Do random time schedules induce polydipsia in the rat?

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The present experiments investigated the role of signals for pellet delivery in the development of polydipsia on random time schedules. In Experiment 1, when an explicit signal or auditory stimulation from pellet dispenser operation was available to the rats, polydipsia developed in all of the animals. In Experiment 2, animals receiving signaled pellet deliveries developed polydipsia more quickly than those receiving unsignaled pellet deliveries. Furthermore, behavioral observations suggested that animals showing polydipsia in the unsignaled group may have been able to detect the operation of the pellet dispenser despite our attempt to mask such cues. In Experiment 3, the information value of pellet-dispenser cues was degraded by the operation of an empty pellet dispenser during the interpellet interval. Under these conditions, almost all animals did not develop polydipsia and the data suggest that for the few that did, pellet-dispenser cues were probably not responsible. Thus, the present findings suggest two conclusions: (1) In studies reporting polydipsia on random schedules, the animals may have been inadvertently provided with cues for pellet availability, and (2) although Pavlovian conditioning may be an important modulator of adjunctive behavior, other factors must also be considered.

Animals exposed to intermittent schedules of food delivery will develop and maintain adjunctive, or interim, behaviors (see Staddon, 1977, and Wetherington, 1982, for recent reviews). For example, a food-deprived rat exposed to an intermittent schedule of food in a situation in which water is available will typically consume copious amounts of water during the intervals between pellets. This phenomenon has been termed schedule-induced polydipsia (SIP) (Falk, 1961). Although a number of hypotheses have been proposed to account for SIP, Staddon (1977) has concluded that the data are most supportive of a motivational account.

Recently, Millenson, Allen, and Pinker (1977) and Lashley and Rosellini (1980) have proposed that schedule-induced behaviors may be modulated by Pavlovian conditioning of motivational states (see also Minor & Coulter, 1982). This view holds that an important determinant of these behaviors is that the inducing schedule establish a conditioned inhibitor (CS−), either through specific presentations of external signals or through temporal conditioning (Pavlov, 1927). The establishment of such a CS−, which indicates that the reinforcer is unavailable, is viewed as eliciting a motivational state within the organism that is conducive to the expression of adjunctive behaviors. The specific behavior displayed is believed to be determined by the species, reinforcer, and environmental stimuli available.

The Pavlovian conditioning hypothesis suggests that an important and possibly necessary condition for the development of SIP is that the inducing schedule establish

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a specific external signal or a temporal period as a CS−. Since, on random time (RT) or random interval (RI) schedules, the probability of reinforcement's occurring is equal over time, the development of a temporal period serving as a CS− would be prevented. Therefore, the Pavlovian conditioning hypothesis predicts that SIP should be difficult, if not impossible, to obtain on these schedules. In support of this prediction, Millenson et al. (1977) found that six of eight animals did not develop polydipsia when food was delivered on a RI 60-sec schedule. Similarly, Lashley and Rosellini (1980) did not observe the development of polydipsia in four of six animals exposed to an unsignaled, RT 120-sec schedule. This reported difficulty of random schedules to induce polydipsia has not, however, been the universal result. Allen and Weidinger (1980) and Shurtleff, Delamater, and Riley (1983) have reported the development and maintenance of polydipsia on RT schedules that appears not to differ from that observed on fixed time (FT) or variable time (VT) schedules. An intermediate pattern of results has been reported by Keehn and Burton (1978), who did observe the development of drinking on an RI 60-sec schedule, although this drinking was lower than that observed on a FI 60-sec schedule. In the present experiments, we attempted to further investigate the conditions under which RT schedules of reinforcement do (or do not) induce polydipsia.

EXPERIMENT 1

Although the discrepancy in the observance of SIP on random schedules may stem from a variety of procedural and/or apparatus differences, the conditioning hypothe-

sis suggests that an important variable in determining whether SIP will be observed may be the presence of cues (CS+s) signaling food availability, which, in turn, would establish the period of their absence as a CS−. Although time cannot serve as a signal for food availability on random schedules, the possibility exists that the occurrence of external signals could result in the conditioning of motivational states and, therefore, in the development of SIP. In support of this proposal, Lashley and Rosellini (1980) have found that when reinforcer delivery was signaled by a 5-sec period of absence of white noise (CS+), thereby establishing white noise presence as a CS−, polydipsia was observed to develop on a RT 120-sec schedule. However, since the signal duration in this study was 5 sec, the schedule differed slightly from more traditional RT schedules inasmuch as the minimum interpellet interval was at least 5 sec. Thus, the purpose of Experiment 1 was to determine whether a brief white noise stimulus (100 msec in duration) would be sufficient to allow for the development of SIP on an RT schedule.

Method

Subjects. Twelve male albino rats obtained from the Holtzman Company were used. Four weeks earlier, all rats had served as subjects in a learned helplessness experiment. The animals were reduced to 80% of their free-feeding body weights (Mean = 433 g) prior to the beginnning of the experiment and were individually housed with water continuously available. The experiment was conducted during the early portion of the light phase of a 12-h light/dark cycle.

Apparatus. Six experimental boxes, measuring 30.5 cm long, 25.5 cm wide, and 27.9 cm high, were used. The two side walls and ceiling were made of clear Plexiglas, and the front and back walls were aluminum. A speaker was mounted on the ceiling, and the floor consisted of stainless steel rods, 0.3 cm in diameter and spaced 1.3 cm apart. A food cup (5.0 × 2.5 × 3.8 cm) protruded from the center of the front wall 1.0 cm above the floor. A hole, 2.0 cm in diameter, was located 5.5 cm to the right of the food cup, and a 100-ml graduated cylinder with a 2.5-mm orifice was positioned 2.0 mm behind the aperture. Each box was enclosed in a sound- and light-attenuating chamber equipped with a houselight and ventilation fan. It should be noted that the pellet dispensers were mounted outside of the sound-attenuating chambers in an attempt to minimize pellet delivery signals. Control of experimental events was implemented by a TRS-80 microcomputer.

Procedure. On Days 1-3, the animals were placed in the operant chambers and given access to 60 45-mg Noyes pellets en masse. Water intake during this period was recorded and served as the baseline intake level. The animals were then given daily 60-min training sessions, for 13 days, during which time they received pellet deliveries, independent of their behavior, on a RT 60-sec schedule. The RT schedule was generated by the computer's pseudorandom-number generator with the limitation that the interpellet interval could vary only between 2 and 120 sec. Half of the rats received signaled pellet deliveries (CS condition); the other half received unsignaled deliveries (NoCS condition). The animals in each group were counterbalanced for weight as well as previous experimental history. The signal, white noise (86 dB), was presented for 100 msec at the same time as the pellet dispenser was operated. The dependent measure was the total amount of water consumed during each session. We followed the convention of Flory (1971) in defining polydipsia as a 200% increase in fluid consumption from baseline levels.

Results and Discussion

Mean levels of water consumption over the two baseline sessions were low and did not differ for the two groups (5.1 and 4.1 ml for the NoCS and CS groups, respectively). When the RT 60-sec schedule was operative, all animals increased their intake levels across sessions, but the groups did not appear to differ in the development or maintenance of SIP. Mean intakes at asymptote (Session 13) were 34.0 and 29.2 ml for the NoCS and CS groups, respectively. Analysis of variance of these water intakes as a function of signal condition and session showed a significant effect of session [$F(12,120) = 28.79$, $p < .001$], but failed to show a significant effect of signal condition or its interaction with session.

These findings, although in agreement with those of Allen and Weidinger (1980) and Shurtleff et al. (1983), fail to replicate those of Lashley and Rosellini (1980), who found that an unsignaled RT 120-sec schedule did not produce polydipsia in the majority of their animals. This failure to replicate our earlier findings was particularly puzzling. After a close comparison of the procedures employed in the present and former experiments, there appeared to exist only two substantive differences. First, the present study employed an RT 60-sec schedule, whereas the former study used an RT 120-sec schedule. Second, and more importantly, the present study used white noise presence as the CS+, whereas the former study used white noise absence as the CS+. Although, by having the pellet dispensers mounted outside the sound-attenuating chambers, we had specifically attempted to remove any pellet delivery signals in the NoCS condition, it is possible that without the presence of white noise throughout the session, the animals in this condition may have been able to perceive the operation of the pellet dispensers. These stimuli would, of course, be predictive of pellet availability, which would effectively remove any differences between the CS and NoCS conditions. Informal observation of the animals in the NoCS condition in Session 13 indeed suggested that pellet dispenser operation was an effective CS+. These animals would terminate any ongoing behavior when a pellet was delivered and would rapidly approach the food cup to consume the pellet. This procedural difference could account for the present failure to replicate our earlier findings, since white noise was present in the Lashley and Rosellini (1980) study for the duration of the session for the unsignaled group, thus minimizing the possibility that the operation of the pellet dispensers could serve as an effective CS+. This possibility was further investigated in Experiment 2.

EXPERIMENT 2

In this experiment, we replicated Experiment 1 with the important modification that white noise absence, rather than its presence, served as the signal for the CS condition. Therefore, white noise was present throughout the

session in the NoCS condition, which should serve to minimize or eliminate the likelihood of the animals' detection of the pellet dispenser operation. In addition, this experiment employed videotape observation of the animals in an effort to further quantify their behavior.

Method

Subjects. Twelve male Holtzman albino rats served as subjects. Seven weeks prior to this experiment, these rats had served in a learned helplessness experiment. The animals were food deprived and maintained in the same manner as outlined for Experiment 1. Mean body weight was 478 g prior to food deprivation.

Apparatus. The chambers used were identical to those described for Experiment 1. A RCA CC-010 color video camera and a JVS recorder were used to videotape the rats' behavior during the final session of the experiment. Control of experimental events was implemented by a TRS-80 microcomputer.

Procedure. The procedure used was similar to that described for Experiment 1. Baseline water intake was determined on Days 1 and 2, and daily training sessions were continued for 17 days. During the training sessions, pellets were delivered on a RT 60-sec schedule. The rats were again divided into CS and NoCS groups, counterbalanced for weight and previous experimental history. However, the signal consisted of a 100-msec absence of white noise presented simultaneously with pellet dispenser operation. The white noise (86 dB) was otherwise constant throughout the session for the signaled condition and continuously present in the unsignaled condition.

On the day following Session 17, all animals were given an additional 30-min session during which a video tape recording was made of their behavior for subsequent scoring by two observers who were unaware of the subjects' experimental conditions. A time-sampling technique was used to score two behaviors, drinking and foodcup, such that the behavior occurring at each 5-sec time mark following a pellet consumption was recorded. Drinking was defined as licking of the water spout, and the occurrence of foodcup behavior was defined as the animal's orienting itself toward the food cup, with its nose within approximately 1 in. of the cup. If neither of these behaviors occurred, "other" was scored. In addition, the total number of times the animal examined the inner portion of the food cup was also recorded.

Results

Figure 1 illustrates the mean consumptions for each condition over the course of Experiment 2. As can be
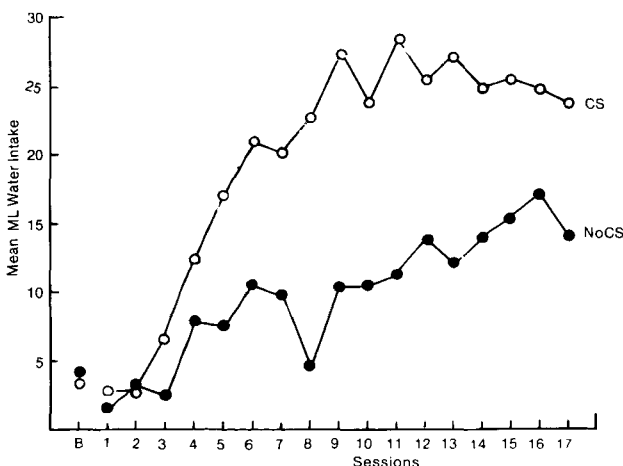

Figure 1. Mean water intake (in milliliters) during the baseline (B) and experimental sessions for the signaled (CS) and unsignaled (NoCS) conditions of Experiment 2.

seen, mean water intakes during the baseline sessions were low and did not differ between the groups. During training sessions, however, differential drinking was observed as a function of signal condition. Animals in the CS condition appeared to increase their intake levels more rapidly than the animals in the NoCS condition, and also appeared to reach a higher asymptotic level of drinking. In general, an analysis of variance of water intakes as a function of signal condition and session supported these observations. A significant signal condition $\times$ session interaction was obtained [$F(16,160) = 2.41$, $p = .003$], as well as a marginally significant main effect of signal condition [$F(1,10) = 4.36$, $p = .063$]. In order to identify the locus of the significant interaction, an analysis of the simple main effect of signal condition in each session was performed. Thus, a significant simple main effect would indicate that the two groups differed in their consumptions in that session. This analysis revealed significant simple main effects in Sessions 8 through 13 [all $Fs(1,170) > 3.81$, all $ps < .05$], supporting the observation that the CS condition developed polydipsia more rapidly than the NoCS condition.

The fact that the main effect of signal condition was only marginally significant, despite the apparently large overall differences in consumptions between the groups (see Figure 1) suggests that there was a large amount of variability in the drinking levels of the animals within a group. Figure 2 shows the intake levels per session for the individual animals in each condition. Only one animal (Subject 24) in the CS group did not show SIP. In the NoCS condition, two animals (Subjects 14 and 16) definitely did not develop SIP, three animals (Subjects 13, 15, and 17), did develop the behavior, and one animal (Subject 18) developed it only marginally.

Behavioral observation of the animals also revealed differences between the signal conditions. Although an analysis of variance as a function of signal condition and a 5-sec time bin revealed no significant differences in the proportion of times these animals were observed drinking, a similar analysis of food cup proximity revealed a significant main effect of signal condition [$F(1,10) = 16.79$, $p = .002$]. The animals in the CS condition were in the proximity of the foodcup on an average of 16% of the observations, whereas the animals in the NoCS condition were in the proximity of the food cup on 37% of the observations. In addition, an analysis of the total number of times each group examined the food cup showed a significant difference [$t(10) = 6.24$, $p < .001$], with the animals in the CS condition engaging in this behavior an average of 132.0 times and those in the NoCS condition doing so 394.5 times.

Informal observation of the videotapes suggested that the three animals who developed SIP in the NoCS condition may have been able to detect some stimulus predictive of pellet delivery. These animals, like the drinkers in the CS condition, consistently terminated any ongoing behavior when the pellet was delivered and immediately and vigorously approached the food cup. Therefore, we categorized the animals as either drinkers (animals show-
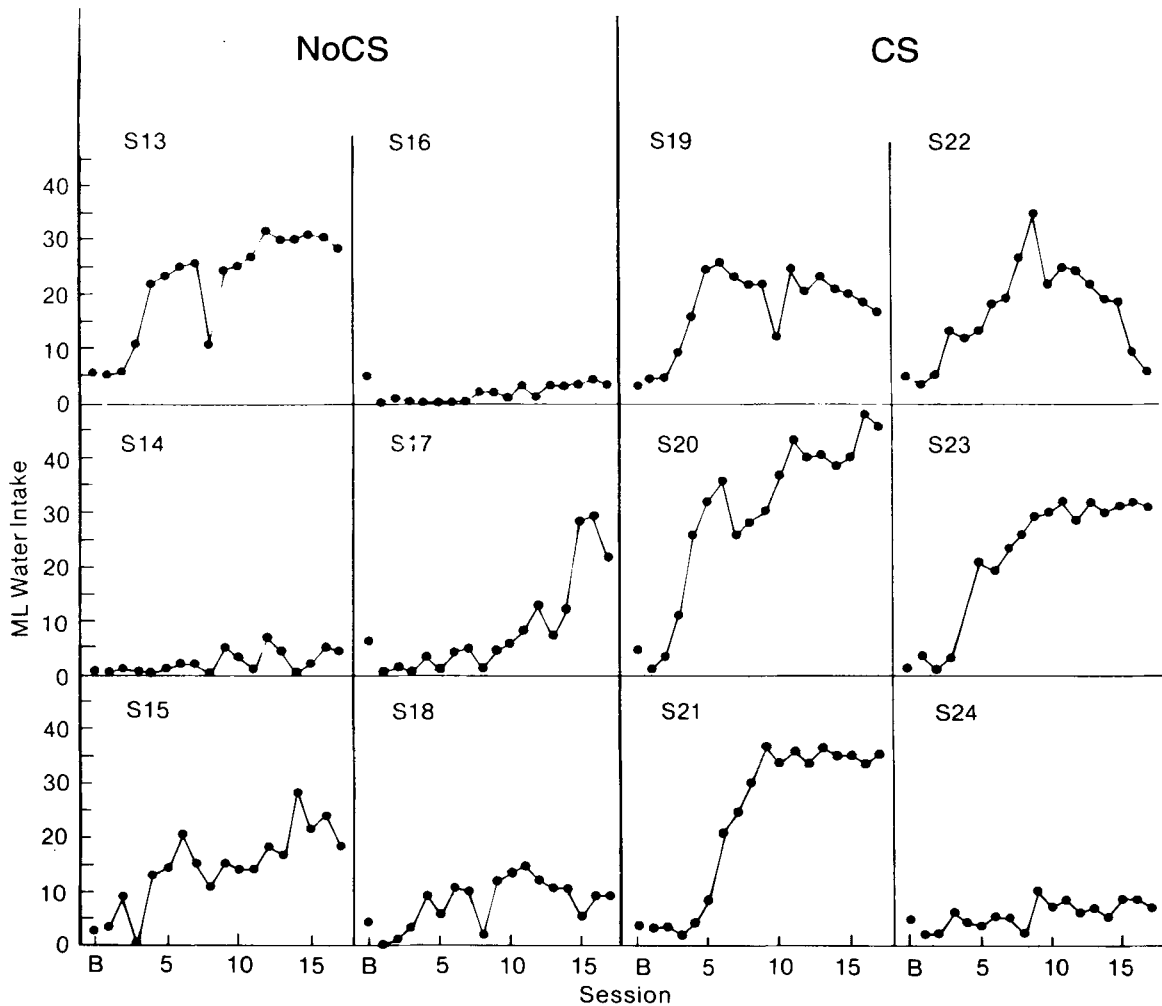
Figure 2. Water intake (in milliliters) during the baseline (B) and experimental sessions for each subject in Experiment 2.

ing SIP) or nondrinkers. Although this categorization is obviously post hoc, and must therefore be entertained with caution, it may provide important information for an understanding of the bimodal nature of SIP in the present study. Figure 3 presents the behavioral data for the drinkers and nondrinker(s) of each condition. As can be seen, all of the drinkers, independent of condition, show the typical postpellet drinking pattern in which drinking occurs primarily during the early portion of the interpellet interval. These animals also show an increase in the probability of being in the proximity of the food cup over the course of the interpellet interval. On the other hand, the nondrinkers tend to show a much less pronounced postpellet drinking pattern and fail to show the increase in the probability of being in the proximity of the food cup over the course of the interpellet interval.

Discussion

In general, the results of the present study replicate those of Lashley and Rosellini (1980) and are consistent with those of Millenson et al. (1977) in demonstrating that

the development of SIP is prevented or retarded when food is delivered on random schedules. More importantly, the present results show that such a schedule can support polydipsia when pellet availability is signaled by a brief stimulus that is simultaneous with pellet dispenser operation.

In addition, the observational data combined with our post hoc categorization of subjects as drinkers or nondrinkers appear to suggest that the three animals in the NoCS condition that did show SIP were detecting a signal despite our efforts to prevent this from occurring. Although we had specifically attempted to minimize pellet delivery signals by including white noise throughout the session for the NoCS group, as well as by mounting the pellet dispensers on the outside of the sound-attenuating chambers, perhaps vibrotactile cues from the operation of the pellet dispenser were detectable and served as a signal for some animals. This finding is particularly important because it suggests that in studies that report SIP on random schedules (Allen & Weidinger, 1980; Shurtleff et al., 1983), a signal for pellet delivery may have been inadvertently provided to the animals by the opera-
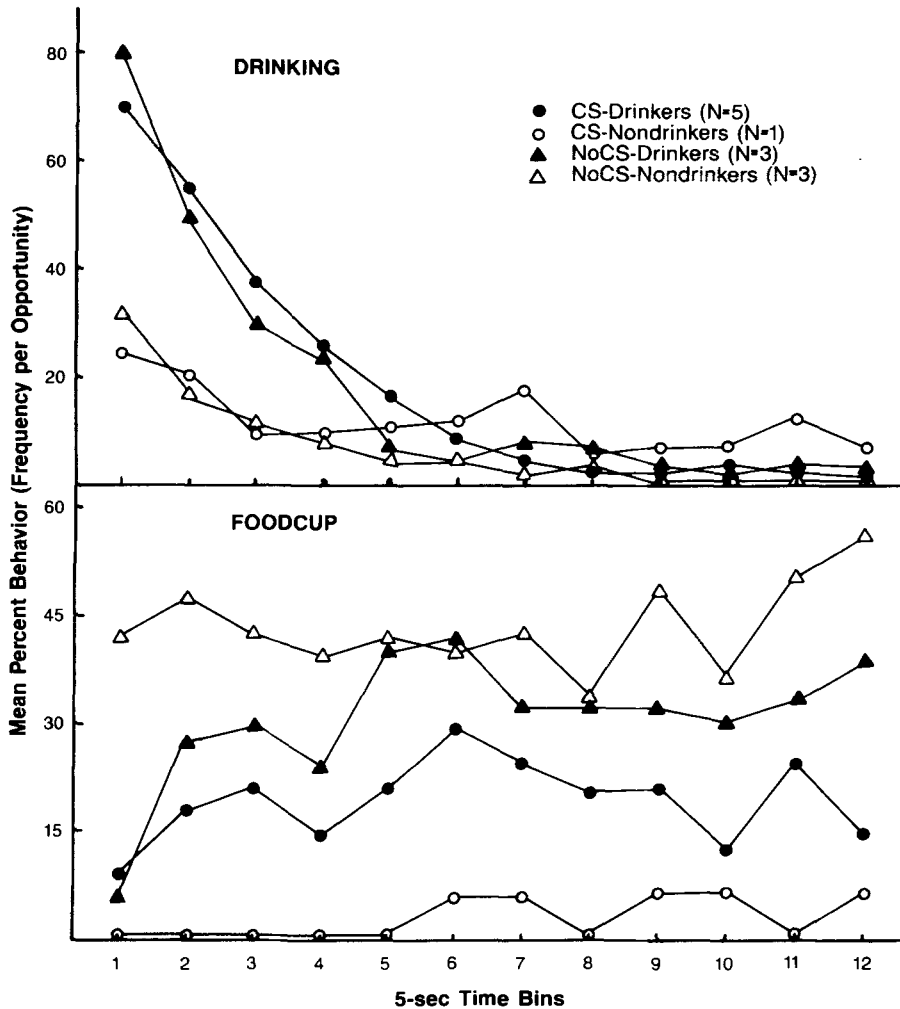
Figure 3. Percentage of observations (frequency per opportunity) of drinking and food-cup proximity for the drinkers (polydipsic) and nondrinkers within the signaled (CS) and unsignaled (NoCS) conditions of Experiment 2 as a function of time within the interpellet interval during Session 18.

tion of the pellet dispenser. This possibility is particularly likely for two reasons. First, in those studies the pellet dispensers were mounted on the operant chambers and would therefore produce both auditory and vibrotactile cues. Second, at least in the Shurtleff et al. (1983) study, the typical postpellet pattern of consumption was observed in animals on the RT schedule.

The importance of signals in the development of SIP on RT schedules is further emphasized by a comparison of Experiments 1 and 2. When the only precaution taken to eliminate pellet-dispenser cues was mounting the pellet dispensers on the sound-attenuating chambers rather than on the operant boxes (Experiment 1), SIP developed in all animals in the NoCS condition. However, when white masking noise was presented throughout the session for the NoCS condition in an effort to reduce the likelihood of these animals' detecting the operation of the pellet dispensers (Experiment 2), SIP was less evident. Experi-

ment 3 was specifically designed to evaluate the presence of pellet-dispenser-produced cues for pellet delivery.

EXPERIMENT 3

Since the results of the previous experiment suggest that we were not completely successful in our attempts to eliminate the occurrence of pellet-delivery signals in the NoCS condition, the present experiment employed a different strategy. If, as we have suggested earlier, vibrotactile stimulation from the operation of the pellet dispenser can serve as a cue for pellet delivery and this is responsible for the development of SIP on RT schedules in some animals, then degrading the information value of this signal should further reduce the incidence of SIP on such a schedule. One method for degrading the contingency between a CS and a US is to occasionally present the CS in isolation (Mackintosh, 1974). Therefore, in the

present experiment, we used a dummy (empty) pellet dispenser to reduce the information value of any vibrotactile stimulation that might occur coincidentally with pellet delivery, and observed its effect on the ability of an RT schedule to induce polydipsia.

Method

Subjects. Nine male Holtzman albino rats served as subjects. Four weeks prior to the present experiment, they had served in a learned helplessness experiment. The animals were deprived and maintained in the same manner as outlined for Experiment 1. The mean body weight of the rats was 564 g prior to food deprivation.

Apparatus. The chambers used were identical to those of Experiment 1, except that each box now housed an auxiliary pellet dispenser which remained empty throughout the experiment. In addition, the grid floor and the water in the tubes served as two electrodes for a drinkometer circuit that was employed to record licks. A TRS-80 microcomputer was used to control the experimental events and record the data.

Procedure. This experiment used a within-subject design and contained three phases: baseline (3 sessions), 20 unsignaled RT 60-sec training sessions, and 10 signaled FT 60-sec training sessions. During the RT phase, white noise was continuously present and the dummy pellet dispensers were operated on an RT 6-sec schedule with the restriction that the two pellet dispensers could not fire simultaneously. Thus, on the average, for each occasion on which a pellet was actually delivered, the dummy pellet dispensers would be operated 10 times during the interpellet interval. During the FT phase, the dummy pellet dispensers were not operated and the signal (CS+) was a 100-msec absence of white noise presented simultaneously with pellet dispenser operation.

Results and Discussion

Figure 4 shows the intake levels per session for the individual animals of Experiment 3. As can be seen, only two (Subjects 21 and 24) of the nine animals demonstrated SIP during the RT phase of the experiment. However, after only 10 FT sessions, six of the nine animals showed SIP, while two appeared to be demonstrating steady increases in consumption and one failed to demonstrate SIP. These data suggest that when the information value of signals on an RT schedule is degraded, the incidence of SIP is reduced. Thus, they are supportive of the Pavlovian conditioning account of SIP, which states that an important and possibly necessary condition for the development of SIP is that the inducing schedule establish a specific external signal or a temporal period as a CS −.

The question remains as to why two of the animals did show SIP during the RT phase. Perhaps, in spite of all our efforts, these animals were still able to detect cues from the entrance of the pellet into the food cup, or possibly they learned to discriminate between the operation of the two dispensers. If either of these possibilites were the case, one would expect to see the typical postpellet pattern of water consumption following pellet delivery for these two subjects, as was observed for the drinkers in the NoCs condition of Experiment 2. Figure 5 shows the postpellet lick patterns for these two subjects during both the RT and FT phases of the experiment. While both animals show the typical postpellet lick pattern during the
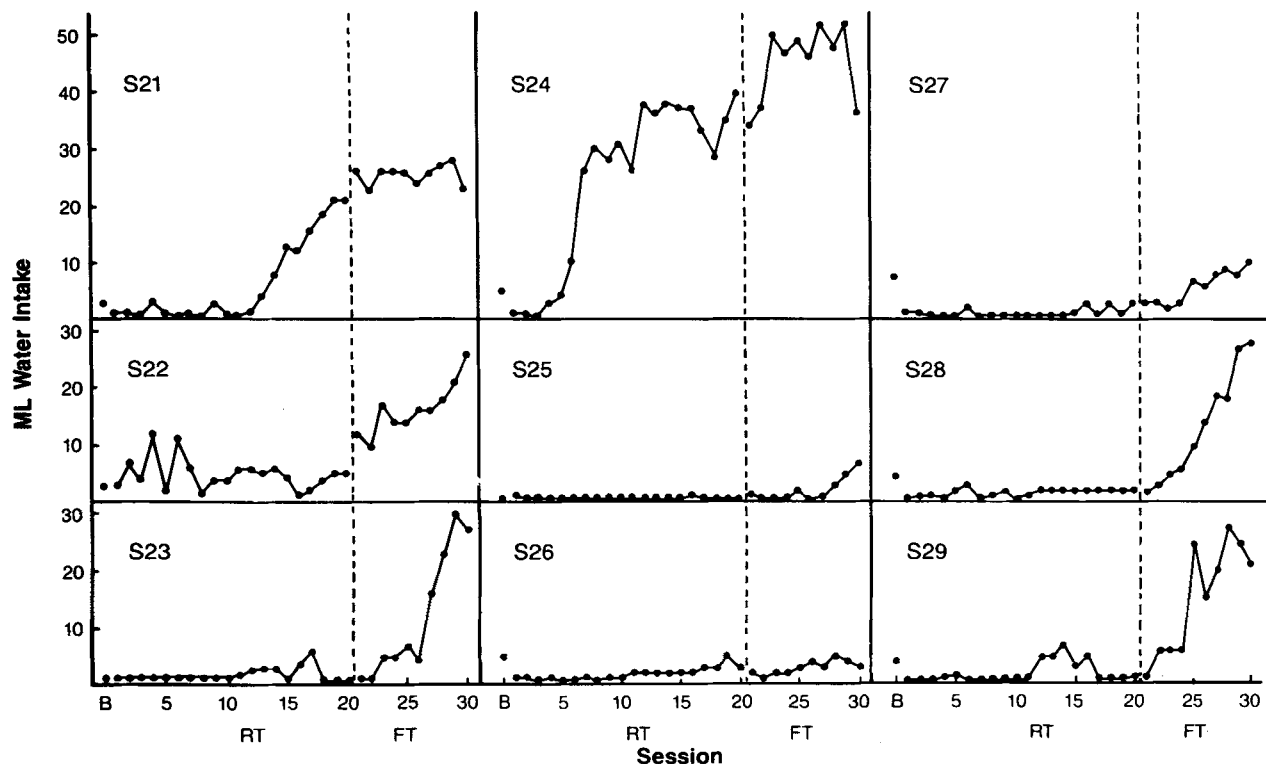

Figure 4. Water intake (in milliliters) for each subject of Experiment 3 during the baseline (B), random time (RT), and fixed time (FT) phases.
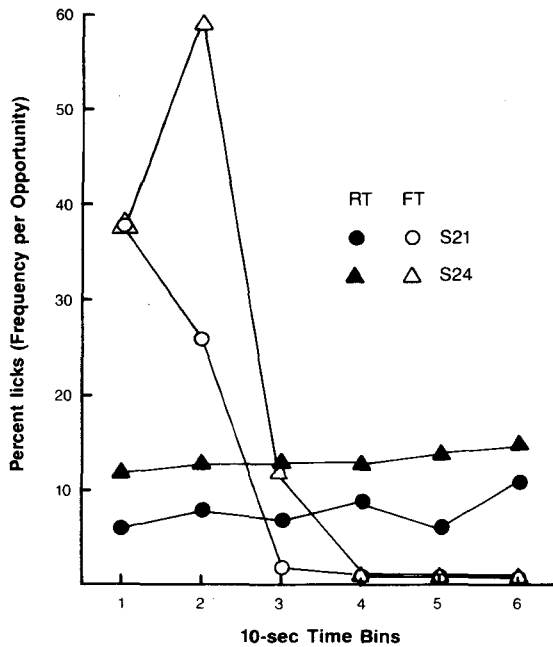
Figure 5. Percentage of licks (frequency per opportunity) during the random time (RT) and fixed time (FT) phases of Experiment 3 as a function of time within the interpellet interval for the two animals demonstrating polydipsia during the RT phase.

FT phase, neither shows it during the RT phase. Thus, these data suggest that although these two animals developed SIP on the RT schedule, it was not due to their perception of pellet delivery cues.

It could be proposed that the reason the majority of the animals failed to develop SIP on the unsignaled RT schedule was because the animals were reinforced for examining the food cup, and this behavior competed with drinking.[1] In order to address this possibility, we performed an essential replication of Experiment 3 with an additional nine animals and one important procedural difference. The difference was in the location of the water spout. In Experiment 3 it was located 7.5 cm to the right of the food cup, whereas in the replication it was located 1.0 cm above the food cup. If examining the food cup competes with drinking on the unsignaled RT schedule, then having the water spout in closer proximity to the food cup should minimize, although perhaps not totally preclude, this competition and result in a greater number of animals demonstrating SIP. However, only one of the nine animals in this replication developed SIP during the RT phase, and this animal, like the two in Experiment 3, failed to show the typical postpellet lick pattern. Thus, it does not appear likely that animals fail to develop SIP under these conditions due to the competition of food-relevant behaviors with drinking.

GENERAL DISCUSSION

In general, the present data are supportive of the Pavlovian conditioning analysis of SIP. Experiment 1 demon-

strated that when pellet delivery was explicitly signaled or when stimulation from the pellet dispensers was available to the rats, polydipsia was observed on an RT schedule. Experiment 2 indicated that when the possiblity for detecting pellet delivery cues was reduced, polydipsia was less evident. Finally, Experiment 3 (and its replication) demonstrated that when the information value of pellet delivery cues was reduced, only 3 out of 18 animals developed polydipsia.

Concerning the disagreement between the studies which report polydipsia on random schedules (Allen & Weidinger, 1980; Shurtleff et al., 1983) and those which do not (Lashley & Rosellini, 1980; Millenson et al., 1977), the current findings emphasize that the observance of SIP may be largely dependent upon the presence of stimuli that are predictive of food availability. That is, in the studies that report polydipsia on random schedules, the animals may have inadvertently detected cues that were positively correlated with pellet delivery.

In most respects, the present Pavlovian conditioned states hypothesis is similar to the state or mood hypothesis proposed by Staddon (1977), which holds that schedule-induced, or interim, behavior such as polydipsia is controlled by two factors: (1) the rat's tendency to drink after eating and (2) the low probability of food delivery during the early portion of the interfood interval provided by the inducing schedule. The major point of difference between these two positions appears to be that Staddon's view allows for the development of polydipsia even on schedules that provide a low, but constant, probability of reinforcement, such as random schedules. The Pavlovian conditioning view, on the other hand, suggests that such schedules should not be capable of supporting interim behaviors such as polydipsia, since they should not allow for the establishment of temporal or external stimuli as conditioned inhibitory stimuli (see Rescorla, 1967). In order to establish a CS−, the inducing schedule must provide a period of relatively low probability of food in a context in which food is otherwise possible (Rescorla & Wagner, 1972). In other words, there must be some portion of the interpellet interval (i.e., the early portion) during which food delivery is less likely to occur than at other times in this interval. Thus, this view predicts that polydipsia should not develop under random schedules under which food delivery is equiprobable throughout the interval. In general, the data of the present study support this prediction.

Minor and Coulter (1982) have recently provided data that support the Pavlovian conditioning hypothesis. Their data clearly demonstrate that SIP is controlled by conditioned inhibitory stimuli. In their experiment, one group of rats (true discrimination) received training on a multiple extinction VT 30-sec schedule in which one stimulus (S+) was present during the VT component and another (S−) was present during the extinction component. A second group (pseudodiscrimination) received identical exposure to the schedule and stimuli, but in this condition the two stimuli bore no consistent relationship to the presence or absence of food. They found that drinking

was largely confined to the S− periods in the true-discrimination group, but that in the group that received pseudodiscrimination training, drinking occurred after food ingestion. Furthermore, following training, the animals were given a stimulus generalization test for drinking which demonstrated an excitatory postdiscrimination gradient for S− in the true-discrimination group only.

The behavior of the animals in the true-discrimination group of the Minor and Coulter (1982) study is consistent with the CS− hypothesis, since their animals drank in the presence of the S− stimulus, which, in that group, should have served as a CS− and elicited a motivational state conducive to drinking. The fact that the animals in the pseudodiscrimination group drank after pellet ingestion is also consistent with the CS− hypothesis, since the minimum interpellet interval on the VT component of the multiple schedule was 6 sec and this 6-sec period could therefore serve as a temporal CS− for this group. Finally, the reason the true-discrimination group drank during the S− period, rather than postpellet, was probably due to the fact that this external CS− had greater salience than the postpellet temporal CS−.

While the absence of polydipsia in the majority of animals under unsignaled random schedules observed in the present study and in those of Millenson et al. (1977) and Lashley and Rosellini (1980) is supportive of the Pavlovian conditioning hypothesis, it would appear difficult for this view to account for the development of polydipsia in any animal on an unsignaled random schedule. However, the data of Experiment 3 clearly show that some animals do ingest excessive amounts of water even under such conditions. Although the incidence of such behavior was small—manifest in 3 out of 18 animals (from Experiment 3 and its replication), these data suggest that factors other than the conditioning of Pavlovian motivational states must also be considered for a comprehensive analysis of SIP.

It is interesting that the animals that did show SIP on the unsignaled RT schedule (Experiment 3) did not show the typical postpellet pattern of licking. There could be two explanations for this finding, one theoretically interesting and the other trivial. The theoretically interesting possibility is that although SIP is usually thought of as being both excessive and temporally constrained (Falk, 1971; Staddon, 1977), these two aspects of SIP may be separable. This would pose a problem for a definition of adjunctive behavior. The less interesting possibility is that these animals may, indeed, have shown a postpellet lick pattern, but may have eaten the pellet at a time other than when it was delivered. Behavioral observation of such animals is needed to resolve this issue.

In conclusion, the present data are supportive of the Pavlovian conditioning analysis of SIP and strongly suggest that previous studies demonstrating SIP on unsignaled random schedules (Allen & Weidinger, 1980; Shurtleff et al., 1983) may have inadvertently provided the animals, with cues predictive of pellet delivery. Although the data generally support a Pavlovian conditioning analysis, it remains for future research to more clearly specify the role of Pavlovian conditioning in SIP. For example, since a small percentage of animals may demonstrate SIP even on an unsignaled random schedule, factors other than Pavlovian conditioning must also be involved.

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NOTE

1. We would like to thank Alliston K. Reid for cogently pointing out this possibility.