**BEHAVIOR INDUCED BY PERIODIC FOOD DELIVERY:
THE EFFECTS OF INTERFOOD INTERVAL**

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Pigeons were exposed to fixed-time schedules of food presentation ranging from five to 300 seconds. Although consistent, stereotyped response patterns developed during interfood intervals on all schedules, there were distinct differences in the behavior observed on schedules with short, as opposed to long, intervals. During the shorter intervals, responses were performed quite vigorously, a feeder-directed terminal response was observed, and most activities were localized near the feeder. On the longer schedules, no feeder-directed terminal response developed, although the birds were usually near the feeder at the end of intervals. The predominant response involved moving about the chamber, often pacing along one of the walls. Performance during short intervals is accounted for quite well by the antagonistic-motivational state hypothesis suggested by Staddon (1977); however, performance during longer intervals is not. Behavior during interfood intervals may more accurately be classified as reflecting a single (food) motivational state and described simply in terms of Craig's (1918) appetitive behavior.

Key words: fixed-time schedules, schedule-induced behavior, terminal response, interim activities, appetitive behavior, pigeons

When hungry pigeons are exposed to periodic-food schedules, a reliable sequence of behavior develops during the interfood interval (Blaine, Innis, & Staddon, 1980; Reberg, Innis, Mann, & Eizenga, 1978; Staddon & Simmelhag, 1971). Staddon and Simmelhag defined two distinct classes of behavior induced by the reinforcement schedule: interim activities and the terminal response. The terminal response is typically stereotyped, often similar in form to the consummatory response; it increases in frequency with postfood time and usually occurs at the time food is presented. Interim activities occur during the early portions of intervals at times correlated with the absence of food and

are generally incompatible with the terminal response. Recently, Staddon (1977) has identified a third class of behavior, facultative behavior, which is not schedule-induced. Activities in this class occur during the middle portions of intervals if time is available.

Evidence has been accumulating that the amount and temporal location of activities on periodic-food schedules are determined by the properties of the terminal response. For example, as food rate increases (interfood interval decreases), the terminal response tends to begin relatively earlier in the interval, which leaves less time for interim and facultative activities. For example, Penney and Schull (1977) have shown that wheel running, an activity that occurs during midinterval for rats, tends to decrease as food rate increases. Other experiments seem to show that as food rate increases, the variability of behavior (measured in several ways) tends to decrease (Motheral & Staddon, Note 1).

The present experiment is a systematic attempt to assess the effect of interfood interval (rate of food presentation) on the types, frequencies, and distributions of activities observed in pigeons during interfood intervals.

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We also present data on competitive and sequential interactions among activities.

METHOD

Subjects

Eight adult male, experimentally naive White Carneaux pigeons, maintained at 80% of their free-feeding weights, were studied. Water was freely available in the home cages and the lights in the housing room were on 24 hours a day.

Apparatus

The experimental chamber was a large (61 by 61 by 61 cm) enclosure with three walls constructed of clear Plexiglas and the fourth of wood painted grey; its key features are shown in Figure 1. In the left-hand side of the wooden wall was an aperture that permitted access to a standard Gerbrands pigeon feeder containing mixed grain; in the right-hand side of this wall was the entrance door for the apparatus. This wall was designated the feeder wall (FW). A TV camera was directed at the Plexiglas wall to the right of the wooden wall, and this wall was designated the observation wall (OW). The wall to the camera's left (i.e., left of OW and opposite FW) was labeled left wall (LW) and the remaining wall, the back wall (BW). The corner of BW and FW was therefore the area of the box closest to the feeder.

Procedure

Four birds (44, 67, 99, and 115) were exposed to a fixed-time (FT) schedule of periodic food delivery, which provided three-sec access to the feeder every five sec (FT 5-sec schedule), for 58 sessions. The other four birds were exposed to either two or three different-valued FT schedules, with interfood intervals of 5, 12, 60, or 300 sec. The schedules to which each of these latter birds was exposed, the number of sessions involved, and the order of conditions (in parentheses) are shown in Table 1. The birds' behavior was visually monitored via closed-circuit TV throughout the experiment. When performance on a schedule had remained stable for at least two weeks, the birds were videotaped and the tapes analyzed. The number of sessions received on each schedule varied considerably. Generally, birds took longer to stabilize on the earlier schedules to

Fig. 1. Schematic representation of the response chamber. The dashed line indicates area of chamber in which birds were usually located at ends of intervals.

which they were exposed and on those schedules with longer interfood intervals. In addition, birds were given more extensive experience on their first schedule, since we were not sure to what extent behavior would drift over time. As there was very little drift in behavior, fewer sessions were given on subsequent conditions. All birds received one daily session of 60 intervals, seven days a week, and were run at about the same time each day.

Observation and recording of behavior. The pigeons were observed via a closed-circuit TV system and asymptotic performance was videotaped for detailed analysis. The use of videotapes in the recording of observational data ensures that the final records are highly reliable, since the initial observations can be rechecked for any inaccuracies. Observational data were recorded for at least three sessions once behavior had stabilized on each schedule. These sessions were within the last 10 sessions of exposure to a schedule. Behavior was re-

Table 1

Interfood interval duration, number of sessions, and order of conditions (in parentheses).

Interfood Interval	Birds			
	101	102	112	116
5 sec	—	113(1)	45(2)	—
12 sec	112(1)	—	28(3)	45(2)
60 sec	64(2)	—	112(1)	27(3)
300 sec	—	71(2)	—	107(1)

coded by means of push buttons and a multi-channel printing counter which printed every second.

Table 2 provides a list of the observed classes of behavior, which have been organized into an orientation category and four behavior categories. In general, the behavior and orientation categories, considered separately, were mutually exclusive and exhaustive; i.e., a bird was scored as facing in one of the four directions and engaging in a behavioral response. A few pairs of responses could occur together; these were: corner and wing flapping (Cor & WFp, e.g., Bird 112), pacing and wing lifting (Pac & WLt, see Table 2, WLt), and shift feet and head movements (SFt & HMFw, FT 5-sec

schedule). During locomotion (L) from one orientation to another, an orientation response was not recorded. It was possible for more than one type of behavior (and the corresponding orientation) to be recorded successively within one second. However, since the printing counter printed only once a second, the duration of activities within a given second was not recorded. The occurrence of two activities during a single second (discounting the above exceptions) occurred when a bird switched from one activity to another in the middle of a second, and thus the sequence of these activities was evident. Although it was possible for discrete responses, such as pecks, to occur more frequently than once a second, the response

Table 2
Behavior Categories and Response Descriptions

Category	Behavior	Description
Orientation	FW	faces wall containing feeder (all birds)
	BW	faces back wall (44, 101, 102, 112, 116)
	OW	faces observation wall (44, 101, 102, 112, 116)
	LW	faces wall to left of observer (44, 101, 102, 112, 116)
Feeder Directed	PeF(F)	<i>pecks feeder</i> , pecks at or just above feeder (67, 102)
	PeFW(F)	<i>pecks feeder wall</i> , pecking movements at feeder wall (44)
	OrF(F)	<i>orients to feeder</i> , stands still with head pointing toward feeder, body may or may not be oriented in same way (112); turns toward feeder (101); jerky head movements toward feeder (99, 115)
	HiF	<i>head in feeder</i> , in most cases the head is pushed down into opening to the feeder or, occasionally, beak is close to and pointing to aperture (101, 102, 112, 116)
Locomotor	Pac	<i>pacing</i> , head and body movements as bird paces back and forth along one of the chamber walls; the extent of the excursion varied within and between birds—it could be one or two steps back and forth or movement along the complete length of the wall; when combined with orientation gives location, e.g. PacFW, pacing along feeder wall (101, 102, 112, 115, 116)
	L	<i>locomotion</i> , any movement of the feet which changes the bird's position or orientation and does not fall under one of the other movement categories; early in intervals often involves backing away from feeder (44, 101, 102, 112, 116)
	T	<i>turn</i> , a movement which brings bird from FW along BW ending at LW (101)
	C	<i>circle</i> , a full 360° circle (116)
Localized	RS	<i>remain still</i> , stretched neck, raised head and remained relatively motionless (101)
	SFt	<i>shift feet</i> , moves feet but does not change position (44, 67, 99)
	Cor	<i>corner</i> , pushes up in corner between FW and BW, breast bone often right up against walls, may be wing flapping but otherwise not moving, orientating to either BW or FW often in alternation (112, 116)
	HMFw	<i>head movements feeder wall</i> , slight head movements from side to side (similar to dizzy motion, Staddon & Simmelhag, 1971) or up and down; bird usually some distance from wall orienting toward feeder (44, 67, 99, 101, 102, 116)
General	WFp	<i>wing flapping</i> (44, 101, 102, 112, 115, 116)
	WLt	<i>wing lifting</i> , bird lifts wings slightly up from body but not high or vigorously enough to classify as wing flapping; may be an incipient or "intension" wing flap, or when accompanying Pac a means of maintaining balance (101, 112, 115, 116)
	G	<i>grooming</i> , i.e., preening (44, 102, 112, 116)
	PeFl	<i>pecking floor</i> (67, 99, 101, 102, 112, 115, 116)

was simply recorded as occurring during that second (with the number of times that it occurred ignored). Not every bird displayed all the classes of behavior listed in Table 2, and the form of a particular response (e.g., pacing) differed slightly from one bird to another. The identification numbers of the birds showing a particular response are listed in parentheses after the response description.

RESULTS

The following general findings became evident when the behavior patterns on the four schedules were examined in several ways. (1) At longer intervals there was an increase in the number of activities observed and the patterns in which they occurred became less stereotyped, so behavior could be characterized as more variable; (2) a feeder-directed terminal

response was observed only on the shorter schedules, primarily FT 5-sec; HiF (a tendency to remain at the feeder briefly, immediately after it was lowered) usually developed only during longer intervals; (3) activities in the locomotor category increased as interval duration increased; both the total amount of time spent moving about the box and the variability in the direction of these movements were augmented.

The data were examined in four ways. (1) Figures 2 to 5 show the probability of occurrence of various activities as a function of postfood time. (2) Table 3 records the proportion of intervals in which each activity was observed. (3) Sequential relations between activities are shown in Figure 6. (4) Finally, the relationship between the time an activity began and the duration of the activity bout is shown in Table 4.

Table 3

The proportion of interfood intervals (of a possible 30) during which each activity was observed for each bird exposed to FT schedules of food presentation. For birds receiving more than one schedule, the order of presentation is indicated in parentheses after the bird's number.

Activity Bird:	FT 5-sec						FT 12-sec			FT 60-sec			FT 300-sec	
	44	67	99	115	102(1)	112(2)	101(1)	112(3)	116(2)	101(2)	112(1)	116(3)	102(2)	116(1)
Orientation														
FW	.93	1.00	1.00	1.00	1.00	.97	1.00	.70	1.00	1.00	1.00	1.00	1.00	1.00
BW	.03					.93	1.00	.97	1.00	.67	1.00	1.00	1.00	1.00
OW	.17									.47	.83	.50	.87	.93
LW	.10									.17	.43	.03	.93	.90
Feeder Related														
FeF		1.00				.97								
PeFW	.70													
OrF			1.00	.93		.50	.50							
HiF					.40		.80	.03	.17	.83	.17	.87	.03	.93
Locomotor														
PacFW				1.00				.20		1.00	1.00	.43	.93	.83
PacBW							1.00		1.00	.63	.93	1.00	.90	.87
PacOW										.33	.53	.40		.90
PacLW										.07		.01		.50
L	.10				.03	.93		.93	.80	1.00	1.00	1.00	.97	1.00
T							.80							
C									.10					
Localized														
RS														
SFt	.67	.97	.97				1.00							
Cor						.97		1.00				.97		
HMFw	.67	.93	1.00		.70				.87	.83		.70	.17	
General														
WFp	.13			.73		.97	.37	1.00	.77	.07	.90	.47	.07	.03
WLt				.57		.17	.13	.47	.50		.93	.20		
G	.03										.07	.10	.60	.57
PeF		.03	.03	.07	.13	.17		.20	.20	.17	.23	.07	.53	.23

Fig. 2. Probability (out of 30 opportunities) of each class of behavior as a function of postfood time for each bird exposed to the FT 5-sec schedule. See Table 2 for description of classes of behavior.

Fig. 3. Probability (out of 30 opportunities) of each class of behavior (left) and orientation response (right) as a function of postfood time for each bird exposed to the FT 12-sec schedule. See Table 2 for description of classes of behavior.

Fig. 4. Probability (out of 30 opportunities) of each class of behavior (left) and orientation response (right) as a function of postfood time for each bird exposed to the FT 60-sec schedule. See Table 2 for description of classes of behavior.

Fig. 5. Probability (out of 30 opportunities) of each class of behavior (left) and orientation response (right) as a function of postfood time for the birds exposed to the FT 300-sec schedule. See Table 2 for description of classes of behavior.

(1) Temporal Patterns of Behavior

The probabilities of occurrence of the various activities displayed by each bird are shown as a function of postfood time in Figures 2 through 5. Data are from the last 10 intervals of each of three sessions of stable responding. The number of occurrences of each activity and orientation during each second of the intervals was tallied and divided by 30 (the number of intervals in the sample and so the number of opportunities for occurrence). In

most cases, responses involving locomotion are represented by filled symbols, and responses occurring while a bird remained in more or less the same location are represented by unfilled symbols. For the birds exposed to more than one schedule, the order in which a particular schedule occurred is given in parentheses after the bird's number.

Figure 2 shows the performance of the six birds exposed to the FT 5-sec schedule. Five birds were naive at the beginning of training, whereas Bird 112 had previously been exposed

Table 4

Correlations between the time in the interval (first second) in which an activity first occurred and the number of consecutive seconds during which it continued (bout length) for nonterminal responses.

Activity	FT 5		FT 12			FT 60			FT 300		
	Bird:	102	112	101	112	116	101	112	116	102	116
<i>Locomotor</i>											
PacFW							+. ₂₄	−. ₁₇		−. ₂₀	+. ₁₇
PacBW					−. ₁₆		−. ₂₈	+. ₂₁	−. ₃₃	−. ₂₂	−. ₁₉
PacOW								+. ₀₉			−. ₃₃
PacLW											−. ₂₃
L		−. ₁₀			−. ₄₆	−. ₆₇ **		−. ₂₁	−. ₁₆	−. ₁₂	+. ₄₅ *
T				−. ₄₀ *							
C						+. ₆₁ **					
<i>Localized</i>											
SFt											
Cor					+. ₁₃				+. ₀₂		
HMFW		−. ₂₈ *					+. ₁₉		−. ₂₉		
<i>General</i>											
WFp		−. ₇₉ *		−. ₀₇	−. ₀₁	+. ₄₃ *		−. ₂₄			
WLt								+. ₃₈ *			
G										+. ₂₉	+. ₀₁
PeFl										+. ₃₂	

*Significant at the .05 level.

**Significant at the .01 level.

to the FT 60-sec schedule. The five naive birds faced the feeder wall throughout intervals. Bird 112 faced the corner of the feeder and back walls, and so oriented toward either of these walls with about equal probability. Each bird developed a stereotyped pattern of behavior consisting of three or four different activities. All birds showed a clearly defined feeder-directed terminal response (F), which involved pecking or orienting to the feeder (see Table 2 for details as these responses differed slightly for individual birds). This response often began three or four sec before food presentation and was more likely to be observed as time in the interval passed, until during the last second of the interval it was occurring with a high probability.

Early in intervals, typically one or two of the recorded types of behavior were observed. These occurred with a high probability during the first second after food presentation and quickly decreased as the interval progressed. The behavior of Bird 115 was an exception to this pattern. This bird began pacing along the feeder wall early in each interval and continued this activity at a high rate until food was presented.

The performance of the three birds exposed to the FT 12-sec schedule is shown in Figure 3.

Responses from the behavior categories are shown on the left and the orientations are shown on the right. Birds 112 and 116 moved away from the feeder area immediately following food presentation, but Bird 101 moved from the feeder wall around to the left wall (L) early in the interval and then began to pace along the back wall (PacBW) at a high rate throughout most of the interval. Bird 116 also spent a large proportion of the middle of the intervals engaged in PacBW, whereas Bird 112 continued to show the Cor response accompanied by wing-flapping (WFp) observed on the FT 5-sec schedule; Cor and WFp activities were observed on about half the intervals three sec after food presentation and continued until the end of the interval. The other two birds each developed a clearly defined terminal response that began about three sec before food was presented; for Bird 101 this involved a cessation of PacBW and on some intervals a turn to FW, orienting toward the feeder (OrF). Bird 116 stood facing the feeder wall, making head movements similar to the dizzy motion response reported by Staddon and Simmelhag (1971).

Performance during intervals of the FT 60-sec schedule is shown in Figure 4. Data from every fifth second of the interval are presented.

Fig. 6. Sequential relationships among activities during the last 10 intervals of three sessions of stable responding during each of the four schedules studied. Data are for the bird first exposed to each schedule. See Table 2 for description of classes of behavior.

All birds showed a tendency to back away from the feeder soon after the tray was lowered, before turning to face and move toward one of the other walls. On at least some intervals, after about 10 sec in the interval had elapsed, all three birds were observed pacing along the observation wall (OW). Both Birds 101 and 112 had a distinct terminal response, pacing along the feeder wall, which increased in probability across the interfood interval. Bird 116 began to show the corner response (Cor) on about one third of the intervals, but PacBW was also a terminal response that began earlier in the interval than Cor.

In Figure 5 the probability of occurrence of various activities at every 25th sec of intervals in the FT 300-sec schedule is shown. As both the orientation and behavior graphs indicate, there was an increasing tendency on the part of both birds to face either BW or FW as the interval progressed. When facing BW, the birds were usually pacing along it. Bird 102 also paced along FW, whereas Bird 116 was less active when facing FW. During the first min or two of the interval there was a considerable amount of general locomotion that took the birds to LW and OW. General locomotion continued to occur, but with a lower probability, throughout the interval. Grooming was also frequently observed during these long interfood intervals.

(2) Overall Occurrence of Activities

The proportion of intervals (out of 30) during which each activity was observed is given in Table 3. Data are for the same intervals in each schedule represented in Figures 2 through 5 and extend the findings shown there. In addition, data for activities that occurred only occasionally or very briefly (and so are not included in the figures) are presented. For example, HiF (head in feeder) occurred briefly following food delivery for Bird 116 on the FT 60 and FT 300-sec schedules; however, this response never continued for enough seconds to be included in the temporal patterns shown in Figures 4 and 5.

Table 3 shows clearly that (1) terminal feeder-directed responses (PeF, OrF, PeFW) were observed only on the shorter schedules, whereas HiF usually developed only during longer intervals (Bird 102 is an exception to this generalization); and (2) activities in the locomotor category occurred consistently on a

large proportion of intervals on the three longer schedules. During FT 5-sec intervals several birds made the SFt (foot-shift) response. Although this behavior was observed to be very vigorous, the birds remained in the same location.

(3) Sequential Effects

The increase in variability in behavior patterns with increased interval duration is clearly evident in the diagrams in Figure 6. This figure shows the sequential relationships among activities for the bird initially exposed each of the four schedules. Data for birds subsequently exposed to a particular schedule were very similar in terms of the increase in the number of activities and the ways in which they were related. No account is taken of either inter-behavior times or activity duration in this method of representation, and the arrows merely indicate the sequence of behavior. Data are from the intervals represented in Figures 2 through 5.

As well as an increase in the total number of activities observed, the pattern in which these activities were performed changed as interval duration increased. On the FT 5-sec schedule a distinct sequence of activities was observed; later-occurring activities never preceded those that occurred earlier (i.e., all the arrows are pointing in one direction in the diagrams). As intervals became longer there was a greater tendency for the birds to switch back and forth between activities, e.g., changing the orientation of the Pac responses or engaging in bursts of wing-flapping during Pac. Nevertheless, clear sequential effects were observed within the intervals on these longer schedules as well. Certain activities, such as head-in-feeder (HiF) and pecking the floor (PeFl), were typically observed very early in intervals. These were generally followed by locomotor responses that took the bird away from the feeder area, e.g., to PacOW. Finally, near the ends of intervals, activity was concentrated in the area of the feeder and involved pacing along both the feeder wall and the back wall.

(4) Relationship between Time of Activity Onset and Bout Duration

Pearson product-moment correlation coefficients are given in Table 4 for the relationship between the time of onset of an activity (sec-

ond in which it first occurred in an interval) and the duration of that activity bout (number of consecutive seconds in which it continued). These data are only for responses the onset or offset of which was not determined by food presentation (e.g., HiF is not included since it always began at the end of food presentation). More statistically-significant correlations were obtained with data from the two shorter schedules. Four of the six statistically-significant correlations for responses on these schedules were negative. Thus, for these activities (HMF_W, 102; WF_p, 112; T, 101; L, 116), bouts tended to be shorter if they began late in the interval. For two other activities (C and WF_p, 116), bout durations were significantly longer the later the activity began. The only two significant correlations for the longer intervals were also positive (WL_t, 112; L, 116).

DISCUSSION

Pigeons display consistent response patterns during interfood intervals of fixed-time reinforcement schedules ranging from five to 300 sec. There are distinct differences, however, in the kinds of activities observed and the nature of the patterns that develop during short, as opposed to long, intervals. Two schedules with relatively short intervals (FT 5 and FT 12-sec) and two schedules with relatively long (FT 60 and FT 300-sec) intervals were studied. During the shorter intervals (1) responses, in general, were performed quite vigorously (although no quantitative measures of vigor were made, observation of the videotapes showed that the birds moved more quickly and forcefully during short intervals); (2) a distinct, feeder-directed terminal response was observed; (3) most activities were localized in the vicinity of the feeder; and (4) these activities occurred in a regular order. In contrast, during the longer intervals (1) responses were less vigorous; (2) no distinct feeder-directed terminal response developed, although the birds were usually in the area of the chamber near the feeder at the end of intervals; (3) the predominant responses involved locomotion, either moving about the chamber or pacing along one of its walls; and (4) there was a greater tendency for birds to switch back and forth between activities.

On the basis of findings with both pigeons (Staddon & Simmelhag, 1971) and rats (Stad-

don & Ayres, 1975) exposed to FT schedules with relatively short intervals, Staddon (1977) proposed a motivational hypothesis to account for the behavior observed on periodic schedules of food presentation. He suggested that two types of behavior are induced (facilitated) under these conditions, and corresponding to each of these is an unique underlying motivational state. Late in intervals, when food is expected, the animal is in a "food state" and performs a food-related terminal response. Early in intervals, when food is never anticipated, the animal is in an antagonistic "non-food state." The behavior that occurs at this time, interim activity, depends on the environmental supports available to the animal (e.g., if water is available a rat will drink). As the time since food presentation increases, this antagonistic motivational state (and its associated behavior) begins to dissipate, whereas the food state (and the terminal response) gradually increases in strength. If the interfood interval is quite short, there is a period in mid-interval when behavior associated with these two states may be in direct conflict. On the other hand, if the period between food presentations is quite long, neither motivational state may dominate at midinterval, and other, non-schedule-induced (facultative) behavior may have time for expression.

The results of this present study provide only partial support for Staddon's hypothesis. The data from the schedules with relatively short intervals, on which performance is quite similar to that reported by Staddon and Simmelhag (1971), are accounted for quite well by the antagonistic-motivational state hypothesis. Performance on the longer schedules, during which no feeder-related terminal responses developed, is not handled quite so readily. On these longer schedules the birds were always pacing along the walls of the chamber near the feeder (FW and BW) at the ends of intervals. In fact, orienting to these walls was at a high level about one third of the way through 60-sec intervals (see Figure 4, right panel) and only slightly later than this during 300-sec intervals. Early in the longer intervals, three of the four birds moved away from the feeder and directed their pacing response to the more distant walls of the chamber. Since no stimuli (e.g., water, another bird) with which to interact were available to the animal during this time, it is impossible to determine if the pi-

geons were in a nonfood-related motivational state. However, very early in intervals some of the birds continued to make feeder-directed responses (HiF) for a few seconds or peck the floor near the feeder (Figure 6 and Table 3), suggesting that a nonfood state is not instituted immediately on the longer schedules.

Early in this century Wallace Craig (1918) observed the behavior of pigeons and doves in a variety of motivational states and suggested that the activities performed by a motivated animal fall into two categories: appetitive and consummatory behavior. Both types of activity are controlled by the same motivational state (e.g., hunger) but occur at different times—consummatory behavior in the presence of the appetized stimulus (food) and appetitive behavior in its absence. Appetitive behavior is characterized as involving “restlessness, varied movements, effort, search” (Craig, 1918, p. 101). Craig also observed incipient consummatory actions during the appetitive phase of a behavior cycle.

Most of the activities observed in pigeons on FT reinforcement schedules could readily be classified as appetitive behavior. Birds typically engage in a good deal of “restless” movement. In the present study, this included shifting from foot to foot during very short intervals (see Figure 2) and pacing back and forth along the walls of the chamber during longer intervals (Figures 4 and 5). When intervals are short and the time of food presentation most discriminable, incipient feeding responses are likely to occur and may be directed at the feeder (see also Reberg et al., 1978).

Other attempts to explain performance on FT schedules have also emphasized a single motivational state. Killeen (1975, 1979) has recorded the level of general activity of rats and pigeons on schedules with intervals ranging from 50 to 300 sec. He suggests that incentives, such as food, produce a heightened state of arousal that invigorates ongoing activity. The shorter the interval the greater the incentive, the arousal, and therefore, the vigor of the behavior observed. This theory is similar in many respects to Bindra's (1974, 1976) theory of incentive motivation, with its notion of a central motive state; both theories emphasize the role of environmental stimuli in determining the nature of the behavior invigorated by an incentive.

Although no direct measure of the intensity

of activity was made in this study, general observation indicated that the birds' behavior was more vigorous during the shorter intervals. This was particularly true of the five-sec intervals; although there was no movement away from the feeder, three of the birds stood near the feeder rapidly shifting from foot to foot during the first one or two seconds of the interval before turning toward the feeder as time for food delivery approached. Activity during longer intervals was less vigorous but involved movement of the bird to locations in the chamber remote from the feeder. The lower levels of arousal induced by the longer schedules, or its dissipation soon after food is removed on these schedules, may permit the birds to engage in exploratory behavior that under natural conditions might involve a greater chance of finding a new source of food.

Since no environmental stimuli relevant to motivational systems other than feeding were present in this study, the results presented here do not permit us to conclude that the birds were in different phases of a “food state” throughout intervals. Findings reported by Blaine et al. (1980) suggest that if other stimuli are available, pigeons rarely interact with them on an FT 27-sec schedule; movement away from the feeder area was the only interim activity occurring with a high probability in the Blaine et al. study. Flory (1969) examined schedule-induced aggressive behavior in two pigeons during interfood intervals ranging from 15 to 960 sec and found that attacks occurred rarely during very short or very long intervals and were most frequent at 60- or 120-sec intervals (for each of the two birds, respectively). Yoburn and Cohen (1979) reported attack behavior during intervals ranging from 30 to 360 sec and Yoburn, Cohen, and Campagnoni (1981) observed schedule-induced attack early in interfood intervals by five of six pigeons exposed to an FT 90-sec schedule of food presentation. Thus, as with schedule-induced drinking in rats (Falk, 1966), the occurrence of schedule-induced attack in pigeons may be most likely during intervals of moderate duration (e.g., about 30 to 300 seconds). Studies that provide access to a variety of environmental support stimuli for pigeons on FT schedules of different durations within and outside this range may help define the limits of the development of schedule-induced behavior. Finally, the occurrence of

schedule-induced attack by pigeons early in intervals is not necessarily incompatible with the view that a single motivational state prevails throughout intervals. In natural settings competition for food among hungry pigeons is often observed to provoke attack, and this kind of behavior is least likely when the availability of food is either very high or very low.

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