

## EXTINCTION-INDUCED AGGRESSION<sup>1</sup>

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Pigeons were conditioned to peck a response key under a procedure that alternated periods of food reinforcement with periods of extinction. The pigeons attacked a nearby pigeon at the onset of extinction. Some also attacked a stuffed model of a pigeon. The duration of attack was an inverse function of the time since the last food reinforcement and a direct function of the number of reinforcements. The pigeons attacked after the last food delivery whether or not the conditioned pecking response was required and whether or not the extinction period was signaled. The food had to be eaten; the mere sight and sound of food being delivered did not produce attack. Prior satiation reduced attack. The phenomenon was not attributable to a past history of competition between pigeons since socially deprived pigeons also attacked. Superstitious reinforcement of attack was not found to be a factor. The results indicated that the transition from food reinforcement to extinction was an aversive event that produced aggression.

When shock is delivered to the feet of an animal, attack results (Ulrich and Azrin, 1962). Other unconditioned aversive stimuli such as shock to the tail (Azrin, Hutchinson, and Sallery, 1964), a physical blow (Azrin, Hake, and Hutchinson, 1965), or intense heat (Ulrich and Azrin, 1962) also cause attack. Perhaps attack will also result from aversive events other than unconditioned aversive stimuli. Evidence exists that parts of a schedule of food reinforcement are aversive. For example, immediately after reinforcement, subjects will respond to terminate a reinforcement schedule that has a high response requirement (Azrin, 1961). One aspect of reinforcement schedules that seems to have aversive properties is extinction. Several investigators have inferred the existence of a "frustrating" or "emotional" state during extinction as reflected by oscillations in the response rate (Skinner, 1938), attacking of the response lever (Mowrer and Jones, 1943), increased vocalization between children (Azrin and Lindsley, 1956), and increased running speed after omission of a food reinforcement

for running (Amsel and Roussel, 1952). The most direct evidence of the aversive properties of extinction has emerged from studies (*e.g.* Ferster, 1958; Ferster and Appel, 1961; Baer, 1962; Holz, Azrin, and Ayllon, 1963; Zimmerman and Ferster, 1963) that have used an extinction period as a punisher for responses. Based on this evidence, the present study attempted to determine whether the aversive properties of extinction of food reinforcement could produce attack. The general rationale was to alternate periods of continuous reinforcement with periods of extinction. A subject was stationed nearby to serve as the target for any attack that might occur.

### EXPERIMENT I

#### *Method*

*Subjects.* Eighteen experimentally naive male pigeons from 1-5 years of age were obtained from Palmetto Pigeon Plant, Sumter, South Carolina. Sixteen were White Carneaux, one was a Silver King, and the other was a White King. All were maintained at 80% of free-feeding weight. Each experimental pigeon was paired with a target pigeon. The 18 target pigeons were White Carneaux, except for S-144 which was a White King. It was paired with the experimental White King. The target pigeons were maintained at free-feeding weight. All pigeons were housed in individual liv-

<sup>1</sup>This investigation was supported by grants from the Mental Health Fund of the Illinois Department of Mental Health, NIMH Grant 4925, and NSF Grant 1987. T. Ayllon and J. Keller provided valuable advice and assistance. Reprints may be obtained from any of the authors, Behavior Research Laboratory, Anna State Hospital, Anna, Illinois 62906.

ing cages with water and grit continuously available.

*Apparatus.* Figure 1 shows a schematic of the apparatus. At one end was a food tray located behind an aperture. Above the aperture was a response key consisting of a plastic panel which was exposed through a  $\frac{3}{4}$  in. diameter hole in the wall and transilluminated from behind. A response was defined as a peck on the key in excess of 20 g. Each response produced a click. Food reinforcement was delivered by raising the food tray to a level that could be reached through the wall aperture. A photocell (not shown) was mounted above the food tray so that a narrow beam of light was interrupted when the head of the pigeon was in the aperture. The duration of food reinforcement was timed by maintaining the food tray in the accessible position for 1.0 sec from the moment of interruption. This photocell and timing arrangement was used to ensure greater control over the actual eating time. During food delivery, the lights behind the response key were extinguished and the tray was illuminated.

The apparatus for recording attack was at the other end of the chamber. Pigeons are known to fight for a variety of reasons (Levi, 1957). The apparatus was designed to provide

objective measurement of attack and to reduce the "spontaneous" fighting so that attack during the study could be more definitely attributed to the experimental conditions. The target pigeon was restrained in a box by a metal band fastened snugly over each wing. The pigeon could move its head freely but the body was relatively immobilized. The restraining box was mounted on an assembly that contained an adjustable spring and a microswitch, the contacts of which closed when a force exceeding 100 g was exerted against the restraining box. This force was sufficient to prevent closure of the contacts by normal spontaneous movements of the target pigeon. Closure of the switch contacts provided the measure of attack by the experimental pigeon against the target pigeon. Attack duration was measured automatically by timers. Since the contacts often opened and closed repeatedly during continued attack, their output was "smoothed" by allowing the timers to run until the contacts remained open for at least 1.0 sec. "Attack duration" refers to the smoothed output.

Closure of the switch contacts depended only partly on the force of the pecking attacks. The target pigeon characteristically moved its head vigorously when attacked in a seeming

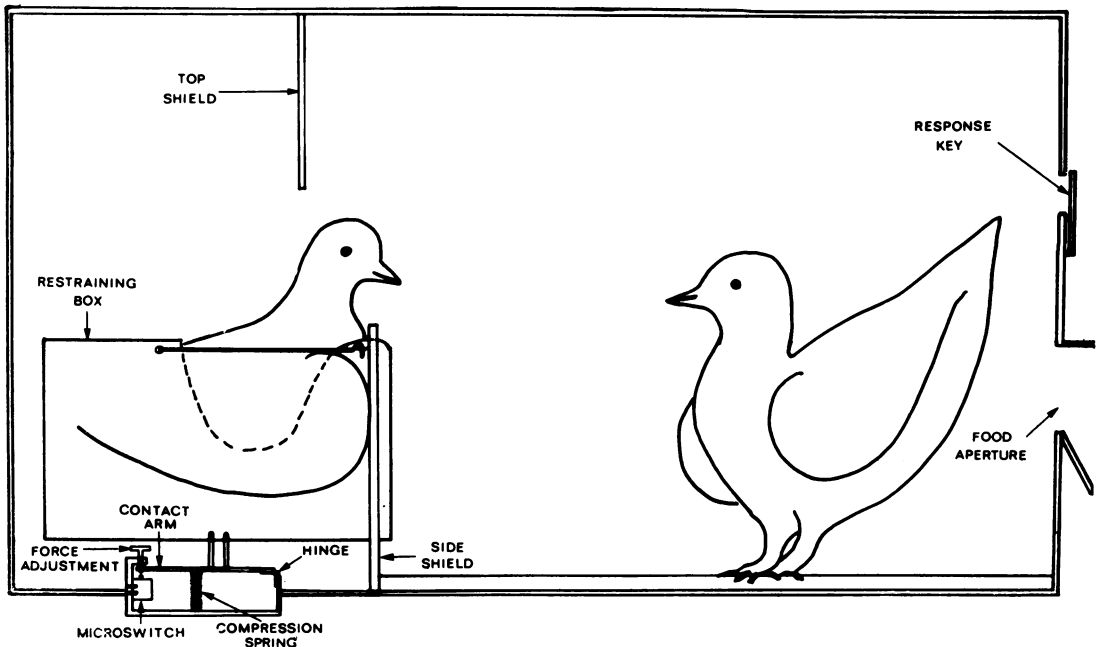


Fig. 1. Schematic of the apparatus for measuring attack. The experimental chamber was 26 by 14 by 14 in. high. Plexiglas shields at the top and on the sides of the restraining box prevented the experimental pigeon from getting behind the target pigeon.

effort to escape or counter-aggress. These "defensive" movements by the target pigeon plus the force of the attacking movements of the experimental pigeon caused the switch contacts to close. Visual observation indicated close correspondence between the automatic record of attack and visual evidence of attack as indicated by physical contact by the beak of the experimental pigeon. Occasionally the switch contacts closed a fraction of a second before the experimental pigeon attacked, this resulting from vigorous defensive head movements by the restrained pigeon when the experimental pigeon struck with its wing or made an abortive peck from a distance before moving in. The contacts closed occasionally as a result of strong movements by the restrained bird in the absence of any attack; the duration of these closures never exceeded 10 sec during any 1-hr session. For one subject, the automatic recording system did not provide a valid measure of attack since the target pigeon with which it was paired adopted a submissive posture, remaining motionless and not resisting attack. The data for this subject are not included since the switch contacts did not close, even though attacks occurred.

The experimental chamber was enclosed in a sound-attenuating enclosure that contained a one-way window and a closed-circuit TV camera for continuous observation. Overhead lights in the chamber provided general illumination. White noise was presented continuously to mask extraneous sounds. A 60 cps tone, produced by a tone generator mounted within the chamber, was used as a discriminative stimulus. Programming and recording were performed automatically by circuits in an adjacent room.

#### *Procedure*

The procedure followed an ABA design consisting of no reinforcement, reinforcement-extinction, no reinforcement again. For some subjects an additional condition of reinforcement-extinction followed (ABAB). During the initial condition of no reinforcement, each experimental pigeon was given from 5-12 sessions of 1-hr duration during which the target pigeon was in the restraining box but the food reinforcement mechanism was inoperative. This phase provided a measure of attack prior to any experimental history of food reinforcement.

For the reinforcement-extinction condition, the pigeons were trained to eat out of the food magazine and shaped to peck the response key. The target pigeon was not present except for one subject, S-214, which was intentionally shaped while a target pigeon was present. Each response produced the food reinforcement. This shaping procedure required one or two sessions, a maximum of 80 reinforcements being given each session. The 60 cps tone sounded continuously. From 10-20 sessions were then given in which periods of continuous reinforcement were alternated with periods of extinction, the tone serving to signal the beginning of the period of continuous reinforcement. During the first 5 min of each session, key pecks were ineffective. After 5 min the tone sounded; the first response during the tone produced food reinforcement. The tone was terminated after this first food delivery and each subsequent response produced reinforcement until 10 were delivered, after which the key pecks were again ineffective for 5 min (extinction). Then the tone sounded, again signaling availability of food reinforcement. This cycle of reinforcement and extinction was repeated eight times for a total of 80 reinforcements and 50 min of extinction during each session, excluding the first 5 min. This procedure remained in effect until responses occurred immediately upon the sounding of the tone, but few responses were made during extinction periods. The tone onset was (experimentally) delayed for 5 sec by any preceding responses in order to prevent superstitious reinforcement (Skinner, 1948) of the response by the tone onset.

The target pigeon was then placed in the restraining box; the alternating reinforcement-extinction procedure was still in effect. To prevent superstitious reinforcement of attack behavior, a 5 sec delay was imposed between occurrence of attack and onset of the tone.

A minimum of 10 sessions were scheduled, this number generally being increased whenever attack duration seemed to show a consistent change during successive sessions.

At least 10 sessions were given during the second condition of no reinforcement and reinforcement-extinction.

The sessions were conducted daily except when the condition of the target bird made it advisable to omit a scheduled session.

### Results

Consider first the effect of the food reinforcement schedule on the key-pecking responses. The top half of Fig. 2 illustrates the typical key-pecking performance in the absence of a target pigeon. The pigeons learned to peck the key within a second or two after the tone signaled the onset of the period of continuous reinforcement. Also, the pigeon pecked the response key with a short latency during the period of continuous reinforcement; less than 1 sec generally elapsed between termination of food delivery and the next key-peck. The figure shows the characteristic burst of key-pecking responses at the onset of extinction.

The lower portion of Fig. 2 illustrates key-pecking performance and attack behavior when the target bird was in the chamber. The usual burst of key pecks occurred. In addition, the pigeon attacked the target shortly after the last response of the burst. Visual observation revealed that attack consisted of strong pecks at the throat and head of the target bird, especially around the eyes. The feathers of the

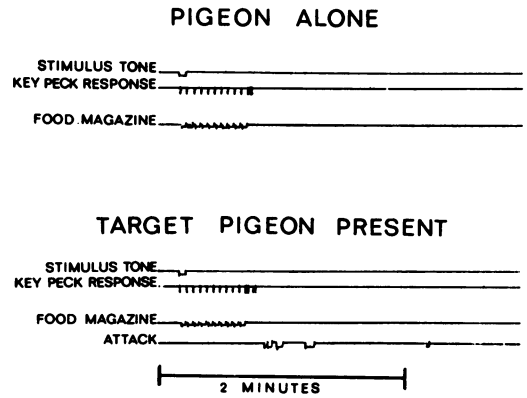


Fig. 2. Simultaneous event recordings of the tone stimulus, the key-peck responses, the delivery of food reinforcement, and the attack against a target pigeon. A target pigeon was present during the procedure described in the lower part of the figure but not in the upper part.

target bird were often pulled out and the skin bruised. The attack was often preceded by a brief period of pacing in front of the wall on which the response key was mounted. Occasionally the pecking attack was preceded by

Table 1  
Attack During Repeated Extinction Periods

Subject No.	Duration of Attack (Sec)							
	No Reinf.		Reinf. + Ext.		No Reinf.		Reinf. + Ext.	
	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.
S-78C	3 ± 3		764 ± 86		99 ± 108			
S-111B	15 ± 8		415 ± 200		76 ± 28			
S-144	0 ± 0		105 ± 30		0 ± 0			
S-203A			353 ± 113		6 ± 5		257 ± 52	
S-205	15 ± 14		1148 ± 88		5 ± 6			
S-205A	3 ± 3		157 ± 81		16 ± 13		64 ± 44	
S-206	12 ± 7		177 ± 130		0 ± 0			
S-208	56 ± 25		92 ± 79		2 ± 3		178 ± 70	
S-209	21 ± 18		1125 ± 84		0 ± 0		734 ± 247	
S-209A	10 ± 10		52 ± 35		0 ± 0		94 ± 16	
S-210			38 ± 18		0 ± 0		173 ± 50	
S-213	10 ± 10		254 ± 58		72 ± 42		289 ± 73	
S-214	10 ± 6		456 ± 234		5 ± 5		459 ± 391	
S-214A	24 ± 14		79 ± 17		16 ± 8		216 ± 50	
S-218A	25 ± 10		30 ± 13		8 ± 12		65 ± 13	
S-220A			223 ± 48		0 ± 0		464 ± 139	
S-225	2 ± 2		288 ± 63		5 ± 5		106 ± 46	

Note.—For three of the subjects (S-203A, S-220A, and S-210) the target pigeons counter-aggressed so vigorously that no aggression occurred after the first day of exposure to the reinforcement-extinction procedure. When three new target pigeons were substituted, attack occurred. These three new target pigeons were paired with the three experimental pigeons for the remainder of the experiment. No data is presented for the initial period of no-reinforcement in the first column of Table 1 for these three pigeons since that data was obtained with the different target bird.

striking movements of the wing or by a slow swaying approach to the target bird with the head lowered. Frequently, the attack was preceded and accompanied by a deep-throated sound.

Table 1 shows the mean and average deviation of attack duration based on the last five days of each condition for all subjects. All pigeons attacked more during the reinforcement-extinction procedure than during the no-reinforcement procedure. The Silver King pigeon (S-78C) and White King (S-144) showed the same increase in attack duration as did the White Carneaux. Attack also occurred for the pigeon (S-214) that was magazine-trained and shaped to respond in the presence of the target pigeon.

Figure 3 illustrates the day-to-day changes of attack duration. The four pigeons in the figure were intentionally selected to illustrate the major intersubject differences in performance. On the first day, most pigeons had a high duration of attack, which decreased to a near-zero level on succeeding days for all pigeons. On the first day of the reinforcement-extinction procedure, duration of attack increased at least tenfold for all pigeons, thereafter declining somewhat for some, *e.g.*, S-214A. For three pigeons, two of which (S-205, S-209) are included in Fig. 3, the attack was so intense and enduring that only five sessions were given in order to prevent serious injury to the target pigeon. When the reinforcement-extinction procedure was discontinued, attack duration gradually decreased for all pigeons. When the reinforcement-extinction procedure was reinstated, the duration of attack immediately increased for all pigeons. The cumulative recordings of the attack in Fig. 4 show that attack was most likely immediately after periods of reinforcement. For most subjects it resulted after each period of food reinforcement. Often attack occurred at the very start of the session, as with S-203A. There was no consistent change in attack as a function of session duration.

Figure 5 presents a summary of the temporal pattern of attack for eight subjects. For all subjects, attack duration was highest during the first 30 or 60 sec after reinforcement was terminated. Thereafter, attack duration was an inverse function of the time since reinforcement, reaching a near-zero level after 4 min.

## EXPERIMENT II

### *Omission of the Conditioned Key-Peck Requirement*

This experiment attempted to determine whether the key-peck response was essential for producing attack.

#### *Method*

Two naive pigeons were used in order to avoid possible superstitious reinforcement of the key-pecking response once it had been conditioned. One was White Carneaux, the other White King. The experimental design and procedure were the same as in Exp I except that the response key was absent. Food was delivered automatically by raising the food tray at the instant the tone sounded and keeping it there for 1 sec after the pigeon inserted its head into the aperture above the tray. The tone was then terminated and the tray lowered for 1 sec. Every 10 presentations of the food tray was followed by 5 min of no food.

#### *Results*

Table 2 shows the mean and average deviation of attack duration for the two experimental pigeons. Little or no attack occurred when food was not delivered. When the free food deliveries were interrupted, attack duration increased severalfold. The duration of attack during this free food procedure appears comparable to that for several pigeons used in the response-produced food procedure (Table 1). The temporal pattern of attack (not shown here) was also comparable. The termination of the food delivery, not the learned key-peck response, seemed to be the critical factor in producing attack. These results also show that the pecking attacks were not simply a "displacement" of the conditioned key-pecking responses.

## EXPERIMENT III

### *Signaled vs Unsignaled Extinction*

Figure 2 showed that a short period of key-pecking typically occurred at the termination of food delivery during the procedure in which a key-peck was required; similarly, visual observation revealed a brief period of lingering about the food magazine at the termination of free food deliveries. These activities seemed to reflect the absence of any distinctive discriminative stimuli regarding the precise mo-

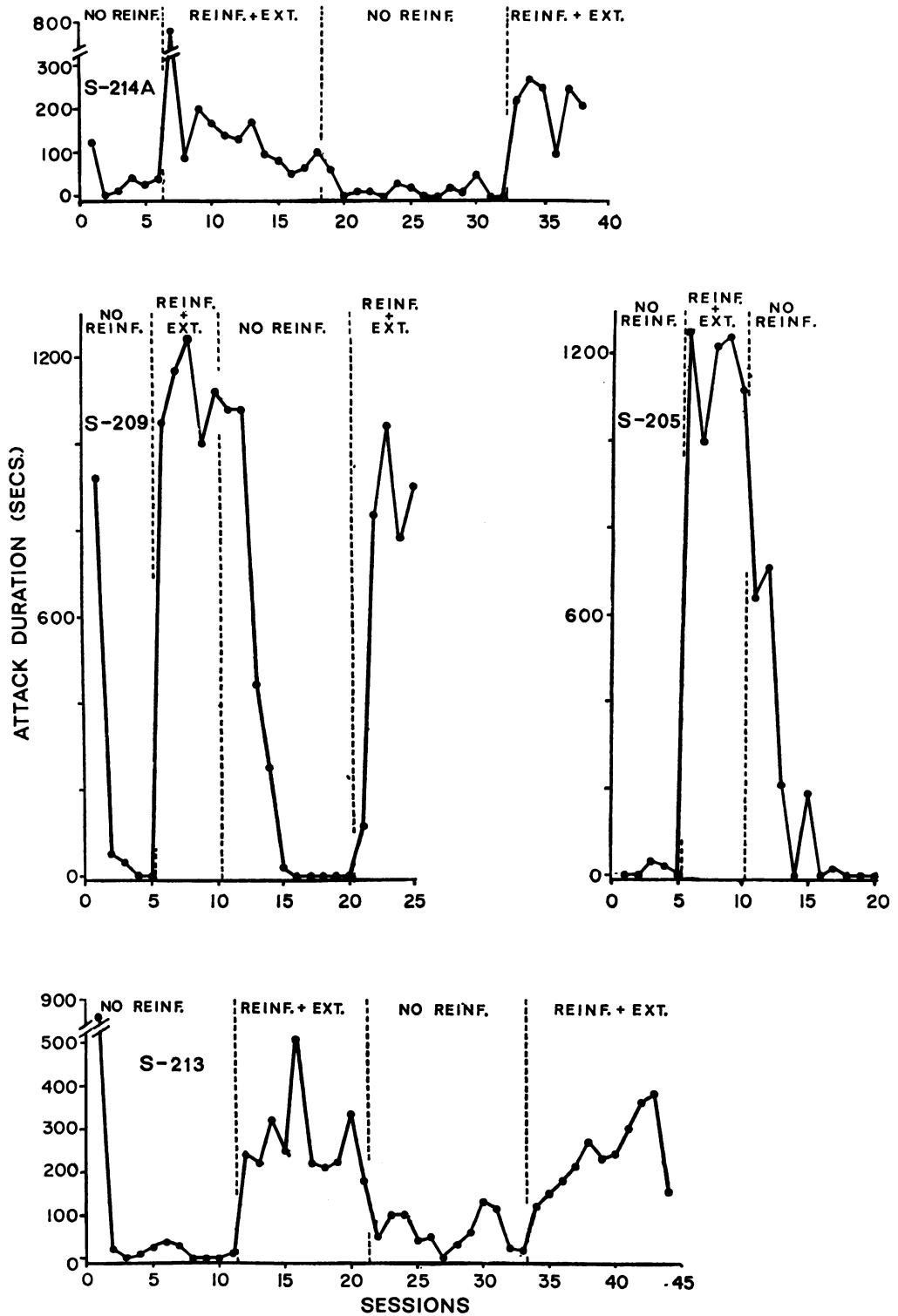


Fig. 3. Duration of attack from the beginning of the experiment for four of the experimental pigeons. "No Reinf." designates the procedure in which no food reinforcement was delivered. "Reinf. + Ext." designates the procedure in which periods of food reinforcement were alternated with periods of extinction during each session.

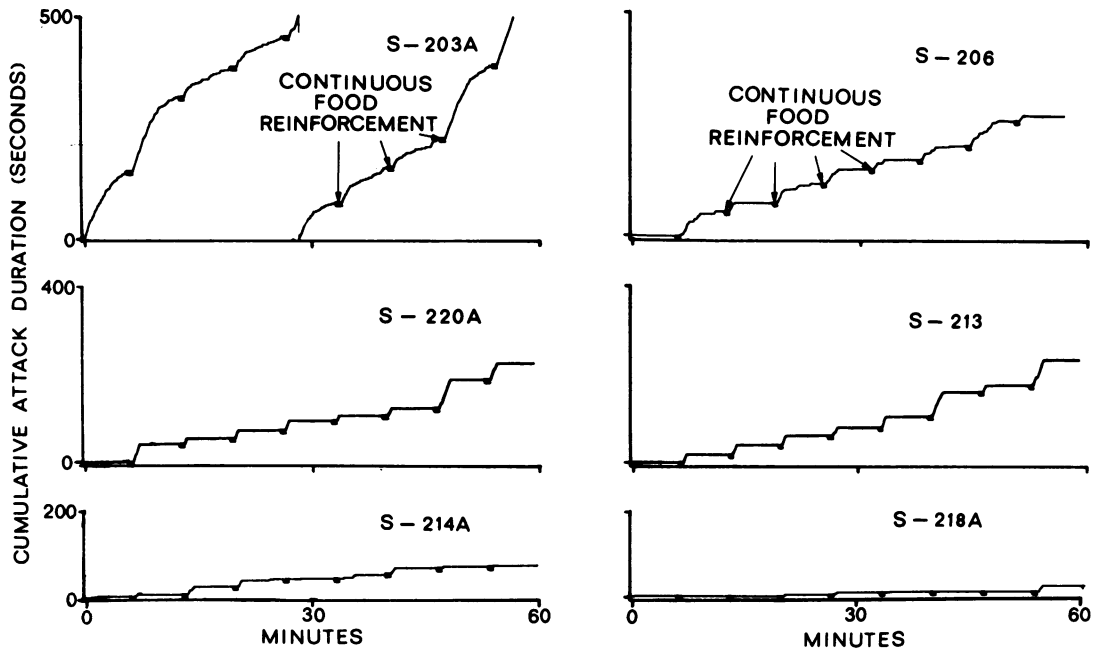


Fig. 4. Cumulative record of the attack behavior of six of the experimental pigeons. The six subjects of Fig. 4 were intentionally selected for presentation on the basis of the large differences in the duration and temporal pattern of attack. Each record is for an entire session. The recorder pen stepped one response for each 1 sec of attack. The solid bar-like markings, as indicated by the arrows, were produced by the short downward deflection of the recording pen during the delivery of food. The key-peck responses that produced the food are not shown in this figure.

ment of transition from food reinforcement to extinction. Perhaps a more clearly defined extinction period might be less aversive, as suggested by Pavlov's observations (1927) of emotional behavior during difficult discriminations, and might not produce attack. The present procedure investigated this possibility by comparing signaled and unsignaled extinction.

#### Method

Two White Carneaux male pigeons were the

experimental subjects; one was experimentally naive, the other (S-144) had been used in the previous procedure (see Table 1). The unsignaled extinction procedure was the same as that used previously: the tone sounded only at the onset of the period of continuous reinforcement. During signaled extinction, the tone sounded throughout the period of continuous reinforcement, terminating immediately after the last food delivery that preceded each 5-min extinction period. S-144 received at

Table 2  
Attack Following Automatic Food Reinforcement

Subject No.	Duration of Attack (Sec)							
	No Food		Free Food + No Food		No Food		Free Food + No Food	
	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.
S-234	1 ± 2		208 ± 64		0 ± 0		1063 ± 35	
S-49B	33 ± 44		386 ± 95		62 ± 21		215 ± 51	

least 10 sessions under each procedure in the order described in Table 3; S-89 received only five sessions in order to prevent serious injury to its target pigeon. A key-peck was required to produce the food. The signaled procedure constituted a multiple continuous reinforcement-extinction schedule (Ferster and Skinner, 1957).

### Results

Table 3 shows appreciable attack during both types of extinction. S-144 attacked slightly less during the signaled than the unsignaled extinction; S-89 showed no clear difference perhaps because of the complications arising from injury to its target bird. Taken together, results for the two pigeons show that the onset of extinction produced attack whether or not the extinction period was signaled by a distinctive stimulus. Although unsignaled ex-

tingtion produced more attack, the difference was slight.

## EXPERIMENT IV

### *Effect of a Single Extended Period of Reinforcement and Extinction*

The preceding results show that attack decreased as a function of time from the termination of reinforcement. One explanation of this relation is that attack decreased only because of some competing behavior, such as standing near the response key, that was preparatory to the onset of the next reinforcement period. The present procedure evaluated this possibility by programming only one reinforcement period during each session and by allowing a longer period of extinction.

### Method

Two White Carneaux pigeons were studied, S-111B and S-225, both of which had been studied previously (see Table 1). The procedure was the same as the signaled extinction procedure described above, except that the period of continuous reinforcement began 30 min after the start of the 60-min sessions and consisted of a single period of 60 food deliveries. Sixty sessions were given to S-111B and 40 to S-225.

### Results

Figure 6 shows segments of several cumulative response records for one pigeon. It can be seen that a few instances of attack occurred before reinforcement in some of the records. During the extended period of reinforcement, little or no attack occurred. In all records, attack resulted shortly after termination of reinforcement followed by briefer attack episodes in some cases. The second pigeon (not shown) was similar in showing little attack before reinforcement, almost no attack during reinforcement, but consistent attack at the onset of extinction. Since only one period of reinforcement was given during each session, the fall-off in attack during extinction cannot be attributed to other competing behavior associated with the onset of the next reinforcement period. The relative absence of attack during the extended food reinforcement period indicates that it is not the delivery of food, but its termination that is primarily responsible for the attack.

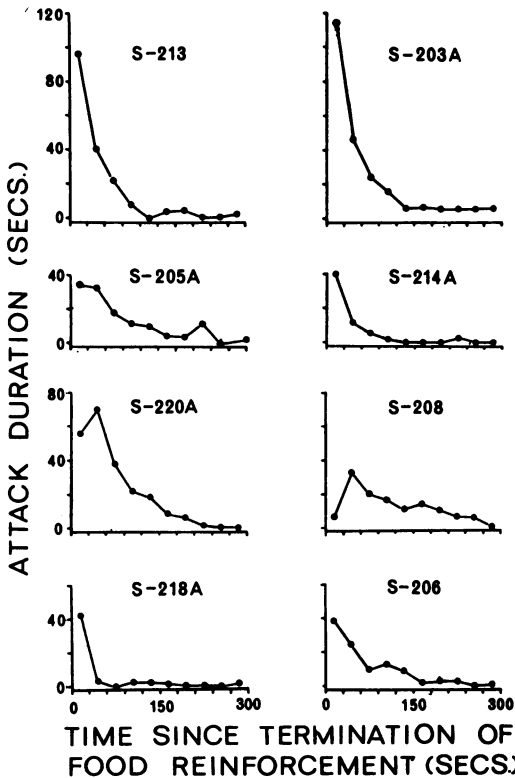


Fig. 5. The average duration of attack as a function of time since the termination of food reinforcement. The 300 sec duration between reinforcement periods was divided into 10 30-sec class intervals. Each point designates the mean duration of attack per session during each of these class intervals for the last five sessions of the first reinforcement-extinction procedure. Each curve is for a different pigeon.



Table 3

Attack During Signaled vs. Unsignaled Extinction

Subject No.	Duration of Attack (Sec)									
	Not Signaled		Signaled		Not Signaled		Signaled		Not Signaled	
	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.
S-144	115 ±	57	91 ±	44	167 ±	80	82 ±	29	143 ±	58
S-89	925 ±	69	905 ±	55	797 ±	193				

## EXPERIMENT V

*Effect of Social Isolation from Other Pigeons*

A possible interpretation of the attack behavior is that the pigeons had an extensive history of competition over food and had been reinforced thereby for successful attack. The delivery of food simply may have reinstated the conditions for competitive attack.

*Method*

The present procedure eliminated the possibility of a history of competitive attack by rearing four White Carneaux pigeons in isolation from other pigeons. If the attack behavior depended on a prior history of competition, these pigeons should show little attack. Contact with other pigeons was limited to the five week period after hatching during which each pigeon was alone with its respective parent bird in isolated breeding cages. Contact with the parent bird during this initial period is considered essential for survival (Levi, 1957). For nine months thereafter, they were housed in individual living cages with no possibility of physical contact with each other or with any other pigeons. Food and water were available at all times. At 10 months of age, the four pigeons were divided into two pairs, one member of each pair being designated as a target pigeon and the other as an experimental pigeon. The general procedure was the same as that described for the pigeons in Table 1.

*Results*

Table 4 shows that the reinforcement-extinction procedure produced substantial attack. The absolute duration was fairly comparable to that of the non-isolated pigeons used previ-

ously. The temporal pattern of attack (not shown) also was the same: attack occurred primarily at the onset of extinction. The com-

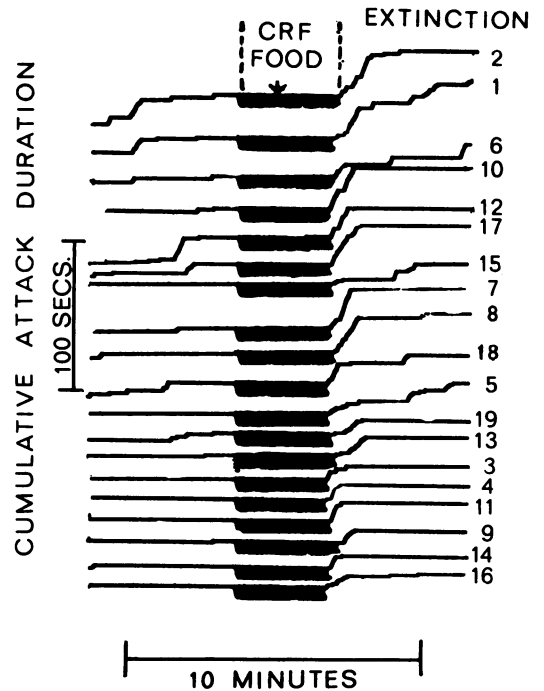


Fig. 6. Cumulative records of the attack behavior of an experimental pigeon. The recorder pen stepped one response for every 1 sec of attack. The pen was deflected downward during each 1-sec delivery of food giving the appearance of a solid horizontal bar during the 60 food deliveries that occurred in the period of reinforcement designated as "CRF FOOD." The records are for 19 consecutive sessions. For considerations of space, the order of the 19 response records has been rearranged; the actual chronological sequence is indicated by the numbers to the right of each curve. The segments shown cover the 5-min period preceding and following the period of continuous food reinforcement. The tone that was used as a discriminative stimulus sounded throughout the period of reinforcement.

parability of results indicates that the attack behavior was not a result of a history of competition over food.

### EXPERIMENT VI

#### *Effect of Food Satiation and Food Inaccessibility Using a Model as the Target*

This procedure investigated which aspect of the food delivery was essential for producing attack. Did the food have to be eaten or was the mere sight of food sufficient? Stuffed pigeons, prepared by a taxidermist, were used as the target in an attempt to reduce some of the variability that seemed to arise from counter-aggression by live target birds.

#### *Method*

Forty experimental pigeons were exposed to the general reinforcement-extinction procedure. The target was a stuffed White Carneaux pigeon. Only 10 of the 40 pigeons attacked the stuffed pigeon; five of these were selected at random to serve as subjects. The apparatus was identical to that shown in Fig. 1, except that a stuffed pigeon was mounted on a stiff wire at the usual location of the live target pigeon. The wire was attached to a switch that closed when a force of 50 g was exerted against the front of the pigeon. The sequence of procedures was: (1) inaccessible food, (2) food reinforcement-extinction, (3) inaccessible food, (4) food reinforcement-extinction, and (5) satiation. At least five sessions were provided for each procedure. The stuffed pigeon was present throughout. During the condition of inaccessible food, the tray was covered by a thin Plexiglas shield. It was raised for 1 sec, lowered for 1 sec, raised again for 1 sec, *etc.* for a total of 10 presentations. Five minutes then elapsed after which another 10 tray presentations were given. During the reinforcement-extinction procedure, the Plexiglas shield was removed

and the food could be eaten. The satiation procedure was identical to the reinforcement-extinction procedure except that food was continuously available in the living cages.

#### *Results*

Figure 7 shows that the reinforcement-extinction procedure produced the same temporal sequence of attack as when live pigeons were used as the target. All five subjects attacked mostly within 30 sec after termination of food reinforcement: the duration of attack again was an inverse function of the time since reinforcement. The bar graph of Fig. 8 shows that the reinforcement-extinction procedure produced a substantial increase of attack for all five pigeons over the level seen when food was inaccessible or when the pigeons were satiated. These results indicate that the food had to be consumed by the pigeon if attack were to occur. No attack resulted if the pigeon was prevented from eating either by a physical obstruction or by prior satiation. The mere sight of food did not produce appreciable attack.

About 25% of the pigeons attacked the stuffed target pigeons, whereas all pigeons studied attacked live target pigeons. The variables responsible for these individual differences have not been identified. Variations were made in the size, posture, position, and degree of movement of various stuffed target pigeons but most pigeons still would not attack. Variations were also made in the degree of food deprivation of the experimental pigeon, the age and strain of the experimental pigeon (White King, Silver King, White Carneaux), the number of food deliveries, and the duration of extinction. All of these changes failed to induce consistent attack against the stuffed target. Stuffed models of birds have been used previously (*cf.* Smith and Hosking, 1965). If a stuffed model had elicited attack consistently

Table 4  
Attack by Socially Deprived Pigeons

Subject No.	Duration of Attack (Sec)					
	No Reinf.		Reinf. + Ext.		No Reinf.	
	Mean	Avg. Dev.	Mean	Avg. Dev.	Mean	Avg. Dev.
S-258	2 ±	2	124 ±	33	33 ±	25
S-255	24 ±	18	290 ±	137	6 ±	9

in this study, it would be a more desirable type of target since the measure of attack behavior would not be confounded by spontaneous movements of the target.

## EXPERIMENT VII

### Number of Food Reinforcements

It has been seen that interruption of eating by a hungry pigeon was a prerequisite condition for producing attack. This implies that food has been delivered for some period before its termination. The present procedure attempted to determine how the number of food deliveries affected duration of attack.

### Method

The same apparatus, procedure, and subjects were used as in the preceding reinforce-

ment-extinction procedure except that a sixth subject was added and only five periods of reinforcement were given each session. Again, a stuffed pigeon served as the target. 0, 1, 3, 5, 10, or 30 food deliveries were given during each reinforcement period, at least three sessions being provided for each number in a scrambled sequence that differed between subjects. When 30 food deliveries were scheduled, sessions were conducted only on alternate days in order to maintain the pigeons at their usual reduced weight.

### Results

Figure 9 shows that duration of attack was a direct function of the number of food deliveries that preceded extinction, reaching an asymptote at 10 food deliveries. The slightly reduced level of attack at 30 food deliveries for S-4A and S-84 probably was caused by partial satiation within a session.

## DISCUSSION

Considerable attention was given to the methodological problems in measuring attack since progress in the study of attack will probably depend greatly on the development of satisfactory measures. Yet, the very nature of attack creates special problems for its long-term study and objective measurement. If the target is defenseless, death can result (*cf.* Roberts and Kiess, 1964). Conversely, if the target is capable of effective counter-aggression, attack gives way to "aggressive" postures, threats, *etc.* and requires subjective rating scales, as has been the case in studying attack between rats (Ulrich and Azrin, 1962) or between monkeys (Azrin *et al.*, 1964). One solution has been to use an inanimate object as the target (Azrin *et al.*, 1964; Azrin *et al.*, 1965; Azrin, Hutchinson, and McLaughlin, 1965). If one desires to study aggression between live animals, however, the pecking mode of attack of pigeons is advantageous for long-term study since it is less destructive than the usual biting attack of other animals. The problem of counter-aggression by the target bird was reduced by partially restraining it. The present method of recording attack provided an objective and fairly accurate record of physical attack between two live animals over relatively long periods of time. The main disadvantages were (1) occasional instances of serious injury to the target

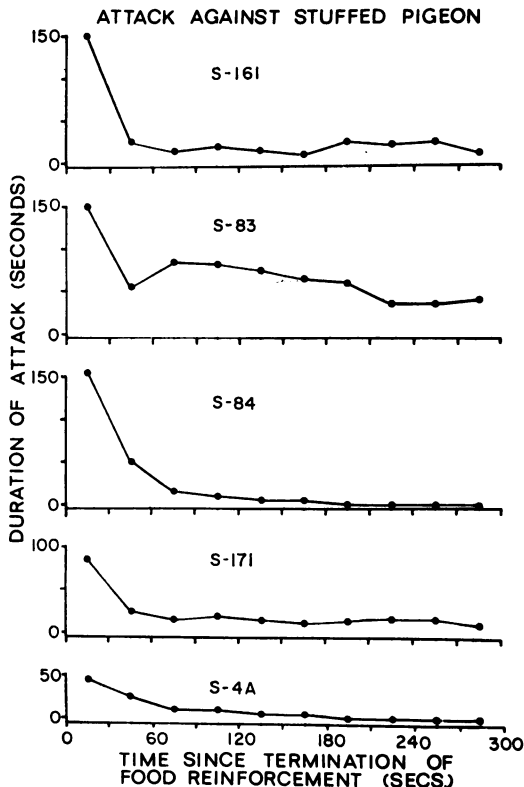


Fig. 7. Duration of attack against a stuffed pigeon as a function of time since the termination of food reinforcement. Each curve is for a different pigeon. The 5-min duration between reinforcement periods was divided into 10 30-sec class intervals. Each point designates the mean duration of attack per session during each of these class intervals. The points are based on 10 sessions constituting the last five sessions of each reinforcement-extinction procedure.

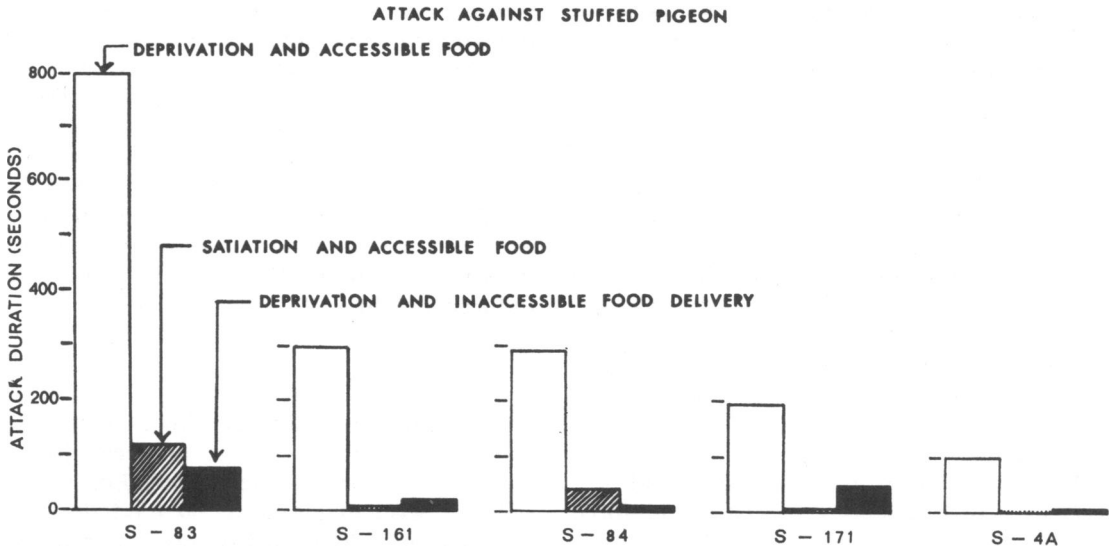


Fig. 8. Mean duration of attack by each of five pigeons against a stuffed pigeon. Each bar in the figure shows the mean duration of attack based on the last five sessions under the designated condition. The white bar designates the condition when the pigeons were food-deprived and the food was accessible (10 sessions); the stippled bar is when the pigeons were satiated, but food was still accessible (five sessions). During this period described by the solid black bar (10 sessions), the pigeon was food-deprived, but the food was inaccessible.

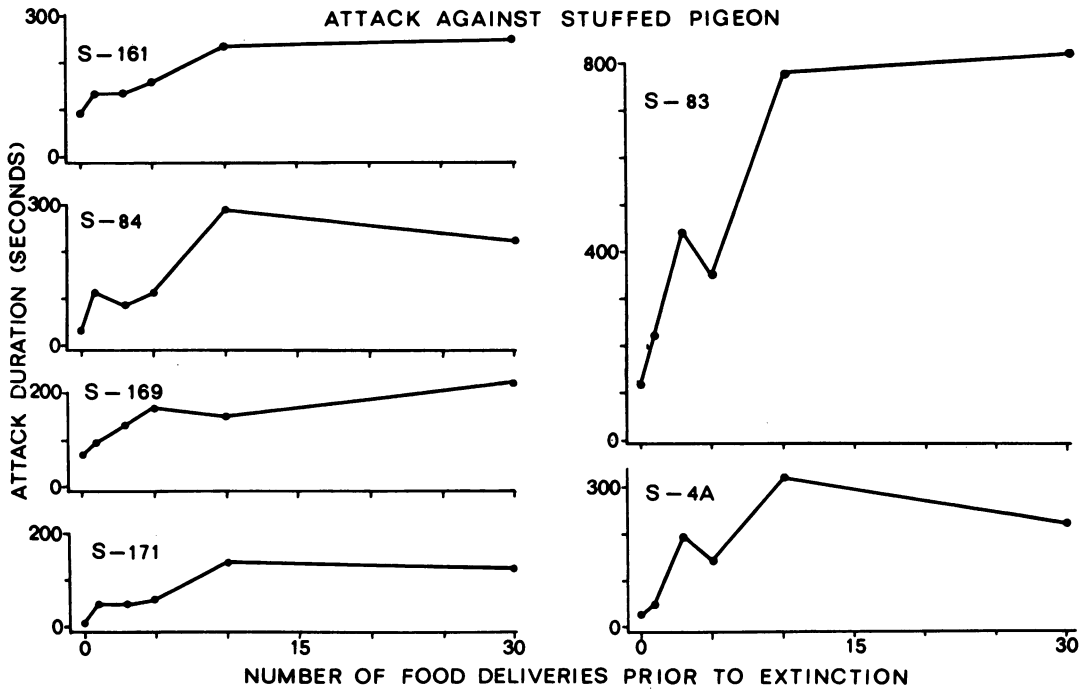


Fig. 9. Duration of attack as a function of the number of food reinforcements that preceded extinction. Each curve is for a different experimental pigeon. Each point is the mean of the last three sessions, or five sessions when five or more were given.

bird and (2) the occasional target bird that counter-aggressed sufficiently to discourage future attack.

For all subjects, the duration of attack was increased by the reinforcement-extinction procedure and maintained for as long as it remained in effect (over three months for some birds). The reversibility of the phenomenon was evidenced by the change in attack duration when the reinforcement-extinction procedure was discontinued, reinstated, and discontinued again.

Even casual observation of pigeons in their coops reveals fighting over food. The present results indicate strongly that the attack observed here was not attributable to competition over food. The target pigeons were restrained in a fixed location with no opportunity to compete. The two pigeons had no previous contact with each other, and the food was not delivered near the target pigeon. It also seems unlikely that the attack can be attributed to generalization from a history of competition since attack occurred for the pigeons that were raised in social isolation.

The simple sight of food and its termination were not sufficient to produce attack. The food had to be consumed. Attack did not occur when the food was not consumed either because the subjects were satiated or because the food was physically unobtainable.

A possible explanation of the attack is that it was maintained by superstitious reinforcement by the food as might be suggested by the results of Reynolds, Catania, and Skinner (1963) who used food as a reinforcer for attack between pigeons. This explanation seems inappropriate for several reasons. First, the birds were food reinforced for several days in the absence of a target bird; yet attack usually resulted on the first day it was introduced. Secondly, a delay was used in the delivery of food to prevent food from being delivered shortly after an attack. Thirdly, the post-reinforcement attack occurred even when only a single period of food reinforcement was used and no possibility existed of a food delivery after this attack. Fourthly, attack very rarely occurred during a period of continuous reinforcement when the possibility of superstitious reinforcement would be greatest.

The finding (Ulrich and Azrin, 1962) that attack is produced by aversive events suggested that occurrence of attack might be a means of

evaluating possible aversiveness of a schedule of food reinforcement. If a schedule of positive reinforcement is aversive, it might be expected to produce attack. Further, that aspect of the schedule that is most aversive might be revealed by identifying the moment of greatest attack. The present findings revealed a high frequency of attack at the moment of transition from continuous reinforcement to extinction. The attack decreased as a function of time from the transition. Therefore, the transition from continuous reinforcement to extinction may be considered an aversive event.

The usual procedure for ascertaining the aversiveness of an event is the escape paradigm: will conditioning result for the response that terminates that event (Holland and Skinner, 1961; Keller and Schoenfeld, 1950)? In attempting to determine the aversiveness of a schedule of food reinforcement, this procedure requires that the subject make a response that produces a time-out from the food reinforcement procedure. The results of studies using that procedure support the present interpretation that some aspects of a schedule of positive reinforcement may be aversive (Pliskoff and Tolliver, 1960; Azrin, 1960; Azrin, 1961; Hearst and Sidman, 1961; Thompson, 1964, 1965).

Many schedules of intermittent reinforcement will probably possess aversive properties since intermittency necessarily involves periods of extinction. A major implication of the present findings is that schedules of reinforcement may produce aggression as a by-product that is not apparent when the individual is studied in isolation. In the present study, the principal effect of the extinction procedure was the burst of key-pecking responses at the onset of extinction when the subject was alone in the experimental chamber. When the target subject was also located in the chamber, it became apparent that extinction had a far greater effect than simply reducing the number of key-pecks.

The present findings have been interpreted as the result of the aversive properties of extinction. Additional evidence with other reinforcers and other types of animals are needed to evaluate the generality of this phenomenon.

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Received October 4, 1965