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ATTACK BEHAVIOR AS A FUNCTION OF MINIMUM INTER-FOOD INTERVAL[1]

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Pigeons were exposed to a procedure in which food was presented after a fixed period of time had elapsed, provided no attack against a nearby stuffed pigeon had occurred during the last 15 sec of the period. As the minimum inter-food interval was increased logarithmically through seven values from 15 sec to 960 sec, attack increased to a maximum and then decreased. For both pigeons, attack predominantly occurred after, rather than shortly before, food deliveries.

Exposure to such stimulus conditions as electric foot-shock or intense heat (Ulrich and Azrin, 1962), electric shock to the tail (Azrin, Hutchinson, and Sallery, 1964), or a physical blow (Azrin, Hake, and Hutchinson, 1965) will produce aggressive behavior in a number of different organisms. Recent experiments with pigeons (Azrin, Hutchinson, and Hake, 1966), rats (Thompson and Bloom, 1966), and monkeys (Hutchinson, Azrin, and Hunt, 1968) establish as an attack-inducing condition the transition from a period of frequent food delivery to one during which food is never delivered. Furthermore, monkeys will bite a nearby rubber tube (Hutchinson *et al.*, 1968), and pigeons will attack another live but restrained pigeon (Gentry, 1968) when key pecking or key pressing is maintained under a fixed-ratio schedule of food presentation. Using squirrel monkeys, Hutchinson *et al.* (1968) observed that biting attacks increased as the response requirement of a fixed-ratio food schedule was increased. In the latter two studies, it is not clear whether the attack behavior was due to (1) the fixed-ratio response requirement, (2) the reinforcement frequency per unit time, or (3) a combination of both.

Azrin *et al.* (1966) provide some evidence that a response requirement is not necessary to produce attack. They reported that the transition from a period when food was response-produced or presented independently of responding to a period when food was not delivered produced attack in pigeons. It is reasonable, therefore, to postulate that frequency of food delivery per unit time is at least one variable of which attack behavior is a function. The present study sought to determine the functional relationship between frequency of food presentation and amount of attack.

METHOD

Subjects

Two male White Carneaux pigeons with some previous exposure to fixed-ratio food schedules were used. They were approximately 2 yr old at the beginning of the experiment and were maintained at 80% of their free-feeding body weights throughout the study. Each pigeon was housed in a separate wire cage located in a temperature controlled and constantly illuminated room. Water was always available in the home cages.

Apparatus

The chamber in which daily sessions were conducted was similar to that described by Azrin *et al.* (1966). At one end of the sound-attenuated enclosure was a solenoid-operated food hopper located behind an aperture. At the other end of the chamber was a taxidermically prepared White Carneaux pigeon, the head and throat areas of which were covered with closely cropped white rabbit fur. A shield partially surrounded the model and restricted the experimental pigeon to the area in front

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of the target bird. The model was mounted on a pivot arrangement such that a microswitch closed whenever a force of 35 g or more was exerted against the model's head. Only those switch closures separated by at least a 1.0-sec interval were recorded as attacks. The total amount of time that the microswitch was closed—that is, attack duration—was also recorded. Scheduling and recording devices were located in an adjoining room.

Procedure

Both pigeons were exposed to a procedure in which grain was presented for 4 sec after a fixed period of time had elapsed, provided no attack had occurred during the last 15 sec of the period. If an attack occurred during the last 15 sec, food was not delivered until a 15-sec period without an attack had passed. This 15-sec protective contingency was incorporated to reduce the possibility of attack being produced and maintained by direct operant reinforcement as reported by Reynolds, Catania, and Skinner (1963) and by Azrin and Hutchinson (1967). The effect of presenting food every 15, 30, 60, 120, 240, 480, and 960 sec was studied. Each interval duration remained in effect until attack behavior showed little systematic variability over five consecutive sessions. Interval durations were increased in order from 15 sec to 960 sec. After exposure to a minimum inter-food interval of 960 sec, recovery points for both birds were obtained at 240 sec. Daily sessions consisted of 60 food presentations.

RESULTS

Figure 1 shows that as the minimum inter-food interval was increased through 960 sec, the rate of attack per session for each bird increased monotonically to a maximum and then decreased. The abscissa of Fig. 1 is logarithmic to allow compact presentation. Attack rate for Bird 1 was greatest at minimum inter-food interval 120 sec. Bird 2, however, exhibited maximum number of attacks per minute at 60 sec. At each of the last four inter-food intervals investigated, Bird 1 made more attacks per minute than did Bird 2. The amount of variability between first and second determination points at minimum inter-food interval 240 sec was quite small for Bird 2 as compared to that for Bird 1. When absolute number of attacks per session, absolute duration of session attack, or per cent of session time spent in attack was plotted against minimum inter-food interval, a bitonic function similar to that shown in Fig. 1 resulted.

Visual observation through a one-way viewing port revealed that attack behavior in the present study was very similar to that reported by Azrin *et al* (1966) and by Gentry (1968). Attacks were primarily directed toward the eyes, head, and throat areas of the target pigeon. Frequently, pecking contacts against the stuffed model were preceded by crouching and wing flapping. Although attacks often included attempts at pulling out bits of rabbit fur, the target pigeon remained essentially undamaged throughout the entire experiment.

The present study also corroborated the finding of Azrin *et al.* (1966) that attack more frequently occurred shortly after rather than shortly before food presentations. This was substantiated by observation of daily event records as well as by analyses of session times for both subjects. At minimum inter-food intervals of 30, 60, 120, 240, 480, and 960 sec, session times—and therefore, inter-food times—never exceeded their minimum scheduled durations. This is evidence that neither bird ever attacked during the 15-sec period preceding a scheduled food delivery since such attacks would, by initiating the protective con-

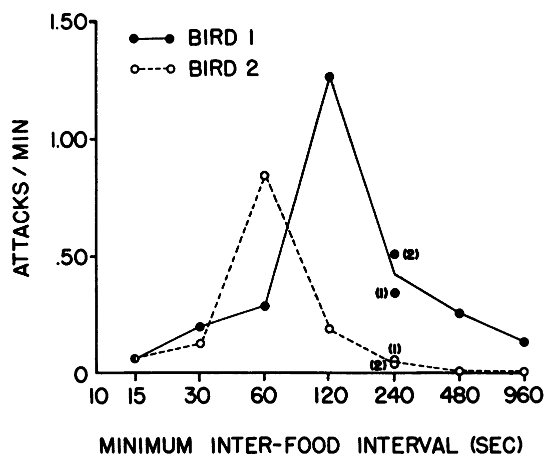

Fig. 1. Number of attacks per minute as a function of minimum inter-food interval (sec) for Birds 1 and 2. The abscissa is logarithmic to allow compact presentation. Each point represents the mean attack rate per session based on five consecutive sessions showing little systematic variability in attack behavior. The small numerals in parentheses indicate first and second determinations.

tingency, increase both inter-food and session times. At minimum inter-food interval 15-sec, however, any attack necessarily initiated the protective contingency and thereby increased both inter-food and session durations above those when no attack occurred. When exposed to this condition, neither pigeon made more than three attacks per session. Furthermore, these attacks occurred shortly after food delivery, as evidenced by the relatively small amount of time that sessions were increased above their minimum scheduled durations. For Bird 1, the maximum increase in session duration was 7 sec (three attacks); for Bird 2, the maximum increase was 6 sec (three attacks). When fewer attacks occurred per session, the increase in session time beyond the minimum scheduled duration was correspondingly less. Thus, at minimum inter-food interval 15-sec, both pigeons (1) exhibited infrequent attack at all sessions, and (2) attacked shortly after, rather than shortly before, food deliveries and, therefore, initiated the protective contingency to a minimal extent.

DISCUSSION

In the present study, a bitonic function obtained between frequency of food presentation and amount of attack against a nearby stuffed model. This finding extends the results of Hutchinson *et al.* (1968) and Gentry (1968) that intermittency of food delivery will produce attack behavior. The number or type of responses typically required by an intermittent food schedule, however, was not necessary for the generation of attack.

Attack occurred even though a protective contingency ensured that attacks and food deliveries were separated by at least 15 sec. This result weakens an explanation of attack on the basis of superstitious reinforcement (Skinner, 1948). Such an account is also weakened by the finding that attack most often occurred after, rather than before, food presentations. Furthermore, attacks seldom occurred during the minimum inter-food interval of 15 sec when superstitious reinforcement of attack would be most likely.

It is possible that attack behavior at minimum inter-food interval 15-sec was suppressed, since the protective contingency arranged that any attack necessarily postponed a scheduled food delivery by 1 to 15 sec depending upon when in the interval an attack occurred. This possibility, however, is unlikely because neither bird showed a decrease in attack frequency either within or between sessions at the 15-sec condition. Such a decrease would be expected if initiation of the protective contingency was acting to suppress ongoing attack behavior. Furthermore, the extent to which attacks at this condition actually increased session times and, therefore, inter-food times, was quite small for both pigeons.

The two-limbed function in the present study is similar to that reported by Falk (1966) for schedule-induced polydipsia as a function of fixed-interval length. There are other similarities between the two behavioral phenomena: (1) both are generated by intermittent rather than by continuous food schedules (Falk, 1961; Azrin *et al.*, 1966), (2) both predominantly occur after rather than before food delivery (Falk, 1961; Hutchinson *et al.*, 1968), (3) both occur even when a protective contingency is scheduled between drinking or attack and subsequent food deliveries (Falk, 1964), (4) both attack and polydipsia occur when food is response-produced and when food is presented independently of such responding (Falk, 1961), and (5) both behaviors have reinforcing properties in that each has been shown to sustain scheduled behavior. Azrin (1964) used a procedure that alternated periods of food reinforcement with periods of no reinforcement. He observed that during the latter condition, a pigeon would fulfill a fixed-ratio response requirement on a second key. The completion of the fixed-ratio produced another pigeon which the aggressor bird then attacked. Similarly, Falk (1966) observed that schedule-induced polydipsia developed under a 1-min variable-interval food schedule even when water was available only through a fixed-ratio requirement on a second lever. Since both behavioral phenomena occur concurrent with scheduled behavior, Falk (1966) suggested that they might both be termed "adjunctive behavior".

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