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AVERSIVE ASPECTS OF A FIXED-INTERVAL SCHEDULE OF FOOD REINFORCEMENT[1]

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The key pecking of pigeons was reinforced according to a fixed-interval schedule of reinforcement. The pigeons were also given the opportunity to attack a restrained target pigeon. The attack rates during the sessions of fixed-interval reinforcement were higher than during the operant level sessions in four of the five pigeons. Most attack occurred during the post-reinforcement pause in key pecking. It was suggested that a fixed-interval schedule of positive reinforcement possesses aversive properties, the most aversive of which are located during the post-reinforcement pause.

Following Azrin, Hutchinson, and Hake's (1966) demonstration of extinction-induced aggression in pigeons, subsequent studies (Hutchinson, Azrin, and Hunt, 1968; Turner and Lyon, 1970; Gentry, 1968; Cherek and Pickens, 1970; Knutson and Kleinknecht, 1970; Dove and Rashotte, 1971) have shown aggression to be elicited by various schedules of positive reinforcement. For example, a fixed-ratio (FR) schedule consistently elicits aggression, most of which occurs during the post-reinforcement pause in key pecking (Hutchinson *et al.*, 1968; Gentry, 1968; Turner and Lyon, 1970; Cherek and Pickens, 1970). Similarly, the aggression elicited by a variable-interval schedule was reported to be most frequent immediately following reinforcement (Dove and Rashotte, 1971). A schedule that reinforces spaced responding, the schedule of differential reinforcement of low response rates, however, has been reported to elicit aggression throughout the session (Knutson and Kleinknecht, 1970). Since no study has reported on the fixed-interval (FI) schedule as a possible elicitor of aggression, the present experiment was conducted. The location of the aggression, if any, within the interval was also examined.

METHOD

Subjects

Five adult female White Carneaux pigeons, all experimentally naive, were maintained at approximately 80% of their free-feeding weights, which in all cases was above 490 g. A large supply of White Carneaux pigeons with various experimental histories and free access to food in their home cages served as target subjects. Daily pairings of target and experimental pigeons were unsystematic.

Apparatus

The wooden experimental chamber contained a Lehigh Valley Electronics intelligence panel, 8 in. (20 cm) from which was a vertical can [4 in. (10.5 cm) diameter and 7 in. (17.5 cm) high] mounted on a small platform in a manner similar to that described by Azrin *et al.*, (1966). Pilot work and a study by Willis (1966) suggested the use of a small chamber in order to increase the probability of attack. Beneath the platform was a microswitch the closure of which was used to record attack behavior. With the target bird restrained in this can, so that only its head and a portion of its breast was visible, the force required to close this microswitch was adjusted to 100 g (0.98N). Each closure of this switch will be referred to as an attack. Gross visual observation indicated that the target bird's movements that were not coincidental with contact from the experimental bird rarely produced a switch closure. When restrained in this manner, the top of the target bird's head was about 10 in. (25 cm) above the floor on which

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the experimental birds stood. Plexiglas shields perpendicular to the sides of the chamber prevented the experimental bird from getting behind the target bird. The response key on the intelligence panel required a minimum force of about 20 g (0.19N) to operate.

The reinforcer was 2-sec access to mixed grain during the shaping session and 8-sec access during all subsequent sessions. A large reinforcer magnitude was used to assure a large contrast between periods of reinforcement and nonreinforcement. Following Azrin *et al.'s* (1966) demonstration that extinction elicited more aggression when it was alternated with a large number of reinforcements, it was expected that such a contrast would increase the probability of aggression. During reinforcement, the green keylight, the dim houselight, and the three lights above the target bird were extinguished.

Standard electromechanical equipment was housed in an adjacent room.

Procedure

Subjects received three to ten 60-min sessions during which the operant level of attack was determined; throughout these sessions no reinforcement occurred. The key peck was then shaped followed by three sessions of continuous reinforcement, during which no target bird was present. The target bird was reintroduced for three additional sessions of continuous reinforcement and remained present during all subsequent sessions. Following shaping of the key peck, all sessions terminated after 20 reinforcements.

Following the last session of continuous reinforcement, the schedule was changed to FI 90-sec, which for four subjects remained in effect for 20 sessions. The fifth subject (S-1850), however, showed little attack during 10 sessions of FI 90-sec reinforcement and so received 20 additional sessions of reinforcement under an FI 270-sec schedule.

To reduce the likelihood of accidental reinforcement of attack, a 5-sec changeover delay contingency operated during all sessions in which the target bird was present. This changeover delay prevented the reinforcer from becoming available for 5 sec subsequent to the first key peck that occurred after the last attack.

Total attacks and session length were recorded and used to compute the overall attack rate during each session. The location of the attacks within successive segments of the intervals was also recorded. Throughout the final 10 sessions, the duration of and the number of attacks during the post-reinforcement pause (that portion of each interval before the first key peck) and the remaining portion of each interval were recorded. Thus, for the final 10 sessions, mean attack rate during the post-reinforcement pause and the remaining portion of the interval was computed.

RESULTS

Figure 1 shows the rate of attack during the 3 to 10 sessions during which the operant level of attack was determined and the 20 sessions during which the reinforcer was delivered according to the FI schedule. Only the 20 sessions of FI 270-sec are presented for S-1850. Birds S-2454 and S-635 showed minimal attack during the operant level sessions. The substantial attack that S-1140 showed during the early operant level sessions disappeared by the final three operant level sessions. Bird S-1850 showed substantial attack during operant level Sessions 2 and 3, but showed only moderate levels of attack throughout most of the remaining operant level sessions. Bird S-1407 engaged in substantial attack throughout all operant level sessions. No attack occurred during the sessions of continuous reinforcement in which the target bird was present; these sessions are not shown in Figure 1. In terms of the overall attack rate (solid curve), three subjects (S-2454, S-1140, and S-635) showed a large and consistent increase in attack rate on exposure to the FI schedule. This elevated attack rate was sustained throughout the 20 sessions of FI reinforcement. The FI schedule produced a small increase in S-1850's attack rate above the final five operant level sessions only. The attack rate for S-1407 increased in only two of the sessions of FI reinforcement. With the exception of S-1140, gross visual observation indicated that the closure of the microswitch below the target bird provided, in general, a reliable index of aggression. While the microswitch was often closed by S-1140's aggression against the target bird, it was also frequently closed by S-1140 hitting the restraining can with its tail, often while pecking the key. Since the proportion of switch-closures pro-

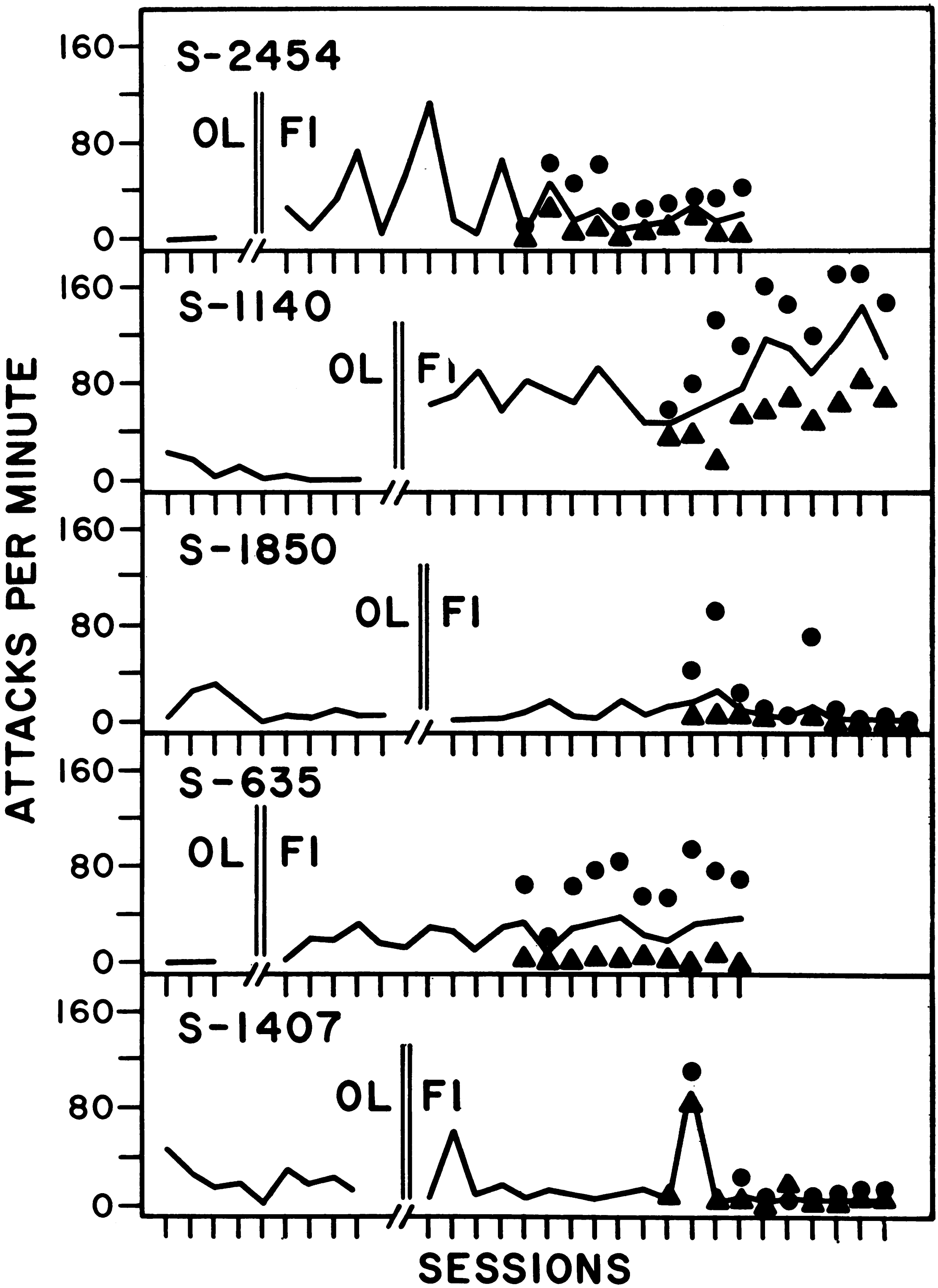

Fig. 1. Attack rate during the operant level (OL) sessions and the sessions of FI 90-sec reinforcement (FI 270-sec for S-1850). The overall attack rate is shown by the solid curve. The attack rates during the post-reinforcement pause (circles) and the remaining portion of the interval (triangles) are also shown.

duced by aggression was not recorded, the quantitative attack rate for S-1140 is equivocal.

For the final 10 sessions, the mean attack rates during the post-reinforcement pause (circles) and the remaining portion of the interval (triangles) have been plotted separately. Clearly, the rate of attack for each subject is higher during the post-reinforcement pause than during the remaining portion of the interval, and only for S-1407 is there no definite increase in attack during the post-reinforcement pause as compared to the operant level. In addition, S-2454 showed substantially higher attack rates during the remaining portion of the interval than during the operant level; in each of these 10 sessions the mean attack rate during this portion of the interval was higher than the mean operant level of attack. Bird S-635's mean attack rate during this portion of the interval was above its mean operant level in seven of the 10 sessions. While S-1140 did show some attack during this portion of the interval, much of this elevated attack rate is an artifact produced by "accidental" hitting of the restraining can.

Figure 2 shows the cumulative records for the final sessions of FI reinforcement for S-1140, S-2454, S-1407, and S-1850. Because of a failure in the recorder, the cumulative record of the next-to-last session is presented for S-635. The upper pen, which recorded cumulative key pecks, reset to baseline after each reinforcement. The lower pen recorded attacks, each attack producing a brief displacement of the pen. As can be seen in this figure, all subjects showed a distinct pause in key pecking immediately after reinforcement. During many of these pauses S-2454, S-1140, S-635, and S-1407 moved to the rear of the chamber and attacked the target bird. These subjects then usually returned to the intelligence panel and key pecked for the remainder of the interval. Closure of the microswitch below the target bird by non-aggressive behavior tends to conceal this relationship between key pecking and attack in the cumulative record of S-1140. Bird S-1850 showed little attack behavior, but most of what did occur was during the post-reinforcement pause.

Figure 3 shows the per cent of total attacks (during the last five sessions of FI reinforcement) that occurred in each of the six successive 15-sec segments of the interval (45-sec segments for S-1850). Most attacks for four of the subjects occurred during the first segment of the interval; the per cent of attacks then decreased over the remaining segments within the interval. The attacks of S-1407 occurred more or less equally often within all portions of the interval.

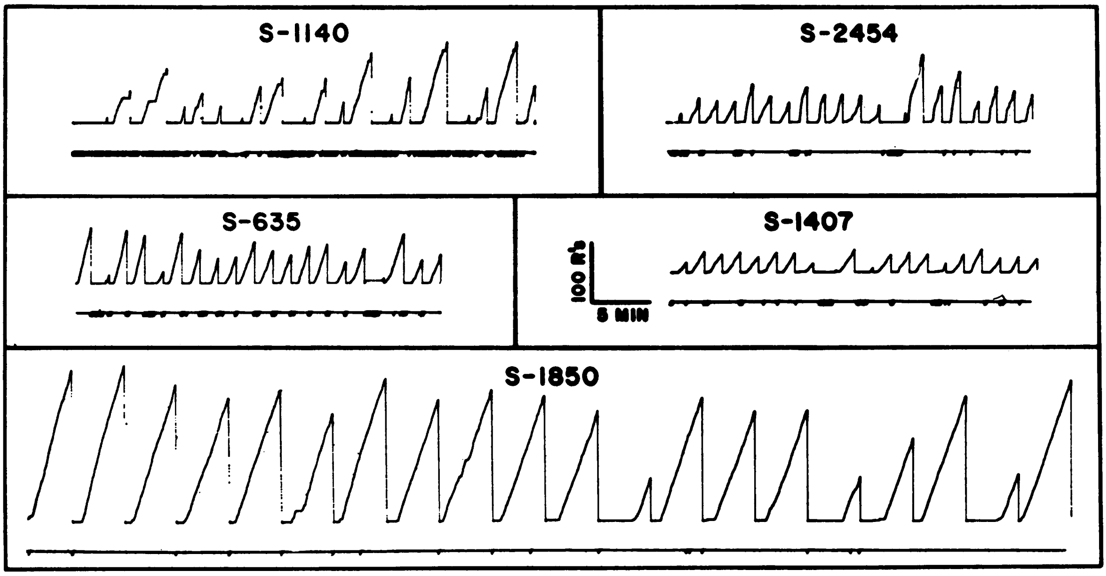

Fig. 2. Cumulative records of the last session of FI reinforcement for S-1140, S-2454, S-1407, and S-1850; the record of the next to last session is presented for S-635. Attacks are indicated by downward displacements of the lower recording pen.

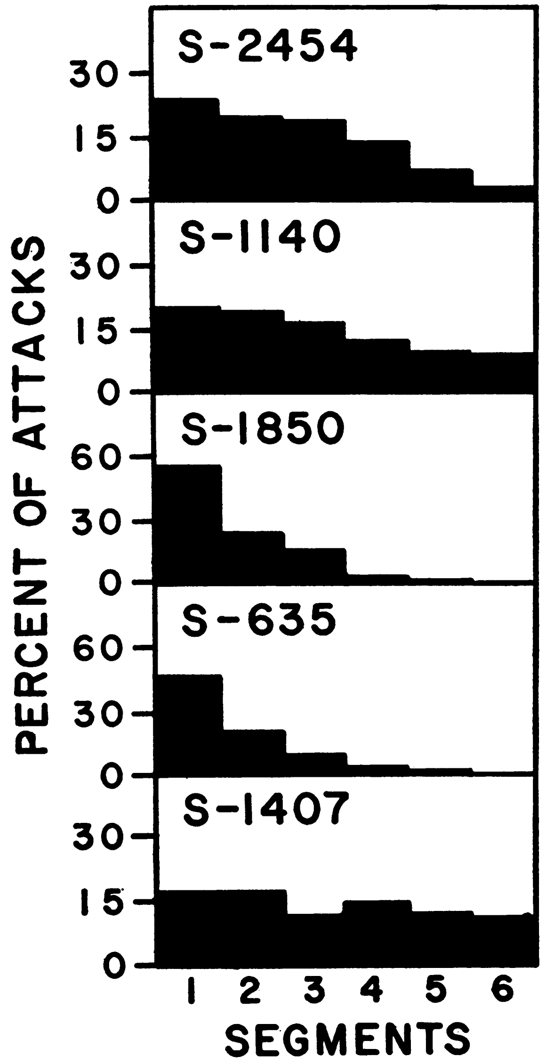

Fig. 3. The per cent of total attacks, based on the last five sessions of FI reinforcement, that occurred in each of the six successive 15-sec segments of the interval (45-sec segments for S-1850).

DISCUSSION

The present experiment showed that exposure to an FI schedule of positive reinforcement increases the amount of some pigeons' attack above their operant level. Although there was large inter-subject variability in the absolute amount of attack elicited by the schedule, the most frequent attack occurred during the post-reinforcement pause in key pecking. An increased rate of attack also occurred during the remaining portion of the interval, in some subjects.

It seems unlikely that the attack in the present study was maintained by accidental reinforcement because accidental reinforcement would have yielded more attack immediately before reinforcement. Figure 3 shows that, in general, most attack occurred immediately after reinforcement and that the amount of attack decreased over the interval.

Flory's (1969) demonstration that the independent delivery of food after a fixed period of time elicits aggression suggests that it is not the response requirement of the FI schedule, but the period of nonreinforcement immediately after reinforcement that elicits the attack. Flory found that an inverted U-shaped function related the duration of the inter-reinforcement interval and the amount of attack elicited. It would be interesting to determine if increasing the value of a response-dependent FI produces a similar function. A qualitatively different function would indicate the existence of different properties within response-dependent and response-independent FI schedules of positive reinforcement.

Given that many unconditioned stimuli elicit aggression (*e.g.*, shock: Ulrich and Azrin, 1962; Azrin, Hutchinson, and Sallery, 1964; intense heat: Ulrich and Azrin, 1962; a physical blow: Azrin, Hake, and Hutchinson, 1965), several investigators (Azrin *et al.*, 1966; Hutchinson, *et al.*, 1968; Gentry, 1968; Turner and Lyon, 1970) have explicitly suggested that elicited aggression be used as an index of aversiveness. Moreover, they suggest a direct relationship between degree of aversiveness and frequency of aggression. Following the demonstrations of extinction-induced (Azrin *et al.*, 1966) and FR-induced (Hutchinson *et al.*, 1968; Gentry, 1968; Turner and Lyon, 1970) aggression, it was suggested that both extinction and FR schedules contain aversive stimuli. Since the most frequent attack was at the beginning of extinction and during the FR's post-reinforcement pause, it was suggested that these were the most aversive aspects of the schedules. This position is strengthened by the findings that both extinction (Rilling, Askew, Ahlskog, and Kramer, 1969; Rilling, Kramer, and Richards, 1971; Terrace, 1971) and an FR schedule (Azrin, 1961; Thompson, 1964; 1965*a*) elicit escape behavior. Appel (1963) suggested, however, that Azrin's data are best explained in terms of stimulus change as a positive reinforcer, rather than the removal of the negative reinforcer, the stimuli associated with the FR's post-reinforcement pause. The reports on FR-elicited aggression, however, strengthen the hypothesis that an FR schedule contains aversive stimuli. Using the punishment paradigm, Thompson (1965*b*) provided further support for this position; Thompson found that a stimulus associated with an FR schedule suppressed pigeons' responding on a variable-interval schedule. Earlier studies (*e.g.*, Ferster, 1958; Baer, 1962; Holz, Azrin, and Ayllon, 1963) had shown a period of extinction to be an effective punisher. The consistency of the findings obtained from these three different experimental paradigms strongly suggests, at least to the present experimenters, that both extinction and an FR schedule contain aversive stimuli. It is, further, suggested that aversiveness may be detected by using either the aggression, escape, or punishment paradigm.

To the extent that aggression is a reliable index of aversiveness, the present results show that an FI schedule of reinforcement possesses aversive properties, the most aversive of which are located during the post-reinforcement pause.

Schneider (1969) suggested that there are two distinct components to steady state FI performance and that an FI schedule may be described and analyzed as a multiple extinction variable-interval schedule of reinforcement, with temporal stimuli serving to distinguish the two components for the animal. The first component is the extinction component during which the response rate is low and constant. The extinction component begins with the termination of reinforcement and ends at the breakpoint, which extends about two-thirds of the way through the interval on the average. The breakpoint is the point at which responding increases from a near zero to a high rate of occurrence. The second or variable-interval component is characterized by a constant and rapid rate of responding. Since other studies (Azrin *et al.*, 1966; Kuntson, 1970; Rilling *et al.*, 1969, 1971; Terrace, 1971) have shown that the extinction component of a multiple schedule is aversive, Schneider's analysis suggests that an FI schedule possesses aversive properties. To the extent that aggression is indicative of aversiveness, the present study supports this two-state analysis of an FI schedule. That is, the attack elicited during the post-reinforcement pause may be viewed as elicited by the first, or extinction, component. The less-frequent attack during the remainder of the interval may be viewed as elicited by the second, or variable-interval, component. It should be noted, however, that in the present experiment, the two components were separated by the first response that occurred in each interval, rather than at the breakpoint.

An alternative, but not necessarily conflicting, interpretation of the present results in terms of a competing response analysis should be considered. It is possible that subjects attacked less frequently late in the interval simply because they were key pecking. That is, the lack of attack might be more indicative of effective response-competition than a lack of aversiveness. A stimulus-probe technique (see Dews, 1970) could be used to test this competing response analysis and to provide further information on the nature of the FI schedule. Another interpretation might view the attack as just another type of adjunctive behavior (see Flory, 1969, for a discussion of the similarities between schedule-induced polydipsia and schedule-induced aggression) and, thus, not necessarily indicative of aversiveness. It is, of course, possible that all adjunctive behaviors are indicative of aversiveness. In any event, subsequent study of the FI within an escape and punishment paradigm should be conducted to verify the present authors' interpretation—that the FI schedule contains aversive stimuli, the most aversive of which are located during the post-reinforcement pause.

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