A CROSS-SPECIES INVESTIGATION OF BEHAVIORAL ADAPTATION TO FIXED INTERVAL, FIXED TIME AND VARIABLE TIME FOOD DELIVERY SCHEDULES

by

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B.S., University of Florida, 1978

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Psychology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

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Acknowledgements

I wish to thank Drs. Jerome Frieman, Charles Perkins, and James Mitchell for their assistance. A special thanks is extended to Jerry Frieman for his advice and encouragement during my stay at Kansas State University.

A sincere appreciation is extended to my parents and grandmother for their financial assistance, support, encouragement, and love during this period of study.

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In 1948, B.F. Skinner reported that when a hungry pigeon is allowed a 5 second access to food every 15 seconds, stereotyped behavior becomes temporally correlated with its delivery. His birds developed behaviors such as counter-clockwise turning, pendulum motion of the head and body, incomplete pecking movements and thrusting of the head into the upper corners of the experimental chamber.

Skinner used this result as further evidence of his position that reinforcers automatically strengthen the emitted behaviors which precede them. The explanation given by Skinner for the results of this experiment was straightforward: The bird happens to be executing some response as the hopper appears and as a result it tends to repeat this response. Skinner (1958) stated:

> We must assume that the presentation of a reinforcer always reinforces something, since it necessarily coincides with some behavior. We have also seen that a single reinforcement may have a substantial effect. If there is only an accidental connection between the response and the appearance of a reinforcer, the behavior is called "superstitious". (p. 85)

Although Skinner's "superstition experiment" was frequently cited by various authors and replicated numerous times, a futher analysis of the situation per se was not undertaken until twenty-three years later when Staddon and Simmelhag (1971) published their reexamination. Staddon and Simmelhag wrote:

> The apparent simplicity and reliability of the phenomenon, coupled with the plausibility of Skinner's interpretation of it, and the more

> exciting attractions of work on reinforcement schedules then developing, effectively stifled further study of this situation. (p. 4)

Their 1971 paper attempted to throw some light on experiments which in the years previous to this time appeared generally in opposition to Skinner's version of the law of effect. There were two kinds of data which they saw as fitting this category. First, Staddon and Simmelhag made reference to "mediating" behavior in experiments with time related reinforcement schedules. These behaviors are those which occur during the waiting period after the previous reinforcement when the animal is not making the reinforced response. One of the best examples of this was provided by Falk (1969) who demonstrated schedule-induced polydipsia: Rats which were allowed continuous access to water while on temporal reinforcement schedules for food showed excessive drinking.

Another example was given by Azrin, Hutchinson and Hake (1966) who demonstrated extinction-induced aggression in pigeons. If birds were conditioned to peck a response key under a procedure that alternated periods of food reinforcement with periods of extinction, they were found to attack a nearby pigeon or even a stuffed replica of a pigeon.

Staddon and Simmelhag speculated that some of Skinner's observations on superstitious behavior could instead be reflecting the same causal factors as these

"mediating" activities rather than the accidental reinforcement of spontaneously occurring behavior.

The second group of experiments Staddon and Simmelhag referred to were those operant conditioning situations where the behavior which developed was more reminiscent of the Pavlovian notion of stimulus substitution. Various examples of such situations are described by Breland and Breland (1961) in their paper, "The misbehavior of organisms". They supply as one example a case in which a pig is conditioned to pick up wooden coins and deposit them in a large "piggy bank". It was found that pigs learned very rapidly and were able to easily meet a ratio of four or five wooden coins to one reinforcement. Over time, however, all the pigs became slower and slower at completing the task. They would repeatedly drop and root the coins on their way to the bank. These "extra" behaviors became so strong in fact that even under severe deprivation they continued, eventually to a point where the pigs were not getting enough to eat in the course of a day.

Of even more interest to the laboratory researcher are the results obtained by Brown and Jenkins (1968) using a procedure called autoshaping. In this case, pigeons come to peck a response key illuminated only a few seconds before food delivery. The autoshaping procedure is, of course, the same as that used in classical conditioning: A key light is illuminated for a few seconds (CS), followed

by the presentation of food (US). Williams and Williams (1969) showed that this autoshaped key pecking could still be maintained even if the key pecking prevented food delivery.

The main point to be made with regard to these studies is that experimenters have often observed food-related behaviors occurring which interfere with the delivery of reinforcement. Staddon and Simmelhag subsequently recognized that Skinner's superstition situation was a case of temporal conditioning (a Pavlovian procedure); therefore, the superstitious behavior Skinner had observed and reported might have not only included the so called "mediating" behaviors, but also food-related activities which emerged just before food delivery.

In order to investigate this further, Staddon and Simmelhag used three schedules: (a) a response-independent fixed-time (FT) 12-seconds, (b) a response-independent variable-time (VT) 8-seconds, and (c) a response-dependent fixed-interval (FI) 12-seconds. Data was obtained detailing both the kind and time of occurrence of various behaviors exhibited by the birds. Table 1 lists the names and descriptions of the 16 classes of activities observed by Staddon and Simmelhag.

At steady state, the behavior which developed fell reliably into two categories. In one case, responses occurred with a low probability immediately following food

Table 1. Activities observed and recorded by Staddon and Simmelhag (1971).

Description of Observed Activities		
Response No.	Name	*Description*
R1	Magazine wall	Orientation response in which the bird's head and body are directed towards the magazine wall
R2	Pecking key	Pecking movements directed at the key
R3	Pecking floor	Pecking movements directed at the floor
R4	1/4 Turn	A response for each 1/4 turn away from the front wall
R5	Flapping wings	Up and down movement of the bird's wings
R6	Window wall	Orientation response in which the bird's head and body are directed towards the door of the experimental chamber
R7	Pecking	Pecking movements directed toward some point on the magazine wall
R8	Moving along magazine wall	A side-stepping motion, a few steps to the right followed by a few to the left
R9	Preening	Beak in contact with the feathers
R10	Beak to ceiling	Bird moves in no particular direction with beak touching ceiling
R11	Head in magazine	Any part of the bird's head is in the magazine opening

Table 1. Activities observed and recorded by Staddon and Simmelhag (1971).

Response No.	Description of Observed Activities Name	Description
R12	Head movements along magazine wall	Bird faces magazine wall and moves its head from left to right or up and down
R13	Dizzy motion	Head vibrates rapidly side to side
R14	Pecking window wall	Pecking directed at the door with observation window
R15	Head to magazine	Bird turns head towards magazine
R16	Locomotion	Bird walks about in no particular direction

delivery and gradually increased in probability during the 12-second interval. These responses which had the highest probability just before food delivery were labeled "terminal responses". Other responses reached maximum probability within the first 6-seconds of the interval. These responses typically decreased to zero by the 10th second and were thus called "interim responses".

The terminal responses were typically an orientation towards the wall of the chamber where the food magazine was positioned (R1) and a pecking movement of the head (R7). Responses such as these would be preparing the bird for the appearance and consumption of food, and it seems fitting that they should occur more frequently as time neared for its delivery. Interim responses, on the other hand, were considerably more variable from bird to bird. Staddon and Simmelhag's contention is that these interim responses are similar to what have in the past been called adjunctive, displacement or vacuum activities.

Recently Fenner (1980) recorded the behavior of pigeons exposed to response-independent schedules of reinforcement and found good temporal patterning like that obtained by Staddon and Simmelhag. Anderson and Shettleworth (1977) observed the occurrence of terminal and interim behaviors when golden hamsters were placed on either a response-dependent or response-independent 30-second schedule and allowed to roam freely in a large

enclosure. They also found that the behavior which occurred was independent of whether food was contingent or noncontingent on lever pressing. Other support for the terminal-interim distinction is provided in the reviews by Falk (1971) and Staddon (1977).

Staddon and Simmelhag observed behavior patterns induced in the context of periodic food deliveries and the experimental environment they used was the operant conditioning chamber. Studies have also been completed, however, which make use of multiple response environments. Staddon and Ayres (1975) gave rats periodic response-independent food deliveries in a situation which allowed them to be in one of six areas. The appropriate behavior in three of these areas was measured. The rats could drink from a water bottle, run in a wheel or explore a tunnel. The most common behavior found to be engaged in was excessive drinking (schedule-induced polydipsia). This occurred early in the interfood interval. Running in the wheel and general activity near the feeder occurred toward the end of the interval.

Shettleworth's (1975, 1978a, 1978b) work with golden hamsters has also provided some excellent data with regard to their performance in various situations. She has investigated the organization of behavior in this species under conditions of food deprivation, punishment, free food, exposure to a strange environment, and shock and food

as unconditioned stimuli. It was found behaviors were often ordered in a particular temporal sequence depending on both the animals' condition and that of the environment.

Beyond the work of Staddon and Simmelhag (1971), Shettleworth (1975, 1978a, 1978b), Anderson and Shettleworth (1977), and Staddon and Ayres (1975), few studies have been concerned with the behavior occurring during the interfood interval on periodic schedules. In general, researcher's interests have focused on an explicitly reinforced response (bar pressing or key pecking). Why this is the case is a question in itself; however, the suggestion that more observational kind of data gathering in situations of periodic reinforcement is needed has certainly not gone unpublished.

> A fairly comprehensive study of what happens when various elements of a single species' behaviour are reinforced with various reinforcers might be expected to show what, if anything, responses that are difficult or impossible to condition have in common in other respects. Thus it might help to show why conditionability may be limited. To make it possible to examine the role of purely motivational factors, such an investigation should include observations of the direct, as opposed to contingent, effects of the reinforcers. (Shettleworth, 1973, p. 246)

> It should be clear that any environment is in fact a multiple response environment. Even when the experimenter provides only one explicit response, it is possible to measure additional responses made by the organism. Careful observation and measurement of what the organism does beyond what the experimental situation requires may contribute greatly to our appreciation of the control and organization of behavior. (Fantino and Logan, 1979, p. 484)

Research based on Staddon and Simmelhag's pro-

> cedure of placing subjects in a situation where food is occasionally but predictably given, and then observing how various responses change, interact, and become ordered in a temporal sequence seems extremely valuable. Their approach should provide empirical data of the kind necessary to determine the existence of functionally similar and different classes of behavior.
> (Hearst, 1979, p. 46)

Even less attention has been given to species differences in performance on periodic schedules of reinforcement. Certainly the examples of species-specific behavior patterns provided by Breland and Breland (1961), Bolles (1970), Seligman (1970) and others, which do not fit neatly into the traditional learning paradigms, deserve further investigation.

Breland and Breland (1961) observed chickens to scratch in the vicinity of food when they feed. In our laboratory, Klacsmann (1978) was able to autoshape chickens, but not pigeons, to scratch a treadle. Klacsmann also found that behavioral contrast occurred with treadle pressing in chickens. His results supported the idea that in order to predict the occurrence of particular behaviors, one may have to consider the class of the response.

It would seem reasonable to suggest, therefore, that in order to investigate which behaviors seem species-typical, and when and under what situations they occur, a study must include at least two species. If subjects of each of two species are placed in identical situations, a comparison of their activities (responses or behaviors) can

be made. This may not only make it possible to determine the existence of similar and different classes of behavior, but also allow us to predict how a particular organism will perform in other situations.

An attempt was made to do this by placing both pigeons and chickens on schedules of periodic food delivery like those employed by Staddon and Simmelhag. An autoshaping schedule was also used to discover how the presence of signalled food delivery would affect the temporal patterning of behavior.

Chickens were selected as subjects because they possess a scratching response when a food stimulus is involved. It was anticipated that by carefully observing and comparing the behaviors performed by the pigeon and chicken, a kind of "behavioral profile" could be obtained for responses typical of environments where food reinforcement is used with these two species.

Method

Subjects

Eight experimentally naive pigeons and eight experimentally naive bantam cochin hens obtained from a local supplier were used. They were maintained at approximately 80% of their free-feeding weights. Supplementary food (mixed grain) was provided in their home cage following each session as necessary.

Apparatus

Subjects were tested in an operant conditioning chamber measuring 55cm by 35cm by 33cm. The ceiling, floor, and two adjoining walls of this chamber were painted white. A third aluminum wall was not painted. A 5.2 cm x 6.4 cm opening in this wall allowed access to a retractable grain hopper located 5 cm above a wire mesh floor. This opening was equipped with a white light which was illuminated when the hopper was extended. A Grason Stadler response key was also mounted on this wall directly above the food hopper 17.5 cm from the floor. The key was covered with tape except during the response-dependent and autoshaping conditions when it was exposed and transilluminated with green light at the proper time . A white house light was positioned in the chamber in the upper corner of the wall opposite the hopper and was

illuminated at all times. The experimental room was also continuously illuminated. White noise, together with the noise of the ventilating fan, served to mask extraneous sounds from the experimental chamber.

The fourth wall of the chamber was made of clear plexiglass to allow for easy viewing and the recording of behaviors on video tape. Behaviors were recorded by an observer using an Esterline Angus event recorder equipped with ten channels. All programming and recording apparatus were located in an adjacent room where the observer made observations from a television monitor. During the response-independent autoshaping procedure a small light was positioned such that it indicated on the monitor when the green key light was illuminated.

Procedure

Food was delivered to different groups of subjects on one of four schedules: (a) a fixed-interval (FI) response-dependent schedule in which food was delivered for the first peck 12 seconds or more after the last reinforcement; (b) a fixed-time (FT) response-independent schedule in which the key was covered and the subject was allowed access to food every 12 seconds irrespective of behavior; (c) a variable-time (VT) response-independent schedule in which the key was covered and the food magazine was presented on the average every 12 seconds irrespective

of behavior; (d) a fixed-time (FT) autoshaping schedule in which the key was dark for 10 seconds, and then illuminated with green light for 2 seconds immediately before food was delivered. For the VT 12-sec schedule the following sequence of interfood intervals was used: 7, 10, 10, 16, 13, 11, 7, 14, 25, 10, 9, 15, 12, 9, 7, 13, 11, 13, 9, 17, 7, 12, 13, 8, 11, 16, 15, 7, 10, 9, and 13 seconds. Two pigeons and two chickens were exposed to each schedule.

Food delivery was a 2 second access to mixed grain. There were sixty-four food presentations in each session and the birds were run daily. There were no habituation sessions and magazine training was carried out in one session. This training consisted of having the birds eat from the hopper on 35 presentations. Birds exposed to the FI 12-second schedule of key-peck-contingent reinforcement were hand-shaped in the session following magazine training.

On the basis of initial observations of the birds, eight behavioral categories were set up on an Esterline Angus event recorder. Two other behaviors (B9 and B10) were later added to allow for the behavioral characteristics of particular birds. In the response-dependent condition, pecks striking the key were recorded automatically. The names and descriptions of the behavior categories appear in Table 2.

All behaviors were recoded by the same experimenter

(MHW) who made the observations in an adjacent room by the use of a television monitor. This procedure allowed some sessions to be taped for later viewing. By requiring another person to review the tapes and again record the behaviors, a measure of reliability was obtained. Birds were run for at least 35 sessions or until a steady state in behavior developed.

Table 2. Names and Descriptions of Observed Behaviors.

Behavior	Name	Description
	Names and Descriptions of Observed Behaviors	
B1	Facing the magazine wall	The bird's head and body are oriented toward the wall containing the food hopper
B2	Pecking	Pecking movements directed toward the magazine wall
B3	Locomotion	Bird walks about in no particular direction
B4	Pecking floor	Pecking movements directed towards the floor
B5	Head in magazine	The beak or more of the bird's head is in the magazine opening
B6	Facing window wall	Bird's head and body are oriented towards the plexiglass door of the experimental chamber
B7	Turning	Bird makes a complete 360 degree turn
B8	Scratching	Behavior in which the bird scratches with one or both feet at the floor grating or magazine
B9	Beak to ceiling	Beak is pointed upwards toward the ceiling of the experimental chamber--Behavior characteristic of Bird P-103
B10	Breast to wall	Breast is pressed against magazine wall--Behavior characteristic of Bird P-106

Results

Figures 1 through 8 display those behaviors which occurred during the interval between food presentations for both pigeons and chickens on the FI, VT and both FT food delivery schedules. Each data point presents the probability (frequency/opportunities) of a behavior occurring within each 1-sec time block following the delivery of food. The data for the 0 to 1-sec time block is plotted at 1 second, data for the 1 to 2-sec time block plotted at 2 seconds postfood time, and so on. Performance is averaged across the last six sessions of steady-state activity. Some behaviors were not included in the Figures because they occurred so infrequently that no patterning over postfood time was observed.

A measure of reliability was obtained by having another person view video recordings of birds from selected sessions. This person recorded the occurrence of behaviors under the same conditions as the experimenter. By then comparing the two records obtained for each bird, a percentage agreement (Hartmann, 1977) was calculated. The calculated percentage agreement for data collected with regard to chickens was 91%. For pigeons this value was 82%. The difference in these values was most likely due to the greater variability in behavior displayed by pigeons.

Facing the magazine wall (B1) was plotted for only

those pigeons on the VT 12-sec schedule. Only on this schedule did B1 occur when no other behaviors were prominent. B1 was also not plotted for any of the chickens because it occurred at a high probability (above .9) in each interval of all schedules.

A written account of each birds' performance at steady-state is provided for both pigeons and chickens. Reference to the Figures, however, provides the clearest view of behavior over postfood time.

Steady-state behavior for pigeons. In Figure 1 the probability of occurrence of various behaviors during the interreward time for pigeons exposed to the FT 12-sec schedule of food delivery is presented. Both birds exhibited the same pattern: a behavior (Beak to ceiling for P-103 and Facing window wall for P-110) occurred early in the interval and decreased in probability by the 6th or 7th second; another behavior increased in probability of occurrence from about the 6th second until the delivery of food. For Bird P-103 this later occurring behavior was Pecking (B2), and for Bird P-110, Head in magazine (B5). The Pecking exhibited by P-103 was directed toward the holes in the magazine wall behind which a speaker was located for the delivery of white noise. It can be seen from Figure 1 that at the moment of food delivery Pecking was also occurring at a substantial level in Bird P-110. It is quite probable that Pecking actually occurred at a

higher probability than indicated because many pecks were not recorded when the birds head was fully in the food magazine.

Figure 2 shows the probability of occurrence of behaviors for pigeons exposed to the FI 12-sec schedule of food delivery. Birds on this schedule exhibited the behavior Facing window wall (B6). It occurred at maximum probability during the 3rd second of the interval and then decreased considerably in its occurrence by the 6th or 7th second. Locomotion (B3) and Turning (B7) also reached maximum probability of occurrence during the 3rd second of the interval. These two behaviors decreased in occurrence by the 5th and 6th seconds. Pecking (B2), a behavior necessary for the delivery of food on this schedule, began increasing in occurrence by the 4th second and reached maximum probability of occurrence in the second preceding food delivery.

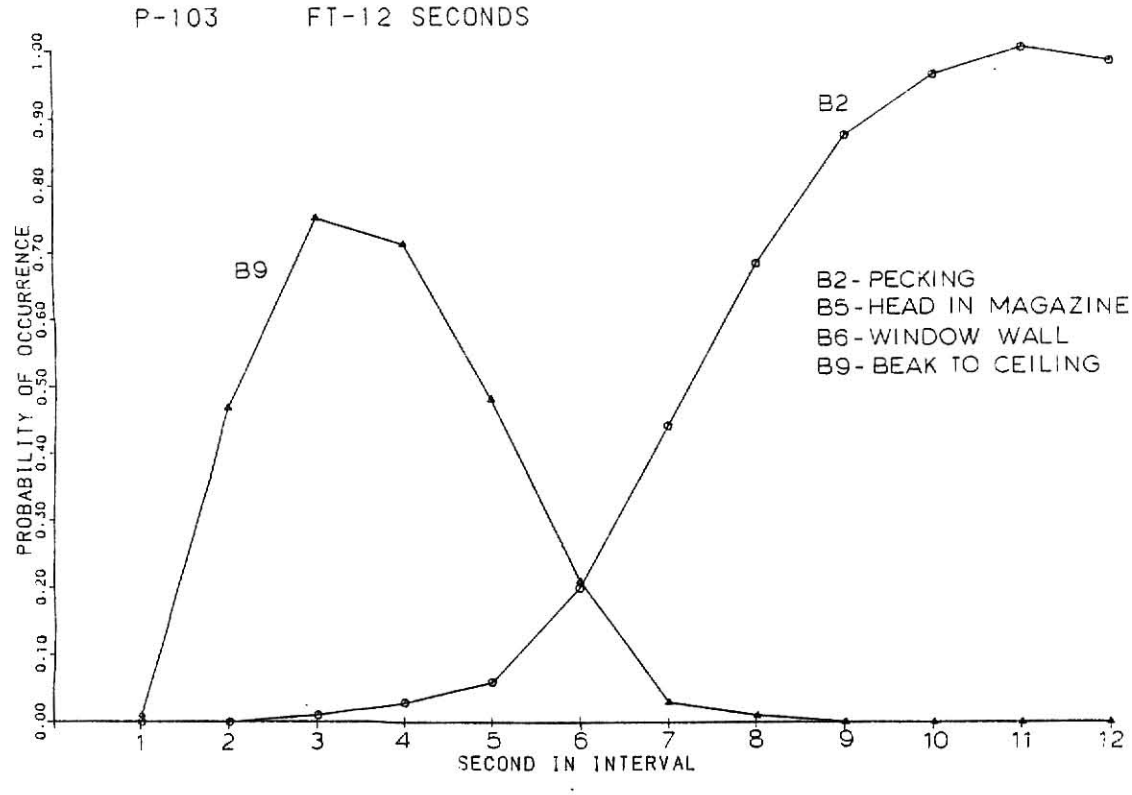
Figure 3 presents the probability of occurrence of behaviors for those pigeons exposed to the VT 12-sec food delivery schedule. Both birds displayed one or more behaviors which occurred at maximum probability before the 11th second. These behaviors included such things as Pecking (B2), Locomotion (B3), Head in magazine (B5), Facing window wall (B6), and Turning (B7). Following the 8th second in Bird P-102 and the 4th second in Bird P-104, Facing the magazine wall (B1) was the behavior most

frequently observed. This general orientation toward the wall containing the food hopper did not occur in conjunction with any other distinct behavior.

In Figure 4, the probability of occurrence of behaviors for pigeons exposed to the FT 12-sec autoshaping schedule of food delivery is presented. For both birds, Locomotion (B3) and Turning (B7) occurred shortly after the delivery of food. Facing window wall (B6) also occurred early in the interval for Bird P-107. The behavior Breast to magazine wall (B10) was a characteristic of Bird P-106. It began to occur during the 3rd second, increased to its highest level by the 8th second, and then dropped to a probability under .1 during the 12th second. Pecking (B2) developed somewhat differently for both birds, however, in both cases it reached maximum probability of occurrence during the last 2 seconds before food delivery. Pecks not striking the key (head bobbing), although occurring more frequently as time neared for the delivery of food, never reached a probability of occurrence above .1 for birds exposed to this schedule. It was because of this low probability that it was not plotted on the graphs.

Figure Caption

Figure 1. Probability of Occurrence of Behaviors for Pigeons Exposed to the Response-Independent Fixed-Time (FT) 12-Second Schedule of Food Delivery.


P-103 FT-12 SECONDS
PROBABILITY OF OCCURRENCE
SECOND IN INTERVAL
B2
B9
B2 - PECKING
B5 - HEAD IN MAGAZINE
B6 - WINDOW WALL
B9 - BEAK TO CEILING

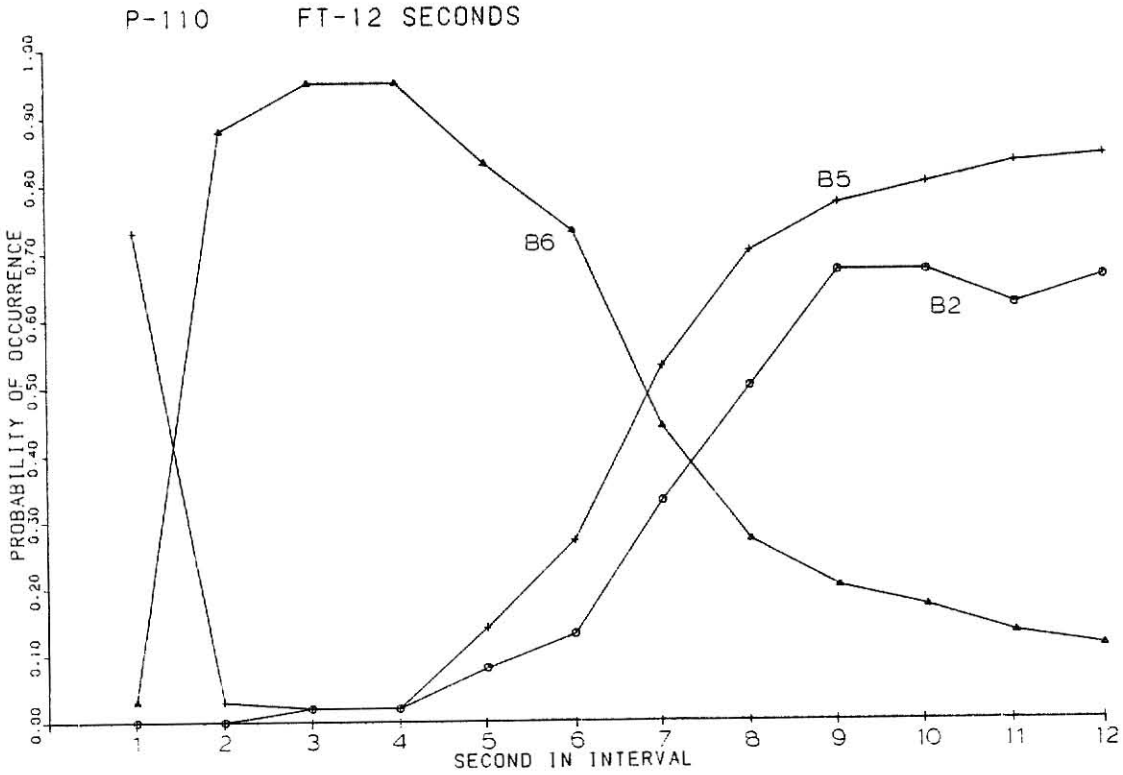
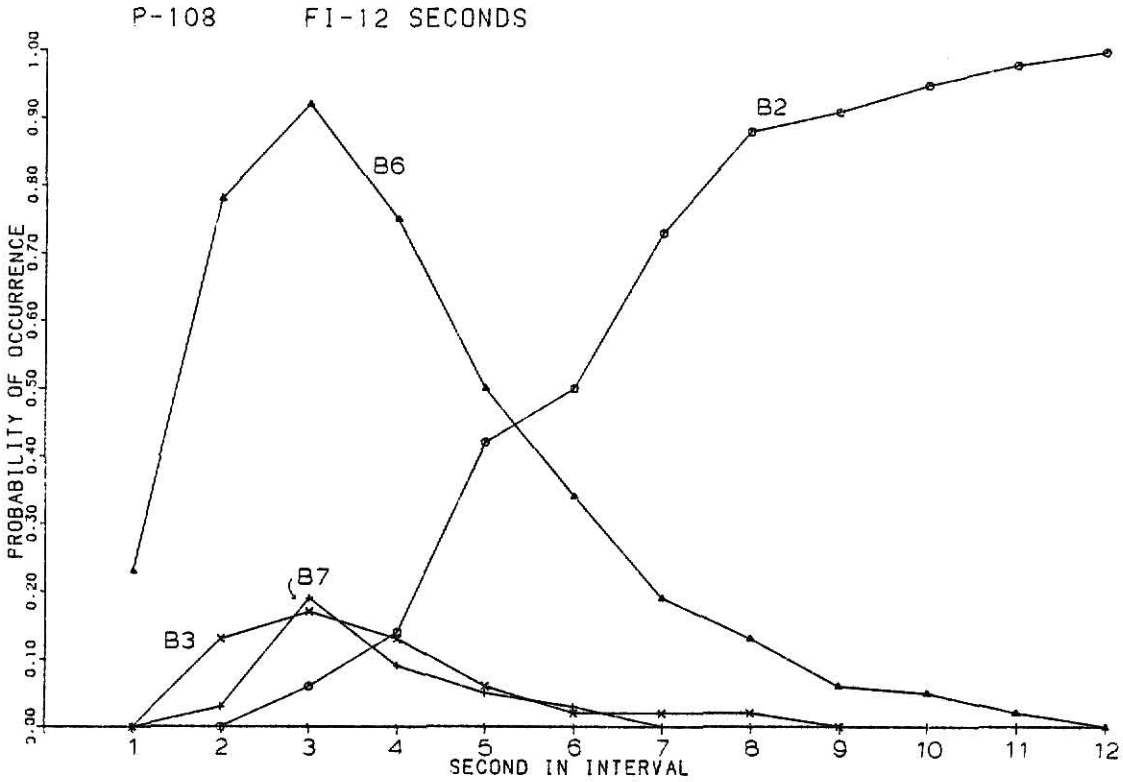

P-110 FT-12 SECONDS
PROBABILITY OF OCCURRENCE
SECOND IN INTERVAL
B5
B6
B2

Figure Caption

Figure 2. Probability of Occurrence of Behaviors for Pigeons Exposed to the Response-Dependent Fixed-Interval (FI) 12-Second Schedule of Food Delivery.


P-108 FI-12 SECONDS
PROBABILITY OF OCCURRENCE
SECOND IN INTERVAL
B2
B6
B7
B3

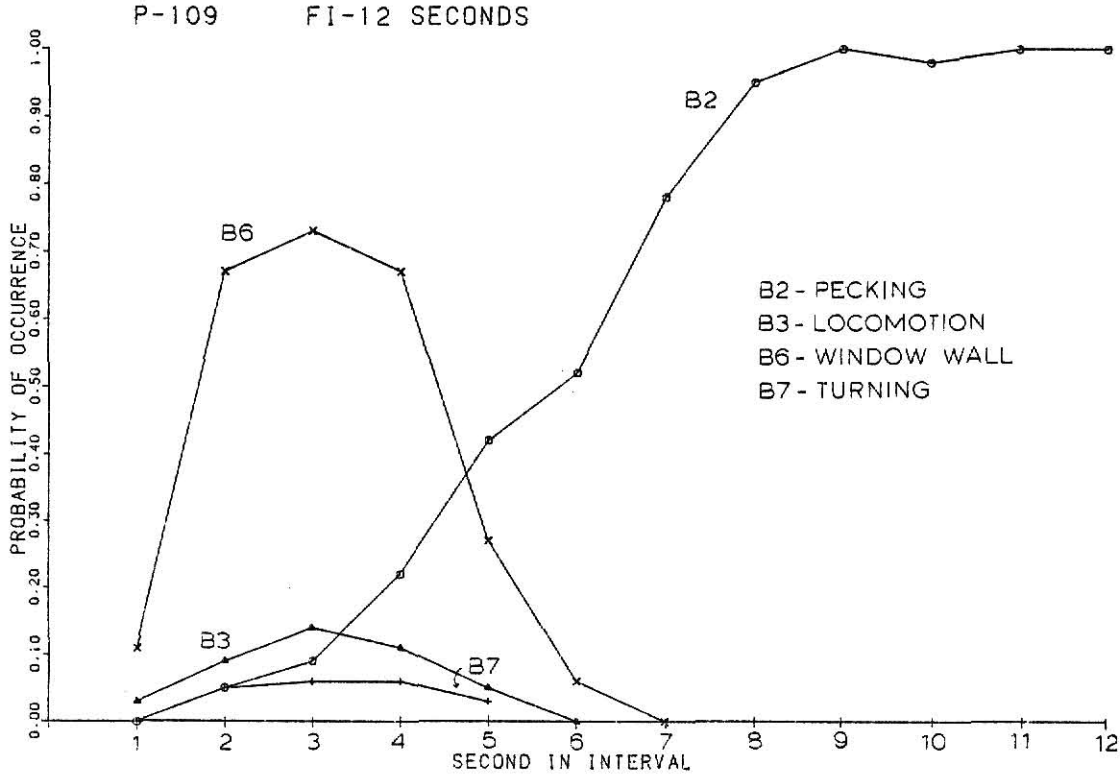
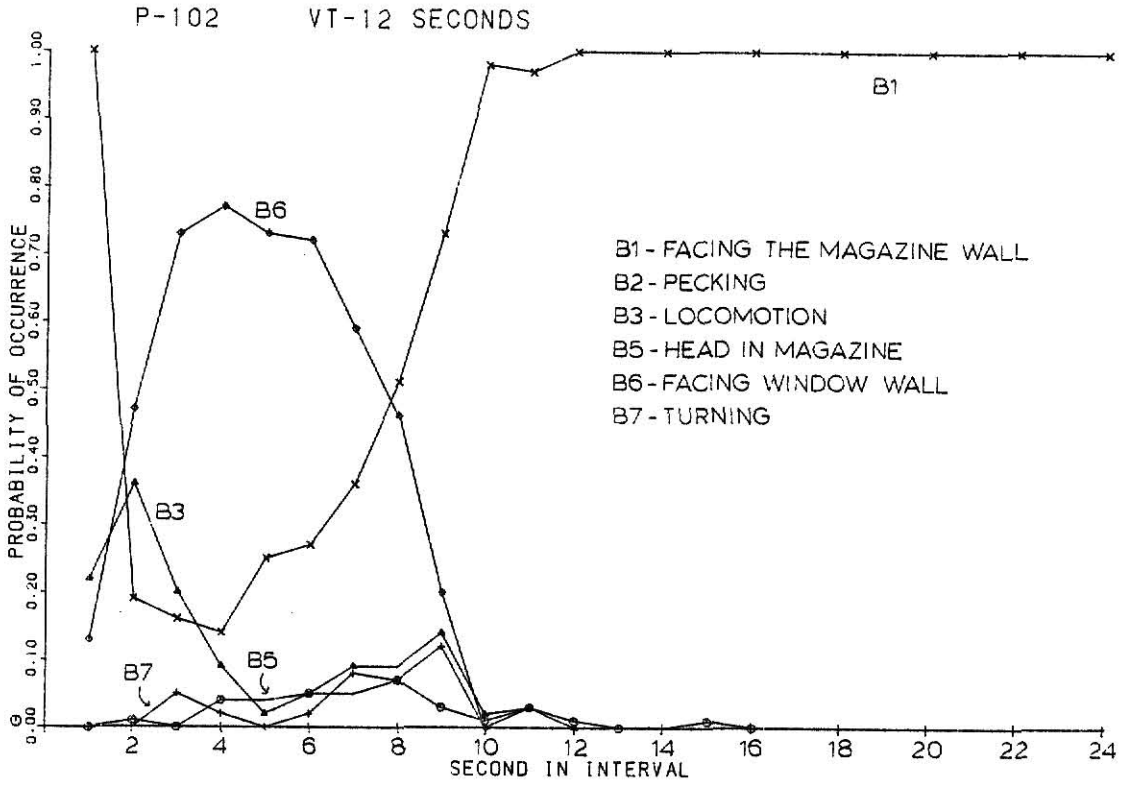

P-109 FI-12 SECONDS
PROBABILITY OF OCCURRENCE
SECOND IN INTERVAL
B2
B6
B3
B7
B2 - PECKING
B3 - LOCOMOTION
B6 - WINDOW WALL
B7 - TURNING

Figure Caption

Figure 3. Probability of Occurrence of Behaviors for Pigeons Exposed to the Response-Independent Variable-Time (VT) 12-Second Schedule of Food Delivery.


P-102 VT-12 SECONDS
PROBABILITY OF OCCURRENCE
SECOND IN INTERVAL
B1
B6
B3
B7
B5
B1 - FACING THE MAGAZINE WALL
B2 - PECKING
B3 - LOCOMOTION
B5 - HEAD IN MAGAZINE
B6 - FACING WINDOW WALL
B7 - TURNING

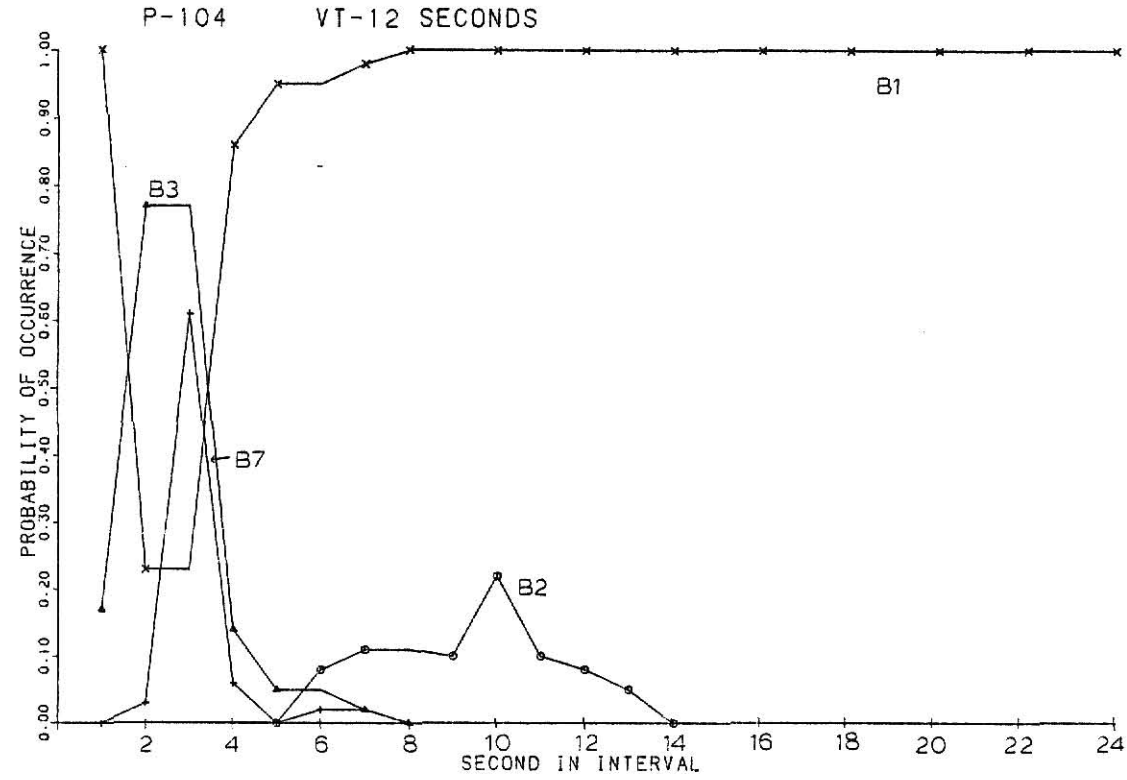
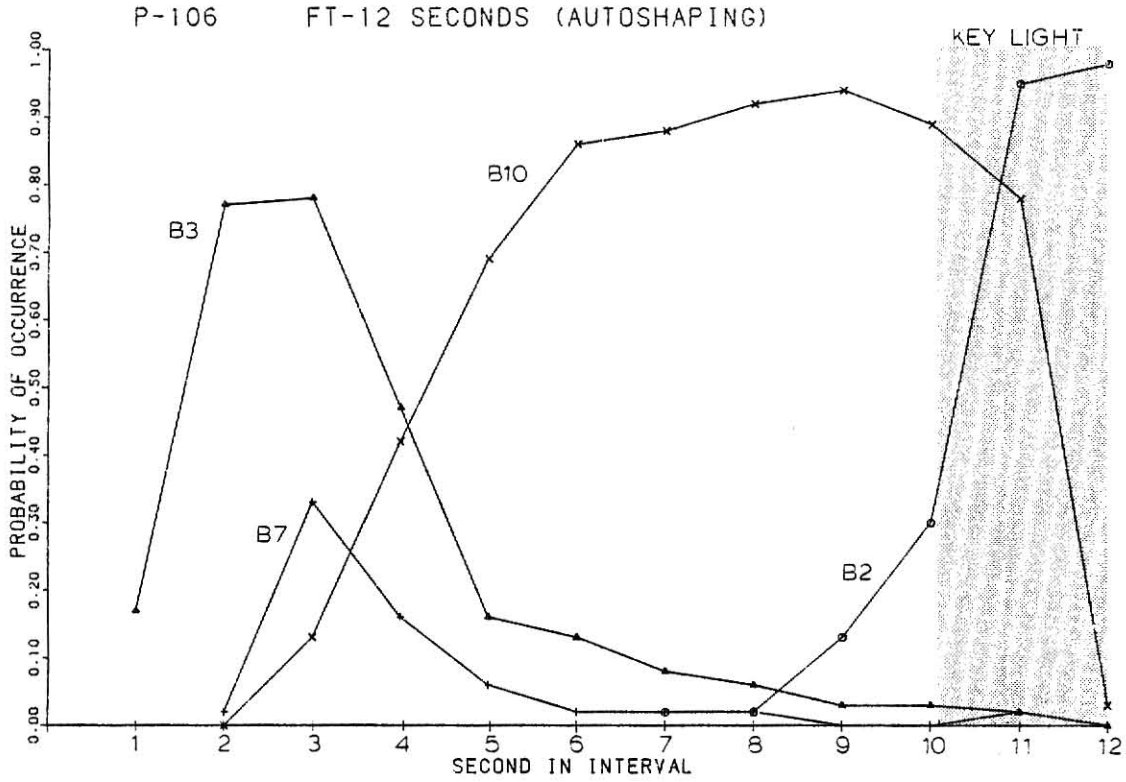
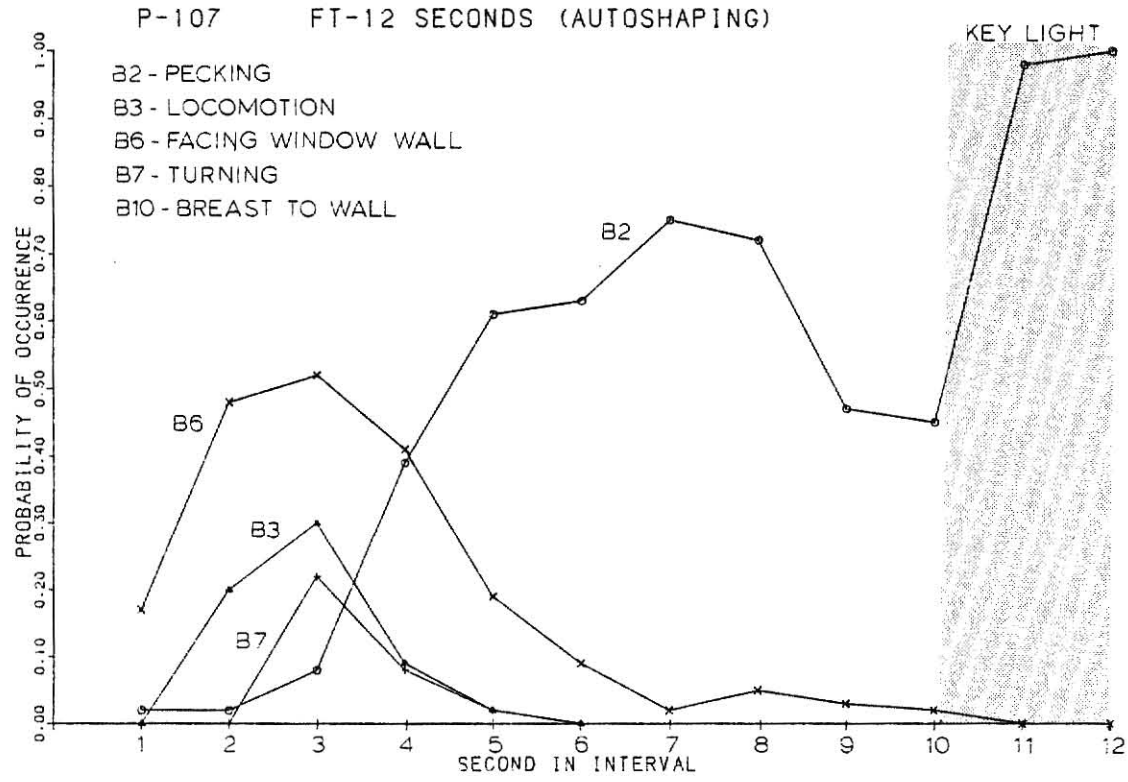

P-104 VT-12 SECONDS
PROBABILITY OF OCCURRENCE
SECOND IN INTERVAL
B1
B3
B7
B2

Figure Caption

Figure 4. Probability of Occurrence of Behaviors for Pigeons Exposed to the Response-Independent Fixed-Time (FT) 12-Second Autoshaping Procedure of Food Delivery.


P-106 FT-12 SECONDS (AUTOSHAPING)
KEY LIGHT
B10
B3
B7
B2
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1
2
3
4
5
6
7
8
9
10
11
12
SECOND IN INTERVAL


P-107 FT-12 SECONDS (AUTOSHAPING)
KEY LIGHT
B2 - PECKING
B3 - LOCOMOTION
B6 - FACING WINDOW WALL
B7 - TURNING
B10 - BREAST TO WALL
B2
B6
B3
B7
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1
2
3
4
5
6
7
8
9
10
11
12
SECOND IN INTERVAL

Steady-state behaviors for chickens. In Figure 5, the probability of occurrence of behaviors during the interfood interval for chickens exposed to the FT 12-sec schedule of food delivery is presented. Bird C-301 showed a sharp increase in Scratching (B8) during the first 3 seconds of postfood time. The probability of occurrence of Scratching remained high until food was delivered. Pecking (B2) occurred at various times throughout the interval, but always at a probability of less than .05. Bird C-302 showed a sharp increase in Scratching during the first 3 seconds of postfood time, and the probability of ocurrence of Scratching continued to remain high until the delivery of food. Scratching was the only behavior occurring consistently for Bird C-302.

In Figure 6, the probability of occurrence of behaviors during the interval between food presentations for chickens exposed to the FI 12-sec schedule of food delivery is presented. Birds C-312 and C-314 demonstrated nearly identical performances. Scratching (B8) was occurring at a high probability by the 4th second, began to decrease in occurrence by the 9th second, and was under a probability of .2 during the last second before food delivery. Pecking (B2) began a steady increase in occurrence at the 8th second postfood time and reached its maximum probability of occurrence during the 12th second.

In Figure 7, the probability of occurrence of

behaviors for chickens exposed to the VT 12-sec schedule of food delivery is presented. Both birds exposed to this schedule showed sharp increases in Scratching (B8) during the first 2 seconds of postfood time. For Bird C-307 the occurrence of Scratching remained at a high probability throughout even the longest intervals. Bird C-308, however, showed a decrease in the occurrence of Scratching beginning around the 6th second postfood time. From the 11th second until food delivery, Scratching fluctuated between a probability of occurrence of .4 and .75 for this bird. Bird C-307 also displayed a very low amount of Pecking (B2).

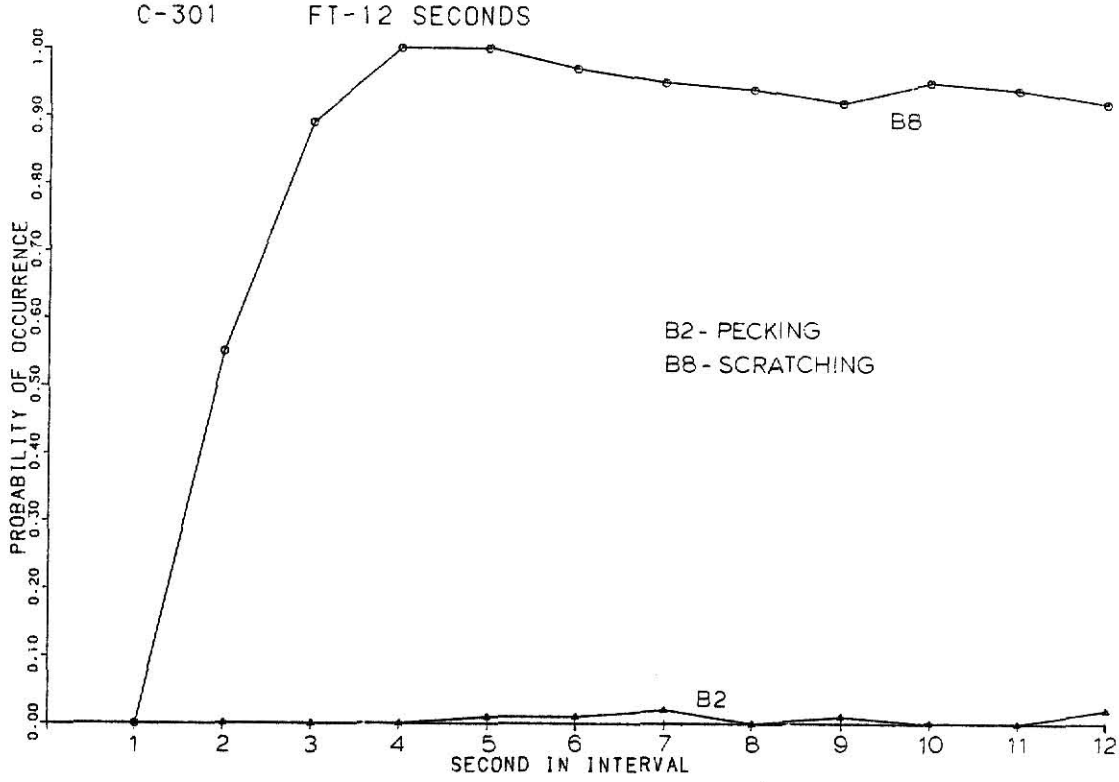
In Figure 8, the probability of occurrence of behaviors for chickens exposed to the FT 12-sec autoshaping schedule of food delivery is presented. Scratching (B8) was the prominent behavior exhibited by both subjects through the 10th second postfood time. During the 11th second postfood time Pecking (B2) became the most frequently occurring behavior in Bird C-313. Pecking did not become the most frequently occurring behavior for Bird C-309 until the last second before the delivery of food.

Both chickens on this schedule had shown greater amounts of Pecking (B2) in earlier sessions (Sessions 5 through 20). In the last 6 sessions, for which data is presented however, Pecking the key had become less frequent in occurrence. A similar phenomenon has been shown to

occur in pigeons given experience on autoshaping schedules for an extended number of sessions (Wasserman, 1973).

Figure Caption

Figure 5. Probability of Occurrence of Behaviors for Chickens Exposed to the Response-Independent Fixed-Time (FT) 12-Second Schedule of Food Delivery.


C-301 FT-12 SECONDS
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
B8
B2 - PECKING
B8 - SCRATCHING
B2
1
2
3
4
5
6
7
8
9
10
11
12
SECOND IN INTERVAL

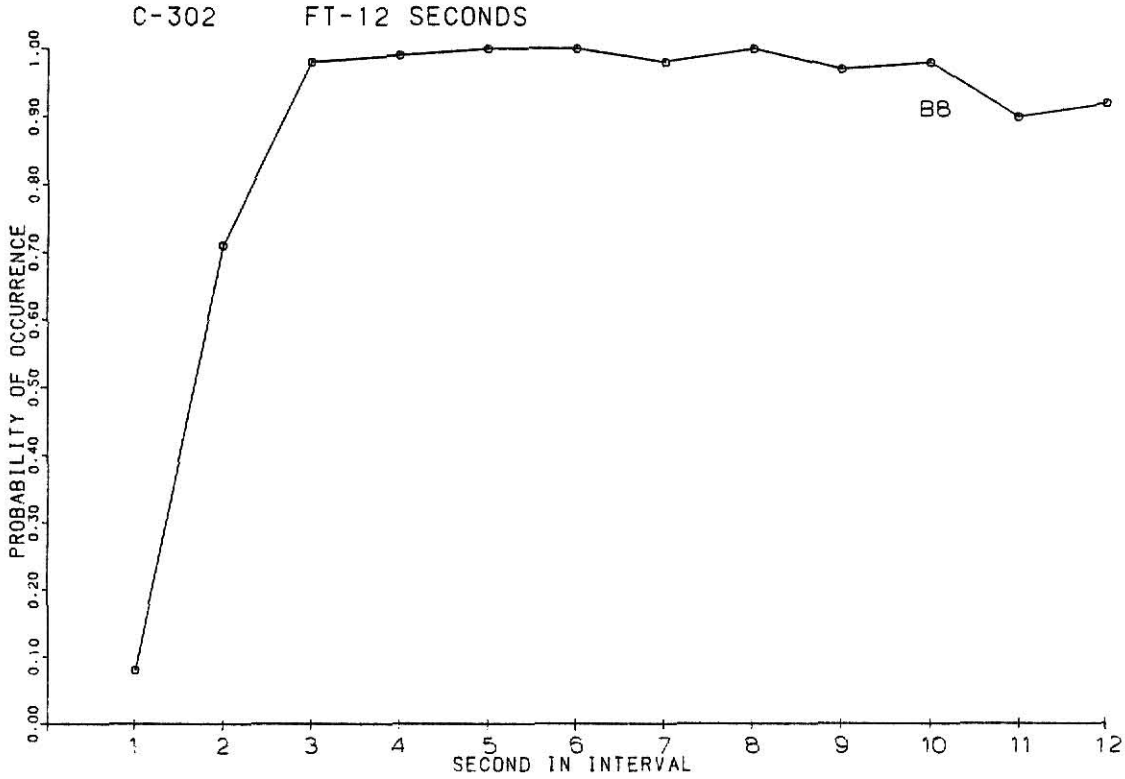
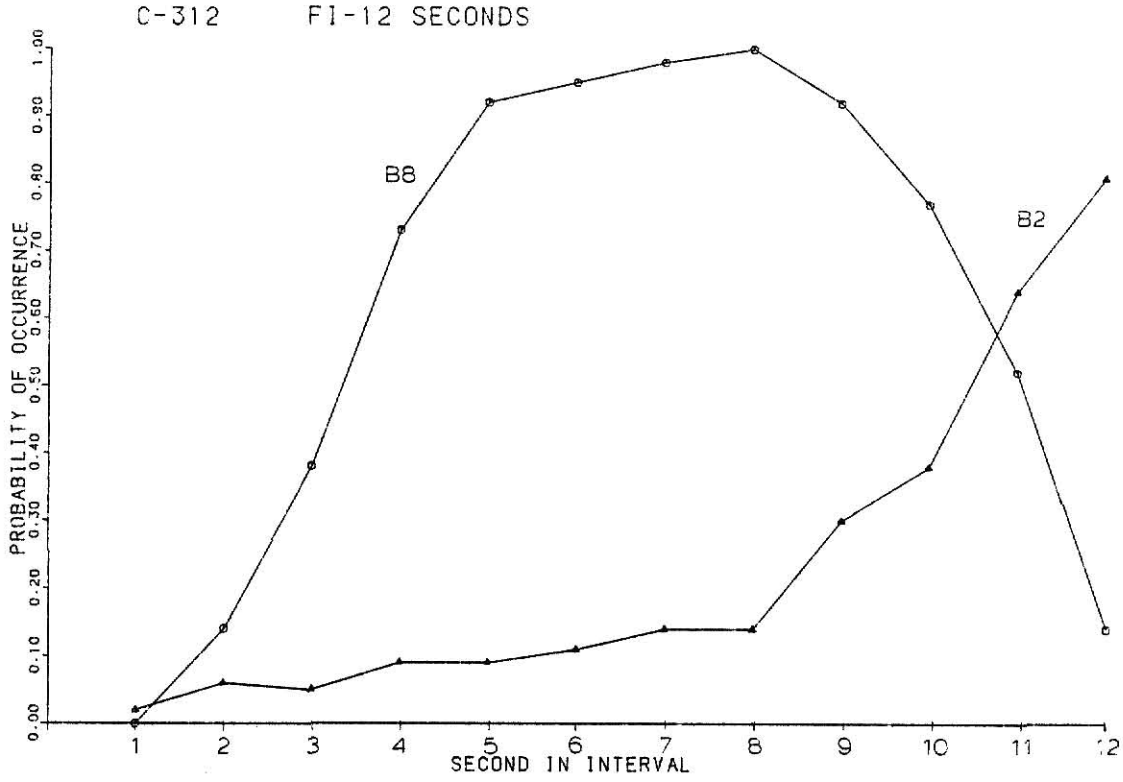

C-302 FT-12 SECONDS
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
B8
1
2
3
4
5
6
7
8
9
10
11
12
SECOND IN INTERVAL

Figure Caption

Figure 6. Probability of Occurrence of Behaviors for Chickens Exposed to the Response-Dependent Fixed-Interval (FI) 12-Second Schedule of Food Delivery.


C-312 FI-12 SECONDS
B8
B2
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1 2 3 4 5 6 7 8 9 10 11 12
SECOND IN INTERVAL

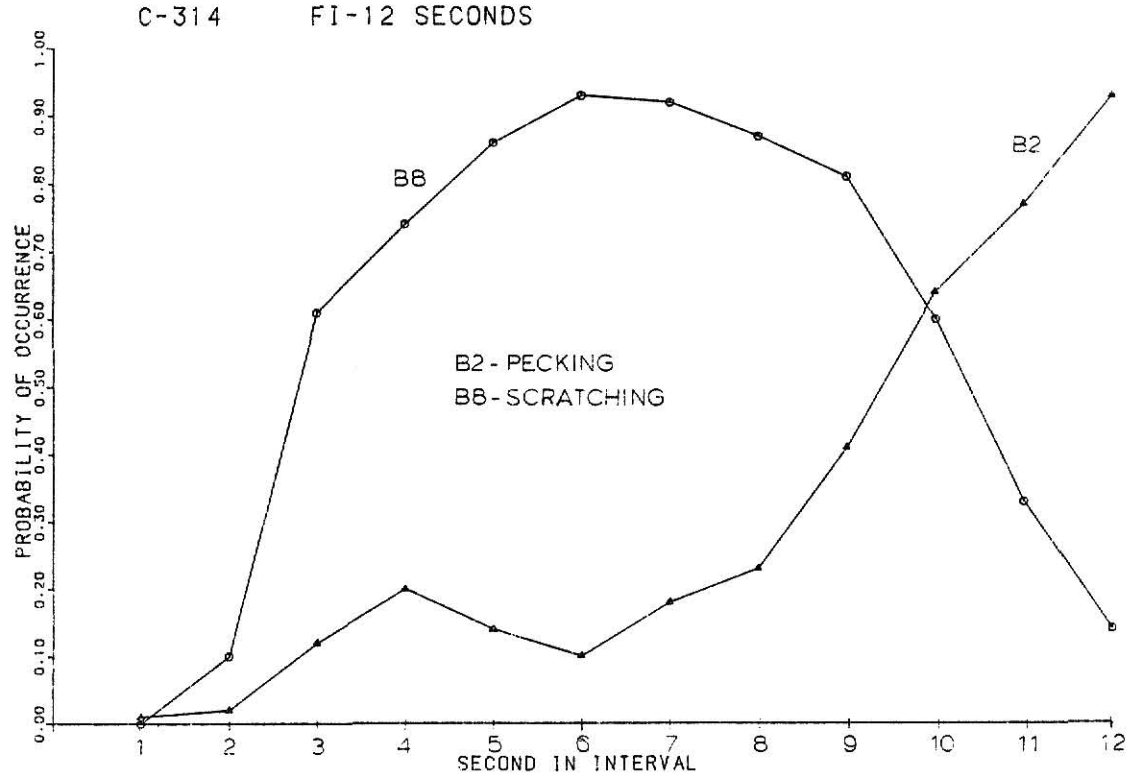
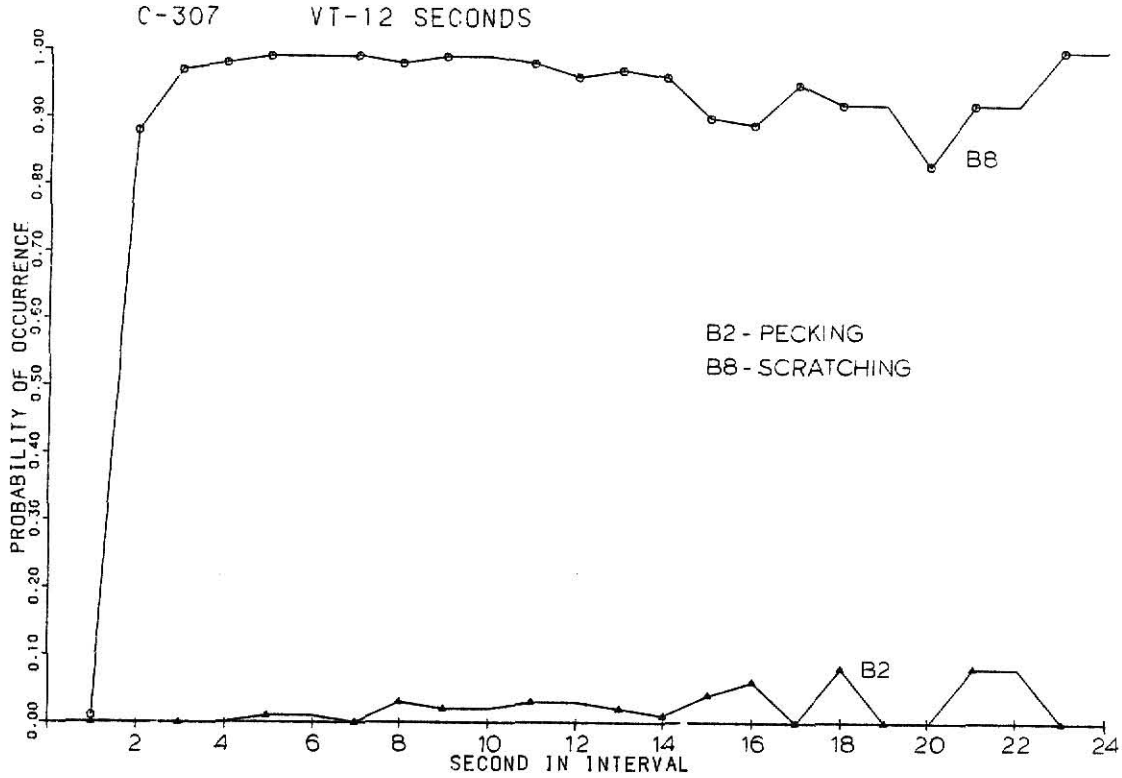

C-314 FI-12 SECONDS
B8
B2
B2 - PECKING
B8 - SCRATCHING
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1 2 3 4 5 6 7 8 9 10 11 12
SECOND IN INTERVAL

Figure Caption

Figure 7. Probability of Occurrence of Behaviors for Chickens Exposed to the Response-Independent Variable Time (VT) 12-Second Schedule of Food Delivery.


C-307 VT-12 SECONDS
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
B8
B2 - PECKING
B8 - SCRATCHING
B2
2
4
6
8
10
12
14
16
18
20
22
24
SECOND IN INTERVAL

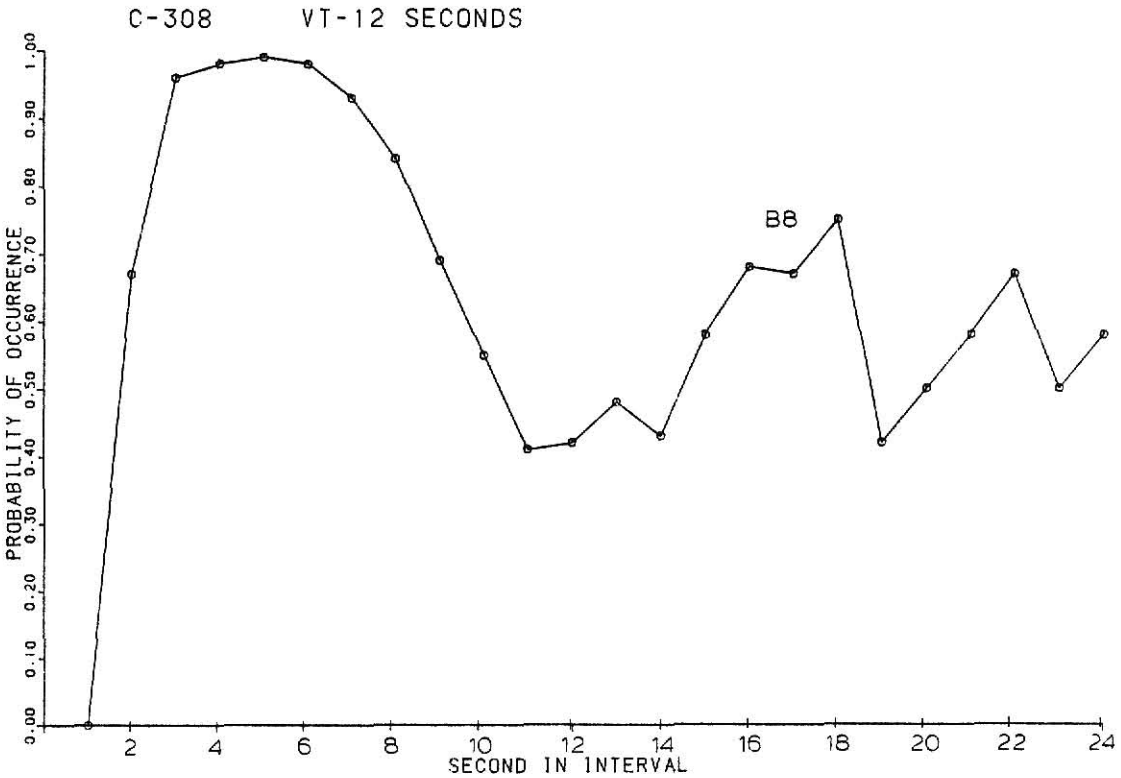
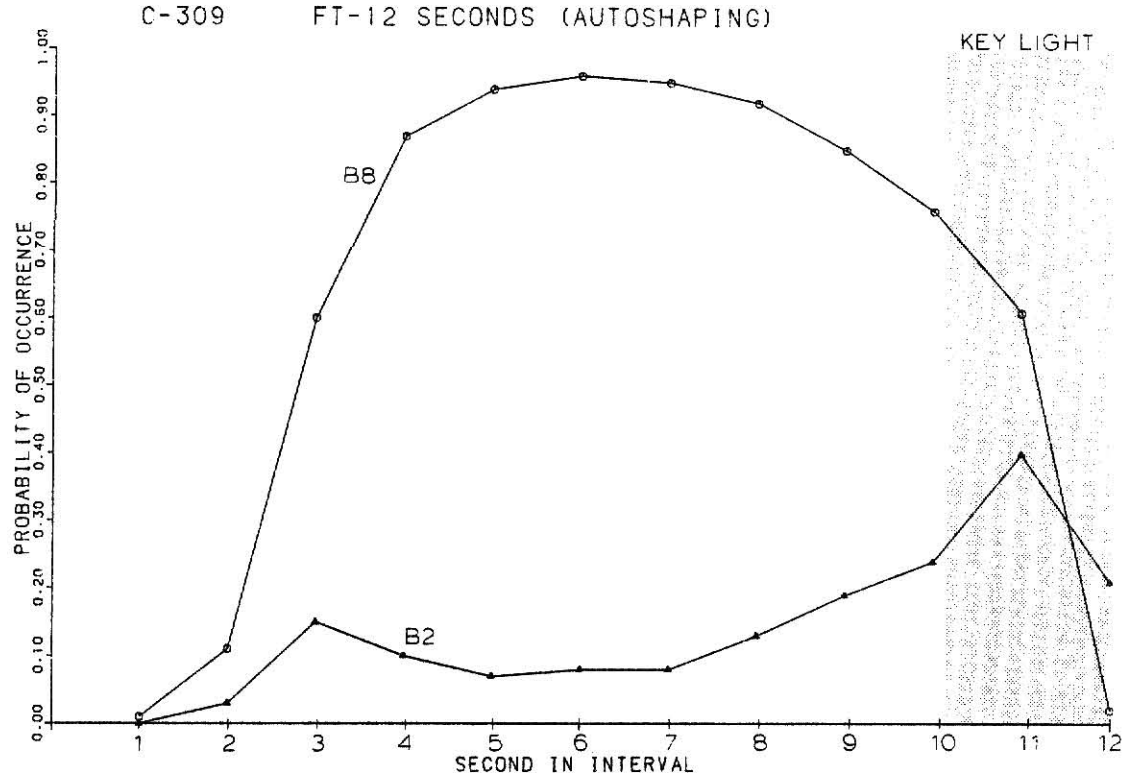
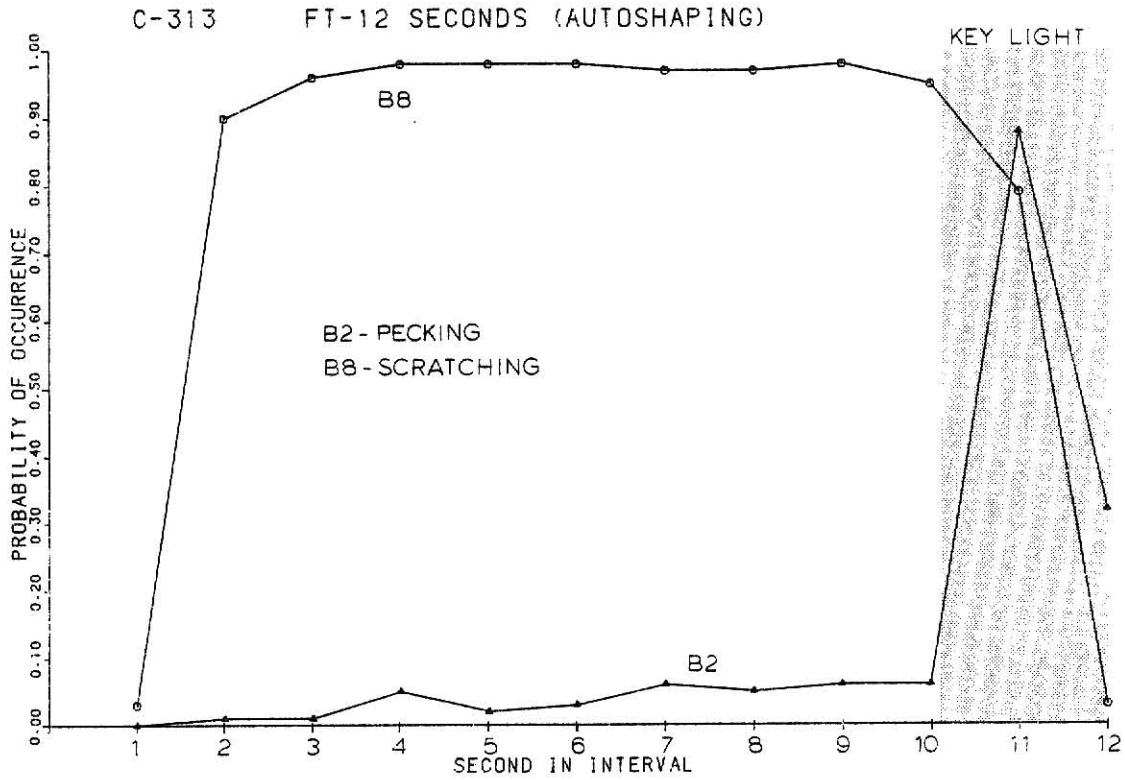

C-308 VT-12 SECONDS
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
B8
2
4
6
8
10
12
14
16
18
20
22
24
SECOND IN INTERVAL

Figure Caption

Figure 8. Probability of Occurrence of Behaviors for Chickens Exposed to the Response-Independent Fixed-Time (FT) 12-Second Autoshaping Procedure of Food Delivery.


C-309
FT-12 SECONDS (AUTOSHAPING)
KEY LIGHT
B8
B2
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1
2
3
4
5
6
7
8
9
10
11
12
SECOND IN INTERVAL


C-313
FT-12 SECONDS (AUTOSHAPING)
KEY LIGHT
B8
B2 - PECKING
B8 - SCRATCHING
B2
PROBABILITY OF OCCURRENCE
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1
2
3
4
5
6
7
8
9
10
11
12
SECOND IN INTERVAL

Discussion

The central aim of this study was to learn more about the temporal patterning of behavior occurring on schedules of periodic food delivery. A cross-species approach was taken in order to allow the comparison of behaviors displayed by chickens and pigeons.

In an earlier study, Staddon and Simmelhag (1971) suggested that the behaviors occurring on schedules of periodic food delivery could be classified as either interim or terminal. Interim behaviors are associated with periods of low reinforcement probability (the first few seconds following food delivery). Under such conditions, subjects will display a general searching behavior (appetitive behavior) for other reinforcers besides the primary reinforcer, or will attempt to escape from the situation. Terminal behaviors, according to Staddon and Simmelhag (1971), occur when the probability of reinforcement is high and are behaviors which are appropriate to the reinforcer. The observed interim and terminal behaviors for pigeons and chickens in the present study are summarized in Table 3.

Pigeons in the present study (Figures 1-4), like the pigeons in Staddon and Simmelhag's (1971) experiment, exhibited a division between interim and terminal activities. Every bird, regardless of which schedule it

Table 3. Observed Interim and Terminal Behaviors.

Pigeons

	Interim	Terminal
FT 12-sec	Facing window wall Beak to ceiling	Pecking Head in magazine
VT 12-sec	Locomotion Turning Facing window wall	Facing magazine wall
FI 12-sec	Locomotion Turning Facing window wall	Pecking
FT 12-sec autoshaping	Locomotion Turning Facing window wall	Pecking

Chickens

	Interim	Terminal
FT 12-sec	?	Scratching
VT 12-sec	?	Scratching
FI 12-sec	Scratching	Pecking
FT 12-sec autoshaping	Scratching	Pecking

was on, demonstrated at least one behavior which reached maximum level of occurrence within the first 6 seconds of the interfood interval, and another behavior which tended to reach its maximum level of occurrence immediately before the delivery of food.

Chickens, on the other hand, only showed the interim-terminal distinction on the FI 12-sec and FT 12-sec autoshaping schedules (Figures 6 and 8). Scratching appears as an interim behavior and Pecking as a terminal behavior for subjects on both schedules. For chickens exposed to the FI 12-sec schedule the increase in Pecking would be expected because at least one peck was required for the delivery of food. Thus, in the last few seconds before the delivery of food, Pecking was the prominent behavior. The increase in Pecking near the time for food delivery for those chickens placed on the FT 12-sec autoshaping schedule can be attributed to the onset of the key light (the CS in a Pavlovian paradigm) at the beginning of the 11th second. Pigeons exposed to these same schedules (Figures 2 and 4) showed increases in Pecking for the same reasons.

For chickens on the other two schedules, the FT 12-sec and VT 12-sec (Figures 5 and 7), Scratching was virtually the only behavior to occur throughout the interval. It was present at a high probability from early in the interreward interval and persisted until the delivery of food.

Although Scratching for these schedules clearly fits the definition of a terminal behavior, the lack of any other behaviors and the possibility that Scratching is appetitive in nature for the chicken suggests it may also be considered an interim behavior. It is for this reason that question marks (?) appear in Table 3 for the occurrence of interim behaviors on the FT 12-sec and VT 12-sec schedules.

There are a couple of reasons which might explain why no clear cases of interim behaviors were evident for chickens on these schedules. It could be that the short length of the interreward interval (12-sec) prevented the occurrence of various interim activities like those displayed by pigeons. Another possibility is that the size of the experimental chamber simply did not allow the chickens, because of their larger size, as much mobility as pigeons. Whether or not interim behaviors will be displayed when such adjustments are made is an empirical question.

The terminal behaviors exhibited by pigeons and chickens proved to be behaviors appropriate for them in food-related situations. For the pigeons, Pecking was the terminal behavior on all but the VT 12-sec schedule. On this schedule (see Figure 3) Facing the magazine wall was most prominent before the delivery of food. Staddon and Simmelhag (1971), however, reported Pecking as the terminal behavior for a similar schedule, a VT 8-sec. It is

difficult to say if the 4 second difference between the schedules in average time at which food is presented influenced what terminal behavior was obtained in each study.

The terminal behavior for chickens depended on the schedule to which they were exposed. Those on the FT 12-sec and VT 12-sec schedules (see Figures 5 and 7) displayed Scratching as the terminal behavior, whereas chickens placed on the FI 12-sec and FT 12-sec autoshaping schedules displayed Pecking as the terminal behavior. Scratching was shown to be a behavior displayed by chickens in previous food-related situations (Breland and Breland, 1961 and Klacsmann, 1978).

A further examination of the autoshaping procedure with chickens would appear to be a good start for sorting out the occurrence of Scratching in food-related situations. The FT 12-sec autoshaping schedule (Figure 8) used in this study showed Scratching to occur at a high level until the onset of the key light. The key light in this case was located above the food magazine. This made it impossible to tell if the Scratching was being directed in the vicinity of the food or towards the key light itself (the CS). The incredible persistence of Scratching, both in front of and into the food magazine, suggests that the location of the food (the US), and not the CS might dictate where Scratching will occur. When Klacsmann (1978) showed

chickens to autoshape to a treadle for food, his results could have actually included many responses to the treadle which were made simply because it was near the food magazine. It would be interesting to see the behavioral effect on the chicken to moving the CS varying distances and heights around the experimental chamber.

Observation of the behaviors made by subjects during the interval between food presentations would appear valuable not only for determining how they interact and become ordered, but also for determining their possible functional similarity.

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A CROSS-SPECIES INVESTIGATION OF BEHAVIORAL ADAPTATION TO FIXED INTERVAL, FIXED TIME AND VARIABLE TIME FOOD DELIVERY SCHEDULES

by

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B.S., University of Florida, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

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1982

Abstract

This study investigated the temporal patterning of behavior occurring on schedules of periodic food delivery for both pigeons and chickens. An earlier study by Staddon and Simmelhag (1971) demonstrated that the behavior of pigeons exposed to such schedules (a FT 12-sec, VT 8-sec, and FI 12-sec) fell reliably into two categories. Those responses which occurred with a low probability immediately following food delivery and gradually increased in probability until food delivery were labeled "terminal responses". Other responses which increased to maximum probability shortly after food delivery and then decreased in probability were labeled "interim responses".

Pigeons exposed to similar schedules in the present study (a FT 12-sec, VT 12-sec, FI 12-sec, and FT 12-sec autoshaping) all displayed behaviors which could clearly be classified as either interim or terminal. On the other hand, the behavior of chickens could be classified as interim and terminal only for the FI 12-sec and FT 12-sec autoshaping schedules. For the other two schedules, FT 12-sec and VT 12-sec, scratching was virtually the only behavior to occur. It was present at a high probability early in the interreward interval and persisted until the delivery of food. It was not obvious that scratching could be classified as an interim behavior according to Staddon and Simmelhag's (1971) definition.

It was suggested that a further examination of behavioral patterns in different species would be beneficial for determining the existence of functionally similar and different classes of behavior.