al.*, 1972; Segal and Oden, 1969).

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