AN ANALYSIS OF RATS' DRINKING-TUBE CONTACTS UNDER TANDEM AND FIXED-INTERVAL SCHEDULES OF FOOD PRESENTATION¹

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Rats' lever presses and drinking-tube contacts were studied under fixed-interval schedules of food presentation and under a tandem schedule composed of three fixed intervals. One group of rats was exposed first to the tandem schedule, next to fixed-interval schedules of comparable interpellet intervals, and once again to the tandem schedule; a second group of rats was exposed first to a fixed-interval and then to the tandem schedule. Under the tandem schedule, lever presses occurred at a higher rate and were more uniformly distributed in time than under the fixed-interval schedule. Tube contacts emitted by rats exposed first to a fixed-interval schedule consisted mostly of tongue contacts, which occurred at a high rate shortly after food; tube contacts emitted by rats exposed first to the tandem schedule consisted mostly of paw contacts, which occurred at a lower rate at times other than shortly after food. Changing the schedule from fixed interval to tandem decreased the frequency of tongue contacts for all rats. Under schedules of food presentation with comparable interpellet intervals, the schedule of food presentation, rather than the rate of food delivery *per se*, determined the topography and temporal locus of drinking-tube contacts.

Key words: schedule-induced drinking, drinking-tube contacts, tandem schedules, fixed-interval schedules, lever pressing, rats

Falk (1961) reported that rats exposed to a variable-interval 1-min schedule of food presentation (VI 1-min) consumed large quantities of water following delivery of 45-mg food pellets (schedule-induced drinking). Subsequent studies have attempted to identify the variables that control this excessive drinking (see Falk, 1971; Segal, 1972). Comparisons of amounts of water consumed under different schedules of food presentation led Falk (1971) to conclude that the rate of food delivery, rather than the schedule of reinforcement, is the major determinant of schedule-induced drinking.

The role of the dependency of food delivery on responses has been evaluated by comparing fluid consumption under response-dependent (such as fixed-interval and fixed-ratio) and response-independent (such as fixed-time) sched-

ules of food presentation that arranged equivalent rates of food delivery. When rates of food delivery were equivalent, comparable magnitudes of drinking were found under fixed-interval (FI) and fixed-time (FT) schedules (Hawkins, Schrot, Githens, and Everett, 1972), and under fixed-ratio (FR) and fixed-time schedules (Burks, 1970) of food presentation.

Water consumption by rats has also been investigated over a wide range of FI schedules (Falk, 1966; Flory, 1971), FT schedules (Hawkins *et al.*, 1972), FR schedules (Carlisle, 1971), and variable-time (VT) schedules (Hawkins *et al.*, 1972). In general, these investigators found that the quantity of water consumed was an inverted U-shaped function of the time between pellet deliveries (interpellet interval). Segal, Oden, and Deadwyler (1965) found that the percentage of pellets followed by licking was also an inverted U-shaped function of interpellet interval.

Schedule-induced drinking is characterized by a sustained burst of drinking-tube contacts shortly after food presentation (Falk, 1971). Keehn and Colotla (1971) referred to drinking-tube contacts that occur within 10 sec of food delivery as "postpellet", to distinguish them from "interpellet" tube contacts, which begin

¹This research, conducted as part of the requirements for a Master's degree by the first author, was supported by U.S.P.H.S. research grant MH-01604 from the National Institute of Mental Health. The authors thank Drs. J. E. Barrett and W. Hodos for helpful comments on an earlier version of this manuscript. Reprints may be obtained from D. R. McLeod, Department of Psychology, University of Maryland, College Park, Maryland 20742.

at least 10 sec after the delivery of food. Interpellet tube contacts were reported by Rosenblith (1970), who studied drinking under a second-order schedule of food delivery. Under a second-order schedule, behavior that meets the specifications of a schedule (such as FI) is treated as a unit. Completion of this unit may be accompanied by a brief stimulus change (as in second-order schedules of brief stimuli) or produce no stimulus changes (as in tandem schedules). The completion of a specified number of these units is followed by some maintaining event, such as food delivery (Kelleher, 1966). The second-order schedule used by Rosenblith (1970) specified the sequential completion of three fixed intervals. Each fixed interval terminated with the presentation of a brief stimulus (a 2-sec flash of light and a click), while every third fixed interval terminated with both a brief stimulus and food. Rosenblith reported drinking not only following food but also after the brief stimulus.

The present study was originally designed to extend the findings of Rosenblith (1970) to other methods of scheduling brief stimuli. To assess the effects of brief-stimulus presentation on drinking patterns, rats were first exposed to a schedule that specified the sequential completion of three fixed intervals without associated stimulus changes. Patterns of drinking under this tandem (*tand*) schedule were to be compared with those generated by various schedules of brief-stimulus presentation. Under the tandem schedule, however, contact with the drinking tube occurred in an irregular fashion throughout the interpellet interval and did not occur shortly after food presentation. In view of the atypical pattern of this behavior, the investigation of brief stimuli was postponed, and a comparison of the tandem schedule with FI schedules of comparable interpellet intervals was undertaken. That comparison is presented below.

METHOD

Subjects

Eight albino Wistar rats, without experimental histories, were obtained from Microbiological Associates, Inc. They were maintained at 80% of unrestricted feeding weights and were housed in separate cages under conditions of constant illumination and temperature. At the beginning of the present study,

the rats were between four and seven months of age.

Apparatus

Two experimental chambers (Gerbrands, Model C) were used. A Gerbrands rat lever, centered 2 cm from the left wall and 3.9 cm above the stainless-steel rod floor, protruded 1.5 cm into the chamber through an aperture in the front wall. A force of 0.15 N was required to operate the lever. A circular aperture, 2.4 cm in diameter, was centered 10.8 cm from the left wall and 4.2 cm above the floor. The tip of a stainless-steel drinking tube, 7 mm in diameter, was centered 1.2 cm behind this aperture. The opening in the tip of the drinking tube in Chamber One was initially 3.5 mm in diameter. This tube was replaced after 110 sessions by a tube with an opening of 2.5 mm diameter. The opening in the tip of the tube in Chamber Two was 2.5 mm in diameter throughout the study. A small container was placed beneath the tip of each drinking tube to collect water spillage. A lamp (GE # 1829, 2W), which served as the house-light, was centered on the rear wall, 9.2 cm from either side wall and 6 cm from the ceiling. Food pellets were delivered to a recessed food cup with a 4.5- by 4.4-cm aperture, centered 1.7 cm to the right of the drinking-tube aperture, and 3 cm from the floor.

Behind the front wall were a Gerbrands 45-mg pellet dispenser (Model D) and a Grason-Stadler contact sensor (Model E4690A-2). The experimental chambers were housed in noise-attenuating compartments, located in a room provided with white noise. All programming was accomplished by solid-state circuitry, located in an adjoining room.

Procedure

Exposure to the tandem before the fixed-interval schedule. In Chamber One, Rats 203, 204, 205, and 206 were trained to approach and eat from the food cup. Following this magazine training, the four rats were exposed to 10 sessions in which each lever press produced one 45-mg Noyes rat pellet (FR 1). This condition was followed by exposure to a tandem schedule composed of three fixed intervals [*tand* FR 3 (FI 40-sec)]. Under this schedule, the first response to occur after 40 sec had elapsed since food delivery terminated the first of three fixed intervals and initiated the

second; the response that terminated the third interval also produced food. Numbers of sessions under each condition are specified in Table 1.

These four rats were next exposed to FI schedules of food delivery. The duration of the FI for each rat was equal to the median interpellet interval from the last 10 sessions under the tandem schedule. These values differed for each rat and are listed in Table 1. During this stage of the experiment, a water-spillage problem was detected and the drinking tube was replaced.

Exposure to the fixed-interval before the tandem schedule. In Chamber Two, following magazine training and five sessions of FR 1, four additional rats (232, 233, 234, and 235) were exposed to FI 167-sec, which was 1 sec longer than the median FI studied with the first group of rats. Following exposure to the FI schedule, all eight rats were exposed to *tand* FR 3 (FI 40-sec).

Lever presses, drinking-tube contacts, water consumption both during the session and in the homecage, and session duration were recorded daily. Sessions always terminated after delivery of 25 food pellets, and were conducted seven days per week. Water was available in the experimental chamber and homecage at all times.

RESULTS

Table 1 shows the schedule values and the median interpellet intervals for each stage of the experiment. The occurrence of schedule-induced drinking has been reported over this range of interpellet intervals (Falk, 1966; Flory, 1971).

Rates of lever presses and of drinking-tube

Table 1

Schedule of food presentation, interpellet interval, and number of sessions under each experimental condition.

Subject	Schedule	Median Interpellet Interval (sec)	Sessions
203	<i>tand</i> FR 3 (FI 40-sec)	166.8	84
	FI 166.5-sec	170.1	100
	<i>tand</i> FR 3 (FI 40-sec)	174.0	111
204	<i>tand</i> FR 3 (FI 40-sec)	190.0	84
	FI 189-sec	191.5	100
	<i>tand</i> FR 3 (FI 40-sec)	223.0	111
205	<i>tand</i> FR 3 (FI 40-sec)	161.1	84
	FI 160.5-sec	162.4	100
	<i>tand</i> FR 3 (FI 40-sec)	180.6	111
206	<i>tand</i> FR 3 (FI 40-sec)	165.4	84
	FI 165-sec	167.6	100
	<i>tand</i> FR 3 (FI 40-sec)	214.1	100
232	FI 167-sec	169.9	30
	<i>tand</i> FR 3 (FI 40-sec)	181.0	113
233	FI 167-sec	169.7	30
	<i>tand</i> FR 3 (FI 40-sec)	186.0	96
234	FI 167-sec	170.4	30
	<i>tand</i> FR 3 (FI 40-sec)	193.7	113
235	FI 167-sec	169.1	30
	<i>tand</i> FR 3 (FI 40-sec)	178.9	113

contacts are presented in Table 2 as means of the last 10 sessions under each condition; ranges are shown in parentheses. The following trends appear in the average performance measures. Mean lever-pressing rates for six of the eight rats were greater under the tandem than under the fixed-interval schedule. Mean rates of tube contacts were greater under the fixed-interval than under the tandem schedule for seven of the eight rats and greater for those rats exposed first to FI than for those exposed first to the tandem schedule.

Table 2

Rates of lever presses and tube contacts expressed as means of the last 10 sessions under each experimental condition. Parentheses contain the ranges.

Subject	Lever Presses per Minute			Tube Contacts per Minute		
	<i>tand</i> (1)	FI	<i>tand</i> (2)	<i>tand</i> (1)	FI	<i>tand</i> (2)
203	10.6(6.8-17.8)	8.8(6.4-11.1)	14.8(13.0-17.6)	23.1(15.3-32.5)	19.4(7.3-26.1)	15.2(9.8-21.4)
204	12.1(7.5-15.8)	13.9(9.6-19.7)	22.5(17.0-27.4)	37.7(32.7-47.2)	46.9(37.2-58.9)	23.2(13.8-28.0)
205	13.3(10.2-17.8)	13.7(11.4-17.2)	12.8(10.9-15.4)	31.2(16.5-44.0)	40.0(23.0-54.4)	26.1(18.0-33.9)
206	43.6(33.5-49.3)	23.7(20.3-27.5)	34.2(23.2-41.1)	1.6(0.2- 2.7)	5.6(3.9- 7.7)	3.0(0.9- 4.5)
232		5.8(4.4- 6.8)	12.9(11.3-15.4)		72.8(44.2-85.8)	56.8(46.6-72.2)
233		7.0(4.3- 9.9)	7.1(4.4- 7.5)		57.9(48.5-68.7)	34.0(13.0-46.7)
234		7.2(5.5- 8.8)	6.8(5.0- 9.3)		31.8(13.7-40.4)	9.1(0.1-21.8)
235		9.6(5.7-13.1)	14.5(12.3-16.7)		79.0(64.1-94.6)	47.9(29.2-62.3)

Drinking-Tube Contacts

Observation of the rats during experimental sessions revealed two types of tube contacts: tongue contacts associated with drinking, and paw contacts associated with rapid rubbing movements along the length of the drinking tube. Three of the four rats exposed first to the tandem schedule and one of the four rats exposed first to the FI schedule consistently rubbed the tube with their paws. Figure 1 presents selected event records for Rats 203, 205, and 235, taken from sessions of FI and subsequent exposure to *tand* FR 3 (FI 40-sec). The first author generated these records by depressing one handswitch during episodes of tongue contacts and another handswitch during episodes of paw contacts. Food delivery was recorded automatically.

Records A, C, and E illustrate the patterns of tube contacts following food delivery under the FI schedule; Records B, D, and F illustrate the patterns of tube contacts following food delivery under the tandem schedule. These portions of the records were chosen to illustrate the temporal distributions of two patterns of tube contacts. In all cases, licking occurred shortly after food delivery or not at all. Paw contacts, however, rarely occurred shortly after food, even in the absence of licking. Whether the majority of tube contacts consisted of tongue or paw movements largely depended on the order in which rats were exposed to the schedules of food presentation. For this reason, Figures 2 and 3 are discussed below with respect to schedule sequence.

Exposure to the tandem before the fixed-interval schedule. (Rats 203, 204, 205, and

Fig. 1. Selected event records illustrating the temporal pattern of paw contacts (P), tongue contacts (T), and food delivery (F) for Rats 203, 205, and 235 under fixed-interval and tandem schedules of food presentation. The investigator depressed one handswitch during episodes of paw contacts and another handswitch during episodes of tongue contacts; food deliveries were recorded automatically. A: Rat 203, Session 99, FI 166.5-sec. B: Rat 203, Session 110, *tand* FR 3 (FI 40-sec), second exposure. C: Rat 205, Session 99, FI 160.5-sec. D: Rat 205, Session 110, *tand* FR 3 (FI 40-sec), second exposure. E: Rat 235, Session 30, FI 167-sec. F: Rat 235, Session 113, *tand* FR 3 (FI 40-sec).

206). The cumulative response records in Figure 2 illustrate performances during each experimental condition for Rats 205 and 203. The response pen was advanced by each contact with the drinking tube and reset by each food delivery. Short diagonal strokes of the response pen indicate the completion of each fixed interval of the tandem schedule; lever presses are represented by deflections of the event pen.

Performances under the initial exposure to the tandem schedule are shown in Records C and F for Rats 205 and 203, respectively. One striking feature of these records is the long pause from food delivery to the first tube contact; in several cases, the first fixed interval of the tandem schedule was completed by a lever press before a tube contact was made. This pattern of tube contacts is quite different from the pattern typically reported following food under intermittent schedules (*cf.* Figure 3, Record A). Observation determined that these tube contacts were not the result of licks but of paw movements. Although Rat 206 emitted fewer tube contacts than did Rats 203 and 205, the pattern of tube contacts was similar for all three rats.

In the present study, tube contacts began either within about 3 sec of food delivery, and are referred to as "postpellet", or after at least 30 sec, and are called "interpellet". During their first exposure to the tandem schedule, Rats 203 and 206 engaged exclusively in interpellet tube contacts. For Rat 205, however, tube contacts underwent a marked change in topography and temporal locus under the tandem schedule. The development of interpellet tube contacts is shown for Rat 205 in Figure 2. During the second session (Record A), a positively accelerated pattern of tube contacts emerged, which became more pronounced during the third session (Record B). By the tenth session under the tandem schedule, interpellet tube contacts predominated. Despite the early appearance of postpellet tube contacts, the final performance of Rat 205 (Record C) under the tandem schedule was similar to that of Rats 203 (Record F) and 206.

Changing from a tandem schedule to a fixed-interval schedule resulted in bursts of tube contacts that occurred sooner after food delivery and varied less in duration over the session (Records D and G). In addition, Rat 203 developed a sustained postpellet pattern

of tube contacts, which consisted of licks at the drinking tube.

On re-exposure to the tandem schedule, the variability in the lengths of the bouts of tube contacts and the pause from food delivery to the first tube contact increased (Records E and H). The frequency of postpellet bursts of tube contacts emitted by Rat 203 decreased considerably as well.

Rats 203, 205, and 206 all emitted interpellet tube contacts with their paws; Rat 204 did not. Even in the absence of paw contacts, however, Rat 204 did not begin to lick the drinking tube for over 30 sessions of exposure to the tandem schedule. The postpellet pattern of tube contacts generated by this rat was similar to that described below for those rats exposed to FI before the tandem schedule (Figure 3). Exposure to the FI schedule had little effect on this rat's pattern of tube contacts, but re-exposure to the tandem schedule resulted in the emergence of interpellet tube contacts and longer pauses from food to the first tube contact.

Exposure to the fixed-interval before the tandem schedule. (Rats 232, 233, 234, and 235). Figure 3 presents records of performances by Rats 232 and 233 under fixed-interval (Records A and C) and tandem (Records B and D) schedules of food delivery. All four rats exposed first to FI emitted a substantial burst of tube contacts shortly after food delivery; these postpellet tube contacts were licks at the drinking tube. Rat 235 displayed both postpellet and interpellet tube contacts (see Figure 1, Records E and F). The interpellet tube contacts were made with the paws. The duration and frequency of postpellet bursts of tube contacts decreased for all four rats on exposure to the tandem schedule.

Lever Pressing

Lever presses are recorded as deflections of the event pen in Figures 2 and 3. The distribution of lever presses depended more on the schedule of food presentation than on the order in which rats were exposed to the schedules. The percentages of lever presses occurring within each fixed interval of the tandem schedule and within each third of the interpellet interval under the fixed-interval schedule were determined for the last 10 sessions of each condition and are presented in Table 3. The percentage of lever presses occurring

within each of the three fixed intervals of the tandem schedule depended on the proximity of the fixed interval to food delivery. The percentages of lever presses within each fixed interval of the tandem schedule were similar for both groups of rats, with few lever presses occurring in the first fixed interval and approximately two-thirds of the lever presses occurring within the last fixed interval of the tandem schedule. The pause from food delivery to the first lever press varied considerably over the session and, for those rats that

emitted interpellet tube contacts, lever presses frequently alternated with tube contacts during the second and third fixed intervals of the tandem schedule.

Under the fixed-interval schedule, a pause in lever pressing after food was generally followed by a fairly uniform pattern of responding. Response rates were lower than under the tandem schedule and the percentage of lever presses was larger during the last third of the interpellet interval than for the third fixed interval of the tandem schedule.

Fig. 2. Performances of Rats 205 and 203 under tandem and fixed-interval schedules of food presentation. Y-axis: cumulative number of tube contacts. X-axis: time. The response pen reset to the baseline upon food presentation, and was deflected downward upon completion of each fixed interval. Lever presses are indicated by diagonal deflections of the event pen. A-C: Rat 205, Sessions 2, 3, 84, *tand* FR 3 (FI 40-sec). D: Rat 205, Session 100, FI 160.5-sec. E: Rat 205, Session 111, *tand* FR 3 (FI 40-sec), second exposure. F: Rat 203, Session 83, *tand* FR 3 (FI 40-sec). G: Rat 203, Session 100, FI 166.5-sec. H: Rat 203, Session 111, *tand* FR 3 (FI 40-sec), second exposure.

Fig. 3. Performances of Rats 232 and 233 under fixed-interval and tandem schedules of food presentation. Y-axis: cumulative number of tube contacts. X-axis: time. The response pen reset to the baseline on food presentation and was deflected downward on completion of each fixed interval. Lever presses are indicated by diagonal deflections of the event pen. A: Rat 232, Session 30, FI 167-sec. B: Rat 232, Session 113, *tand* FR 3 (FI 40-sec). C: Rat 233, Session 30, FI 167-sec. D: Rat 233, Session 96, *tand* FR 3 (FI 40-sec).

Figure 4 presents a comparison of mean water intake in the experimental chamber to that in the homecage over the last 10 sessions of FI and of subsequent exposure to the tandem schedule. The number above each histogram refers to the percentage of the total daily water intake consumed in the experimental chamber. Chamber water intake was greater under the FI than under the tandem schedule

for seven of the eight rats, and the percentage of the daily water intake consumed in the chamber was greater under FI for all rats, even though one rat (235) consumed more water in the chamber under the tandem schedule. Water intake in the chamber was also greater under both schedules for those rats exposed to the FI before the tandem schedule (bottom panel of Figure 4).

Table 3

Percentage of lever presses emitted during each fixed interval of *tand* and during each third of FI based on the last 10 sessions of each experimental condition.

Subject	tand(1)			FI			tand(2)		
	1	2	3	1	2	3	1	2	3
203	8	30	62	1	9	88	3	23	74
204	3	33	64	1	4	95	12	25	63
205	7	37	56	3	18	81	8	28	64
206	2	24	74	1	10	89	3	17	80
232				2	15	83	3	23	74
233				4	20	76	12	25	63
234				2	9	89	8	28	64
235				3	20	78	3	17	80

DISCUSSION

Rats' lever presses and drinking-tube contacts were studied under fixed-interval and tandem schedules of food presentation with comparable interpellet intervals. Rates and patterns of lever pressing depended on the type of schedule but not on the order of schedule presentation: lever presses occurred at higher rates and were distributed more uniformly across the interpellet interval under the tandem schedule. Rates and patterns of drinking-tube contacts depended, however, on both the type of schedule and the order in which the schedules were presented. All rats

exposed first to the FI schedule emitted tube contacts within about 3 sec after food delivery; three of four rats exposed first to the tandem schedule emitted tube contacts only after a considerable time had elapsed since food delivery. Most of the tube contacts emitted by rats exposed first to the FI schedule consisted of licks at the drinking tube; most of the tube contacts emitted by three of four rats exposed first to the tandem schedule consisted of paw

movements along the length of the drinking tube. Changing the schedule from tandem to fixed interval resulted in postpellet tube contacts for only one of three rats; changing the schedule from fixed interval to tandem decreased the frequency of postpellet tube contacts for all rats. For seven of eight rats, water intake in the experimental chamber and the rate at which tube contacts occurred were greater under the FI schedule.

Fig. 4. Chamber and homecage water consumption for each rat under tandem and fixed-interval schedules of food presentation. Y-axis: water intake in millilitres in the chamber (dark histograms) and in the homecage (light histograms). X-axis: schedule of food presentation. The numbers above the histograms refer to the percentage of the total daily water intake consumed during the session. Rats 203, 204, 205, and 206 were exposed first to a tandem schedule; Rats 232, 233, 234, and 235 were exposed first to a fixed-interval schedule of food presentation.

In addition to measuring water intake during a session, most researchers concerned with schedule-induced drinking have also recorded the rat's contacts with the drinking tube. This practice has allowed examination of how tube contacts are distributed in time, as well as their frequency of occurrence. Because the contact sensor records all contacts indistinguishably, however, it may be inadvisable to use electronic recording of tube contacts as a primary measure of drinking without also observing the animals during experimental sessions. Over the last 10 sessions of the present study, Rat 205 emitted almost twice as many tube contacts as did Rat 203, but consumed less water per session. Similarly, during the last 10 sessions of FI, Rat 235 averaged almost 60 more tube contacts per session than Rat 233, but consumed almost 3 ml less water per session. Similar discrepancies were reported by Burks (1970). It is clear that contact sensors record more than just licking.

Two features of the behavior seen under the tandem schedule stand out: the persistent occurrence of interpellet tube contacts, and the low probability of schedule-induced drinking. The emergence of interpellet tube contacts under intermittent food schedules is not a new finding. Segal (1969) presented data from a rat that displayed both postpellet and interpellet tube contacts; interpellet tube contacts eventually predominated under FI 240-sec. Rosenblith (1970) reported a "second type of drinking", which alternated with lever presses maintained by a second-order schedule of brief-stimulus presentation. Keehn and Colotla (1971) distinguished between postpellet and interpellet tube contacts emitted by rats responding under FI 5-min. The tube contacts reported by these investigators, and those observed in the present study, fall into two distinct categories that differ not only with respect to temporal locus, but with respect to pattern and, in the present case, with respect to topography.

Most of the interpellet tube contacts observed in the present study were made with the paws, rather than with the tongue. Other researchers have also noticed a type of tube contact with rats other than licking. Ten Eyck and Schaeffer (1969) observed that paw and nose contacts occurred when food presentation was dependent on "licking", and Colotla, Keehn, and Gardner (1970) observed the oc-

currence of nose contacts when food presentation was dependent on lever pressing. The proximity of the drinking tube to the lever in the present study may have been a factor in the alternation between lever pressing and tube contacts. Wuttke and Innis (1972) suggested this possibility to account for the alternation between lever pressing and interpellet tube contacts reported by Rosenblith (1970).

The low probability of drinking that resulted from exposure to a tandem schedule is inconsistent with the view that rate of food delivery *per se* controls schedule-induced drinking. The rates of food delivery were approximately the same under the tandem and fixed-interval schedules, but the amounts of water consumed under the schedules differed. Both the pause from food delivery to the first tube contact and the topography of the tube contacts differed under the two schedules. It is unlikely that the variable nature of the interpellet intervals under the tandem schedule decreased the probability of drinking, since similar effects have not been found under schedules with variable durations between food deliveries (Falk, 1967). It is also unlikely that the number of responses specified by the tandem schedule decreased the probability of drinking, since schedule-induced drinking has been found under FR schedules, which also specify multiple responses (Carlisle, 1971).

An alternative explanation for the different patterns of tube contacts and different levels of drinking generated by the tandem and fixed-interval schedules is that the two schedules produced different patterns of lever pressing. It is conceivable that the manner in which tube contacts interacted with lever presses depended on the pattern of lever pressing controlled by the two schedules. It is also conceivable that, since the order of schedule presentation was a major determinant of the final tube-contact performance, the pattern of behavior during the development of schedule control may have played a crucial role in the resultant performance. In the present study, and in Segal's (1969), the pattern of interpellet tube contacts was initially positively accelerated. This initial positive acceleration, along with the eventual alternation of tube contacts with lever pressing, suggests that the two behaviors may be related in some way. Interpellet tube contacts were frequently initiated only after a lever press had occurred

under the tandem schedule. In many cases, this was the first lever press to occur after food delivery and also the lever press that initiated the second fixed interval of the tandem schedule. Smith and Clark (1974) also reported the occurrence of lever presses before tube contacts with rats under differential-reinforcement-of-low-rate schedules. It is possible that certain temporal constraints on the distribution of schedule-controlled responding can modulate the sequence of other behaviors that occur between food deliveries.

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Received 2 June 1975.

(Final Acceptance 12 December 1975.)