THE EFFECTS OF TWO RESPONSE-ELIMINATION PROCEDURES ON REINFORCED AND INDUCED AGGRESSION¹

RANDALL K. FLORY, ERIC L. P. SMITH, AND BARBARA B. ELLIS

HOLLINS COLLEGE

Pecks against a stuffed pigeon were reinforced according to a fixed-interval schedule for one group of pigeons and a variable-interval schedule for a second group. Red and green stimulus lights were alternately illuminated. Subsequently, food deliveries no longer occurred during one color (extinction). In the presence of the other color, food was presented only when no attack occurred for 30 sec. When attack produced food, all pigeons generally exhibited characteristic fixed-interval or variable-interval response patterns. Two birds in each group frequently exhibited postreinforcement schedule-induced aggression. Attack was reduced to low levels at approximately the same rate by extinction and differential reinforcement of other behavior. For birds that had previously exhibited schedule-induced aggression, the initial reduction of attack during the second experimental phase was followed by induced attack immediately after food delivery in the differential-reinforcement-of-other-behavior component and upon onset of the extinction component. Either extinction or differential reinforcement of other behavior may eliminate reinforced aggression but may be relatively ineffective for reducing induced attack.

Key words: reinforced aggression, schedule-induced aggression, fixed-interval schedule, variable-interval schedule, differential-reinforcement-of-other behavior schedule, extinction, attack response, pigeons

Although much research has been devoted to the determination of those environmental conditions that are responsible for the development and maintenance of aggression, less is known about procedures for eliminating aggression. Some investigators (Azrin, 1970; Baenninger and Grossman, 1969; Roberts and Blase, 1971) have found physically painful punishment effective in suppressing aggressive behavior; others (Ulrich, Wolfe, and Dulaney, 1969) have reported that punishment procedures temporarily enhanced attack before eventually reducing or eliminating it. Aggressive behavior also initially increases before eventually decreasing when it is no longer operantly reinforced (Reynolds, Catania, and Skinner, 1963; Ulrich, Johnston, Richardson, and Wolff, 1963).

Recently, techniques of response elimination

other than punishment and extinction have received attention. In omission training (Grant, 1964), or differential reinforcement of other behavior (DRO) (Reynolds, 1961), a reinforcer is delivered only when a particular response does not occur for a specified period of time. The few studies that have investigated the use of this procedure for eliminating social behavior in human (Sewell, McCoy, and Sewell, 1973) and animal subjects (Baisinger and Roberts, 1972; Reynolds *et al.*, 1963) found that a DRO schedule either decreased or eliminated aggressive behavior without undesirable side effects. None of these investigations, however, compared the effectiveness of DRO with other response-elimination methods. Using a procedure similar to that employed by Zeiler (1971), the present study assessed, within the same organism, the relative effectiveness of extinction and a DRO schedule for reducing or eliminating aggressive behavior maintained by either a fixed-interval or variable-interval schedule of reinforcement.

METHOD

Subjects

Eight male White Carneaux pigeons, approximately 5 to 6 yr of age, were used. Two

¹This report is based on a portion of a thesis submitted by the second author to the Graduate School of Hollins College in partial fulfillment of the requirements for the M.A. degree. The research was supported in part by National Science Foundation Undergraduate Research Participation Grant GY-10,000. We wish to thank Charlotte Collings for her assistance in preparation of the manuscript. Reprints may be obtained from Randall K. Flory, Department of Psychology, Hollins College, Roanoke, Virginia 24020.

birds, AC 1 and AC 4, had exhibited fixed-interval schedule-induced aggression against a stuffed pigeon in a previous study; the other six pigeons were experimentally naive. Each pigeon was maintained at 80% of its free-feeding body weight and was housed in a wood and wire cage located in a constantly illuminated temperature- and humidity-controlled room. Water and grit were always available in the home cages.

Apparatus

One end of a pigeon chamber similar to that described by Azrin, Hutchinson, and Hake (1966) contained a food magazine located behind a 4.6- by 6.0-cm opening. At the other end of the chamber, 35.5 cm from the wall containing the grain hopper, was a taxidermically prepared White Carneaux pigeon, the head and throat of which were covered with a white synthetic fur hood. A force of 50 to 55 g (0.50 to 0.55 N) applied to the model's head closed a microswitch. Only those switch closures separated by at least 200 msec were recorded as discrete attacks. An inanimate rather than live target was used to eliminate the problem of target injury and to prevent the confounding effects of counter-aggression by the target subject (*cf.* Azrin *et al.*, 1966).

In each upper corner of both the Plexiglas shield surrounding the target and the wall containing the grain hopper were two stimulus lights, green in the left corners and red in the right, that flickered at a rate of 10 flashes per second when illuminated. A houselight provided general illumination during sessions, and a ventilation fan and white noise source masked extraneous sounds.

Procedure

To determine the operant level of attack before any schedule training, each pigeon was initially exposed to a baseline condition during which food was never presented. Throughout this and all other experimental conditions, the red and green stimulus lights were alternately illuminated for 300 sec each, and a change from one color to the other was signalled by a 1-sec tone. When attack rate showed little or no systematic variability over five 1-hr baseline sessions, each bird was magazine trained and then trained to peck the stuffed target for food. A photoelectric cell

arranged that timing of 4-sec grain presentations did not begin until the subject's head entered the hopper. For Pigeons AC 1, AC 11, AC 12, and AC 14, attack was then reinforced according to a fixed-interval (FI) food schedule that was gradually increased to a value of 2 min. For Pigeons AC 4, AC 16, AC 17, and AC 19, attack was reinforced according to a 2-min variable-interval (VI) food schedule. Subjects were exposed to the FI or VI schedule (1) for a minimum of 40 sessions and (2) until overall attack rate between sessions, and component attack rate within sessions, showed little or no systematic variability over five sessions. During this experimental phase, the components and reinforcement schedule were independent; that is, the FI or VI schedule was unaffected by color changes.

In the final phase, one component was correlated with extinction (EXT) of reinforced attack, the other with a 30-sec DRO schedule according to which food was presented only when 30 sec of no attack elapsed. Each onset of a 300-sec component initiated a new 30-sec DRO period. The DRO schedule was correlated with green for half of the subjects exposed to the FI or VI schedule and with red for the remainder. During this phase, sessions were shortened to 30 min (three red-green cycles rather than six) so that the number of food presentations per session would remain approximately equal throughout the study. Pigeons were exposed to the *mult* DRO EXT condition (1) for a minimum of 20 sessions and (2) until component attack rates showed little or no systematic variability over five sessions. Finally, it was arranged that an EXT component could not end until its scheduled 300-sec duration had elapsed and no attack had occurred during its final 10.5 sec.

Behavior was observed visually and recorded by either of two observers (ES or BE) during at least (1) three baseline sessions, (2) four of the final FI or VI schedule sessions, (3) the first three sessions of the DRO EXT condition, and (4) four of the final DRO EXT schedule sessions. Each pigeon was also visually monitored, on an intermittent basis, during other sessions throughout the study. In addition to recording stereotyped behavior other than attack, each observer noted the topographical characteristics of attacks that occurred shortly after food delivery or during periods of nonreinforcement and of attacks that occurred before

Fig. 1. Attack rates for Pigeons AC 1, AC 11, AC 12, and AC 14 during the last five sessions of the pretraining baseline, the last five sessions of the condition in which attack was reinforced according to a 2-min fixed-interval (FI 2) food schedule in either stimulus component, and during all sessions of the condition in which a 30-sec DRO schedule or extinction was in effect during alternating components. The vertical arrow in the graphs for Birds AC 1 and AC 14 indicates the point at which a 10.5-sec changeover delay was instituted between offset of the extinction component and onset of the DRO component.

rather than after reinforcement. These characteristics included the locus and intensity of attack, the presence or absence of vocalizations, and the subject's posture and movements.

RESULTS

Figures 1 and 2 show attack rates for each subject. To conserve space, rates are shown

Fig. 2. Attack rates for Pigeons AC 4, AC 16, AC 17, and AC 19 during the last five sessions of the pretraining baseline, the last five sessions of the condition in which attack was reinforced according to a 2-min variable-interval (VI 2) food schedule in either stimulus component, and during all sessions of the condition in which a 30-sec DRO schedule or extinction was in effect during alternating components. The vertical arrow in the graphs for Birds AC 4 and AC 17 indicates the point at which a 10.5-sec changeover delay was instituted between offset of the extinction component and onset of the DRO component.

only for the last five sessions of (a) the baseline condition and (b) the FI (Figure 1) or VI (Figure 2) schedule condition. The operant-

level attack rates for Birds AC 1, AC 11, AC 12, AC 14, AC 16, and AC 19 reached zero within 16 or fewer sessions, but the baseline rates for

Pigeons AC 4 and AC 17 required more than 50 sessions to stabilize and never consistently reached zero.

Although within-component attack rates showed no systematic variability across sessions for any subject exposed to the FI schedule, Component 2 rates were higher than Component 1 rates in 57 of the 91 sessions for AC 11 and 98 of the 104 sessions for AC 14. For subjects exposed to the VI schedule, attack rates in each component did not differ in any systematic way.

The final section of each graph in Figures 1 and 2 shows attack rates during the *mult* DRO EXT schedule. During the first session of this condition, Component 1 attack rates for Birds AC 1, AC 4, and AC 17 were considerably higher than those occurring in either component during the last five sessions of the FI and VI schedule condition. Across the next several sessions of the *mult* DRO EXT schedule, attack generally decreased to low levels at approximately the same rate during either component. Following this reduction, Pigeon AC 12 never attacked in either component; Birds AC 11, AC 16, and AC 19 stopped attacking, first in the DRO component and then in the extinction component. For Pigeons AC 1, AC 4, AC 14, and AC 17, however, the initial reduction of attack during the multiple schedule was followed by increased attack in the extinction component. Attack also increased somewhat in the DRO component for AC 1.

The vertical arrows in Figures 1 and 2 indicate the points at which a 10.5-sec COD was introduced at the transition from EXT to DRO. If attack during the EXT component was adventitiously maintained by the onset of stimuli correlated with the DRO schedule, then the inclusion of the COD should have attenuated such attack. Since the component rates of Pigeons AC 11, AC 12, AC 16, and AC 19 stabilized at or near zero, the COD was not instituted for these subjects. As Figures 1 and 2 indicate, the COD had no consistent effect on the EXT component attack rates of Birds AC 1, AC 4, AC 14, and AC 17.

Figures 3 and 4 show the mean number of target contacts in consecutive 30-sec periods of each component. Although the attack frequency under the FI 2-min schedule fluctuated considerably across 30-sec periods in either component, birds exposed to the VI 2-min schedule emitted an essentially constant num-

ber of attacks in each 30-sec segment. Graphs labelled DRO EXTINCTION (a) show that, before introduction of the COD, the attack frequency of Birds AC 1, AC 4, and AC 17 was greatest during the early 30-sec periods of the EXT component and generally decreased as this component progressed. For Pigeon AC 14, however, attacks were equally distributed across the EXT component.

The COD resulted in attacks shifting from the latter to initial portions of the EXT component. The proportion of attacks occurring in the initial half of the EXT component increased from 71% without the COD to 82% with it for AC 1, from 74% to 81% for AC 4, and from 60% to 76% for AC 17. Within-component attack frequencies are not shown for Birds AC 11, AC 12, AC 16, and AC 19 since the responding of each stabilized at a low or zero level during the *mult* DRO EXT condition.

Two clearly distinguishable types of aggressive behavior were observed. One form, exhibited by all subjects during exposure to the FI or VI schedule, occurred in bursts consisting rarely of more, and usually of fewer, than three pecks. Such attacks, which corresponded to conditioned aggression described by Reynolds *et al.* (1963), were invariably directed at the area just above the beak and between the eyes of the target.

The second type of attack resembled natural species-specific aggression in pigeons (Smith and Hosking, 1955) and, therefore, corresponded to what Reynolds *et al.* (1963) described as unconditioned aggression. Such attack consisted of relatively long bursts of forceful target contacts. Whereas the locus of conditioned attack was restricted to a small target area, that of unconditioned attack included the entire head and throat areas of the model and often was directed at the target's eyes. Birds grasped the model and shook it vigorously. Bursts of unconditioned aggression were often preceded and/or followed by a distinctive rocking motion accompanied by lowering of the head, pennerection, and low-pitched vocalizations. Target contacts were often preceded by a charge at the model.

Each observer readily distinguished conditioned from unconditioned aggression, and crosschecks indicated that their independent descriptions of either form were in close agreement. In addition, visually recorded instances

Fig. 3. Mean number of attacks in consecutive 30-sec periods of each component. Data for the FI 2 graphs are based upon the last five sessions of the condition in which attack was reinforced according to the FI 2-min food schedule. Data for the DRO EXTINCTION (a) graphs are based on the last five sessions in which attack was under the *mult* DRO EXT contingency; those for the DRO EXTINCTION (b) graphs are from the last five sessions of the *mult* DRO EXT+COD contingency.

Fig. 4. Mean number of attacks in consecutive 30-sec periods of each component. Data for the VI 2 graphs are based upon the last five sessions of the condition in which attack was reinforced according to the VI 2-min food schedule. Data for the DRO EXTINCTION (a) graphs are based upon the last five sessions in which attack was under the *mult* DRO EXT contingency; those for the DRO EXTINCTION (b) graphs are from the last five sessions of the *mult* DRO EXT+COD contingency.

of either form of attack were highly correlated with characteristic patterns of responding on cumulative records.

Figures 5 and 6 show sample cumulative

records for the four subjects that engaged in both forms of aggression. Pigeons AC 1 and AC 14 exhibited response patterns similar to that shown in the enlarged segment b of Fig-

Fig. 5. Sample cumulative records for Pigeons AC 1 and AC 14. Each attack steps the recorder pen cumulatively in an upward direction, and downward deflections of this pen indicate food presentations. For Bird AC 1, Record (17) is from Session 85, and Record (2) is from Session 138. For Bird AC 14, Record (3) is from Session 113, and Record (4) is from Session 146. Broken vertical lines indicate occurrences of components. The insert b is an enlarged segment of Record (1).

ure 5; Birds AC 4 and AC 17 exhibited patterns similar to the enlarged segment d of Figure 6. In such instances (labelled at points a through f in each figure), food delivery was followed by a sequence of relatively high-rate attack of the unconditioned type. Following these bursts, attack of the conditioned form then occurred at a somewhat lower and positively accelerated rate for Pigeons AC 1 and AC 14, and at a lower but constant rate for Birds AC 4 and AC 17.

Records (2) and (4) of Figures 5 and 6 show that onset of the EXT component typically resulted in immediate attack, observed to be of the unconditioned form, which often continued throughout most of the component. During the DRO component, all eight subjects typically engaged in some stereotyped activity other than attack. Postreinforcement unconditioned attack was exhibited frequently by Pigeons AC 1 and AC 14, and somewhat less frequently by Pigeons AC 4 and AC 17, at the onset of 30-sec DRO periods. Observation revealed that each of these four birds also exhibited unconditioned attack during pre-training baseline sessions. Pigeons AC 11, AC 12, AC 16, and AC 19, however, exhibited only conditioned attack throughout.

DISCUSSION

As in the studies by Reynolds *et al.* (1963) and Ulrich *et al.* (1963), two distinct types of aggressive behavior occurred. Conditioned attack, which topographically resembled key-peck responses, was established and maintained directly through operant-conditioning procedures. This form of attack occurred at zero or near-zero levels when its occurrence was not reinforced during baseline and extinction conditions, and also when its occurrence postponed food delivery during the DRO schedule. During conditions of intermittent reinforcement, however, attack of this form occurred at relatively high rates and showed patterning characteristically engendered by FI or VI schedules (*cf.* Ferster and Skinner, 1957).

Unconditioned attack, unlike the conditioned form, resembled instinctive aggression in pigeons, required no specific training for its establishment, and predominantly occurred at points that were temporally most distant from upcoming food delivery. Thus, the unconditioned form of attack qualifies as an "ad-

junctive behavior" which, according to Falk (1966, 1971), includes a variety of extra, unprogrammed behavioral phenomena that resemble displacement activities and are induced, rather than directly maintained by intermittent schedules of reinforcement. Such adjunctive or schedule-induced activities generally occur shortly after reinforcement, when the probability of further reinforcement is low and when the conditioned or reinforced response (*e.g.*, conditioned attack in the present study) is not occurring.

The use of a stuffed target may have been responsible for the occurrence of induced attack in only four of the eight subjects studied. Azrin *et al.* (1966), for example, reported that 25% of their pigeons exhibited extinction-induced attack against a stuffed pigeon, while nearly 100% attacked live but restrained targets under otherwise identical conditions. Also, Azrin and Hutchinson (1967) reported that attack frequently persisted throughout the signalled availability of food, but no such "intrinsic momentum" (p. 401) was noted in the present study. Our results suggest that the persistent aggression reported by Azrin and Hutchinson resulted principally, if not solely, from movements and counterattack by their live targets. In support of this suggestion, Reynolds *et al.* (1963) reported that during unconditioned fighting resulting from target counteraggression, the aggressor pigeon "would not respond to the grain dispenser, even though free of the other bird's grasp" (p. 73).

When Zeiler (1971) trained pigeons to key peck on a fixed-ratio schedule, and then shifted them to a *mult* 30-sec DRO EXT schedule, the DRO schedule produced a rate at least as low and usually lower than that produced by extinction in every session. In addition, DRO required fewer sessions than did extinction to reduce responding to zero or near-zero levels. Zeiler also reported the occurrence of spontaneous recovery of key pecking during extinction, but not during DRO following inter-session intervals of 72 hr.

A comparison of Zeiler's results and those of the present study reveals that aggression, like key pecking, was rapidly reduced to low or zero levels in both components of the *mult* DRO EXT schedule during the first few sessions. Subsequently, the DRO schedule controlled a rate that was at least as low and usually lower than that controlled by extinc-

Fig. 6. Sample cumulative records for Pigeons AC 4 and AC 17. Each attack steps the recorder pen cumulatively in an upward direction, and downward deflections of this pen indicate food presentations. For Bird AC 4, Record (1) is from Session 98, and Record (2) is from Session 147. For Bird AC 17, Record (3) is from Session 120, and Record (4) is from Session 167. Broken vertical lines indicate occurrences of components. The insert d is an enlarged segment of Record (3).

tion for the three birds that exhibited only the conditioned form of attack in the present study. The fourth subject that exclusively exhibited conditioned aggression never attacked

in either component of the *mult* DRO EXT schedule after the first session. No bird revealed spontaneous recovery.

Pigeons that exhibited induced attack, how-

ever, revealed considerably different effects of the *mult* DRO EXT schedule. After initially declining to a low rate, attack during extinction increased over sessions. The transition from the relatively high reinforcement density provided by the DRO schedule was sufficient to induce the unconditioned form of aggression in these four birds. Furthermore, attack rate during the DRO component never stabilized at a zero level.

Rather than eliminating unconditioned attack, the DRO schedule induced it in all four pigeons that exhibited this form of aggression. Similarly, lick-dependent delays of pellet delivery have not substantially reduced the occurrence of a related adjunctive behavior, schedule-induced polydipsia (Falk, 1964; Flory and Lickfett, 1974; Hawkins, Schrot, Githens, and Everett, 1972). Thus, although a DRO schedule can be used to decrease permanently the probability of operantly conditioned behavior, it may not eliminate induced or adjunctive behavior.

REFERENCES

- Azrin, N. H. Punishment of elicited aggression. *Journal of the Experimental Analysis of Behavior*, 1970, 14, 7-10.
- Azrin, N. H. and Hutchinson, R. R. Conditioning of the aggressive behavior of pigeons by a fixed-interval schedule of reinforcement. *Journal of the Experimental Analysis of Behavior*, 1967, 10, 395-402.
- Azrin, N. H., Hutchinson, R. R., and Hake, D. F. Extinction-induced aggression. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 191-204.
- Baenninger, R. and Grossman, J. C. Some effects of punishment on pain-elicited aggression. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 1017-1022.
- Baisinger, J. and Roberts, C. L. Reduction of intraspecies aggression in rats by positive reinforcement of incompatible behaviors. *Journal of the Experimental Analysis of Behavior*, 1972, 18, 535-540.
- Falk, J. L. Studies on schedule-induced polydipsia. In M. J. Wayner (Ed.), *Thirst: first international symposium on thirst in the regulation of body water*. New York: Pergamon Press, 1964. Pp. 95-116.
- Falk, J. L. Schedule-induced polydipsia as a function of fixed-interval length. *Journal of the Experimental Analysis of Behavior*, 1966, 9, 37-39.
- Falk, J. L. A theoretical review: the nature and determinants of adjunctive behavior. *Physiology and Behavior*, 1971, 6, 577-588.
- Ferster, C. B. and Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Flory, R. K. and Lickfett, G. G. Effects of lick-contingent timeout on schedule-induced polydipsia. *Journal of the Experimental Analysis of Behavior*, 1974, 21, 45-55.
- Grant, D. A. Classical and operant conditioning. In A. W. Melton (Ed.), *Categories of human learning*. New York: Academic Press, 1964. Pp. 10-13.
- Hawkins, T. D., Schrot, J. F., Githens, S. H., and Everett, P. B. Schedule-induced polydipsia: an analysis of water and alcohol ingestion. In R. M. Gilbert and J. D. Keehn (Eds.), *Schedule effects: drugs, drinking, and aggression*. Toronto: University of Toronto Press, 1972. Pp. 95-128.
- Reynolds, G. S. Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 57-71.
- Reynolds, G. S., Catania, A. C., and Skinner, B. F. Conditioned and unconditioned aggression in pigeons. *Journal of the Experimental Analysis of Behavior*, 1963, 6, 73-74.
- Roberts, C. L. and Blase, K. Elicitation and punishment of intraspecies aggression by the same stimulus. *Journal of the Experimental Analysis of Behavior*, 1971, 15, 193-196.
- Sewell, E., McCoy, J. F., and Sewell, W. R. Modification of an antagonistic social behavior using positive reinforcement for other behavior. *Psychological Record*, 1973, 23, 499-504.
- Smith, S. and Hosking, E. *Birds fighting*. London: Farber and Farber, 1955.
- Ulrich, R., Johnston, M., Richardson, J., and Wolff, P. The operant conditioning of fighting behavior in rats. *Psychological Record*, 1963, 13, 465-470.
- Ulrich, R. E., Wolfe, M., and Dulaney, S. Punishment of shock-induced aggression. *Journal of the Experimental Analysis of Behavior*, 1969, 12, 1009-1015.
- Zeiler, M. D. Eliminating behavior with reinforcement. *Journal of the Experimental Analysis of Behavior*, 1971, 16, 401-405.

Received 26 February 1976.
(Final Acceptance 14 July 1976.)