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INDUCED ATTACK DURING MULTIPLE FIXED-RATIO, VARIABLE-RATIO SCHEDULES OF REINFORCEMENT[1]

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Two pigeons were exposed to a multiple schedule of reinforcement: in the presence of one discriminative stimulus, key pecks produced grain according to a fixed-ratio schedule; in the presence of a second discriminative stimulus, key pecks produced grain according to a variable-ratio schedule. The key-peck requirements in the two components were increased in successive stages from 50 to 125 responses. Live target pigeons were restrained at the rear of the chamber. Attacks against the targets were automatically recorded, and a variety of measures of attack behavior were taken. Attacks, when they occurred, always followed grain presentation. All measures revealed higher levels of attack during the fixed-ratio component at all parameter values. All measures generally increased with increases in fixed-ratio values with both birds, and with increases in variable-ratio values with one bird. With the other bird, only the per cent of reinforcements followed by attack increased with increases in variable-ratio value; all other measures first increased and then decreased. Both increasing and bitonic functions relating induced attack to schedule parameters have been reported in experiments usually employing a single measure of attack. The measures have varied widely among these experiments. It is suggested that further studies of induced attack examine a wider range of schedule parameters and that relationships among measures be studied.

In experiments on schedule-induced aggression, positive reinforcement is usually dependent upon operant responding (*e.g.*, key pecking), and a target is available. Under some schedule parameters, animals will attack either restrained animals of the same species or a variety of inanimate objects. Attack, when it occurs, is primarily a post-reinforcement phenomenon. Schedule-induced aggression has been studied during fixed-ratio schedules (Cherek and Pickens, 1970; Cohen and Looney, 1973; Flory, 1969*a;* Gentry, 1968; Hutchinson, Azrin, and Hunt, 1968; Knutson, 1970; Lyon and Turner, 1972), fixed-interval schedules (Cherek and Heistad, 1971; DeWeese, Webbe, and Malagodi, 1972; Richards and Rilling, 1972), response-independent fixed-time schedules (Flory, 1969*b*), variable-interval schedules (Dove, Rashotte, and Katz, 1974), and differential-reinforcement-of-low-rate schedules (Knutson and Kleinknecht, 1970).

Studies of induced aggression during fixed-ratio schedules may be summarized in terms of the following characteristics. First, some results suggest that attack behavior varies as a direct function of the parameter value (Flory, 1969*a;* Hutchinson *et al.*, 1968; Knutson, 1970; Lyon and Turner, 1972). Cohen and Looney (1973), however, suggested that a bitonic function relates attack behavior to the value of a fixed-ratio schedule. Second, these results have been obtained under a variety of procedures including increasing parameter values in successive experimental stages with the targets being live pigeons (Cherek and Pickens, 1970; Knutson, 1970; Lyon and Turner, 1972), taxidermically prepared pigeons (Flory, 1969*a*), and a mirror (Cohen and Looney, 1973). In one study (Hutchinson *et al.*, 1968), squirrel monkeys served as subjects, with a rubber bite tube as the target. Third, a variety of measures of attack behavior have been employed: total number of attacks (Gentry, 1968; Hutchinson *et al.*, 1968; Knutson, 1970); total number of attack episodes (Flory, 1969*a*); overall rate of attacks (Cherek and Pickens, 1970; Cohen and Looney, 1973); local rate of attacks (Cohen and Looney, 1973); time spent attacking (Knutson, 1970); and per cent of schedule components in which attacks occurred (Flory, 1969*a;* Lyon and

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Turner, 1972). Fourth, these studies may be characterized as short-term studies at one or two schedule values (Gentry, 1968; Flory, 1969*a*), short-term parametric studies (Cherek and Pickens, 1970; Lyon and Turner, 1972), and long-term parametric studies (Cohen and Looney, 1973; Hutchinson *et al.*, 1968; Knutson, 1970).

The present experiment had two objectives. The first was to compare the levels of attack induced during several parameter values of a fixed-ratio schedule with those induced during equivalent values of a variable-ratio schedule (equal arithmetic means). Comparisons of responding maintained by fixed-ratio and variable-ratio schedules have shown consistent differences in the rates and patterns engendered under equivalent parameter values. Overall response rates are usually higher and post-reinforcement pauses are both shorter in duration and less frequent in occurrence under variable-ratio schedules (*e.g.*, Ferster and Skinner, 1957). Similarly, under concurrent schedules, pigeons have shown preference for variable-ratio over fixed-ratio components (Sherman and Thomas, 1968). These differences in responding maintained by the two forms of ratio schedules suggest that related differences might similarly characterize the manner in which the two schedules control the occurrence of induced attack.

The second objective was to examine several measures of attack behavior, including most of those used in previous experiments. This was done for several reasons: first, rarely has rationale been provided for selecting any one of the measures; second, little attention has been directed at studying the relationships among them; and third, the possibility exists that reported differences in the forms of the functions relating induced attack to schedule parameters may be partly due to the use of different measures.

METHOD

Subjects

Four experimentally naive, adult male White Carneaux pigeons were approximately 1-yr old at the beginning of the study. Two birds were randomly selected as subjects, and the other two served as targets. Pairs of experimental and target birds were established on the first experimental day and never varied. The birds were individually housed, with health grit and water continuously available. Target birds were maintained at their free-feeding body weights, while experimental birds were maintained at 80% of their free-feeding weights. A 12-hr light-dark cycle was maintained in the colony room. Experimental sessions occurred during the first quarter of the light cycle.

Apparatus

The experimental chamber was fitted with a standard BRS-Foringer two-key stimulus panel (BRS PH-002). The left key was covered with a metal plate for the duration of the experiment. Pecks with a force in excess of 20 g (0.20 N) against the right response key defined a response and produced a loud click from a feedback relay. During the 3.5-sec grain-reinforcement cycle, the white houselights and the key stimulus were off, and the raised food magazine was illuminated with white light.

The apparatus for recording attack behavior was similar to that described by Azrin, Hutchinson, and Hake (1966) and Knutson (1970), and was located at the rear of the chamber, 10 in. (25.4 cm) from the stimulus panel. This restraint unit for the target bird was constructed of clear Plexiglas, and was mounted on a spring-loaded metal plate. A microswitch assembly was located beneath the metal plate such that a force of 115 g (1.1 N) against the front of the restraint unit activated the microswitch and recorded a single attack for each such displacement. Defensive movements of the target bird did not activate the microswitch at this force requirement. The requirement was only coincidentally the same for both pairs of birds.

The target bird was confined within the restraint unit by foam cushions positioned below and to the rear of the target. An adjustable front opening on the top of the unit allowed for the extrusion of the target bird's head, neck, and upper breast. An inverted, U-shaped, clear Plexiglas shield was mounted 1.5 in. (3.8 cm) in front of the target, with the apex of the shield at the level of the target's head and the two limbs extending down vertically to mounting posts (Knutson, 1970). Opaque panels were located in a vertical plane above the target and bordering on each side of the inverted U-shaped shield, thus allowing only two routes of access to the target—either over the apex of the shield, or between the downward extensions of it. In addition to specifying the topography of attack, the shield also reduced the probability of serious injury to the target, and facilitated the displacement of the restraint unit only during periods of actual attack (the attacking bird had to contact the shield before reaching the target).

Three direct measures of attack were obtained: number of attacks, attack duration, and number of attack episodes. The number of attacks was a direct count of each stabilimeter displacement. Attack duration was the cumulative time spent in attacking. The timers measuring attack duration began operation when one attack was recorded, and continued until a 1.0-sec interval occurred with no attacks. An attack episode was defined as any attack or series of attacks separated by at least 1.0 sec from any other attacks. From these direct measures were derived the following: the average number of attacks and attack episodes per reinforcement, attack duration per reinforcement, overall rate of attacks and attack episodes, proportion of time spent attacking, and relative rate of attacks. The per cent of reinforcements followed by at least one attack was obtained directly from cumulative recordings.

Daily sessions were monitored *via* closed-circuit television equipment. Standard electromechanical scheduling and recording equipment was located in an adjoining room. Masking noise was provided by an exhaust fan and a white-noise generator.

Procedure

The key pecking of the two experimental birds was maintained under a two-component multiple schedule of reinforcement. The houselights were on except during grain reinforcement. In the presence of a red keylight, key pecks were reinforced according to a 50-response fixed-ratio schedule (FR 50). In the presence of a white keylight, key pecks were reinforced according to a 50-response variable-ratio schedule (VR 50). Equal probability variable-ratio programming tapes were derived from Fleshler and Hoffman's (1962) progression for equal probability variable-interval schedules. The FR and VR components alternated after 10 reinforcements, and sessions began with either component on a random basis. After rates and patterns of key pecking had stabilized under the baseline multiple schedule (*mult* FR 50 VR 50), the restrained target was introduced. A protective contingency ensured that attacks were never followed immediately by grain presentation. It was necessary that an interval of at least 2.0 sec and at least two key pecks followed the occurrence of the last attack before grain reinforcers were available.

The parameter values of the FR and VR components were simultaneously increased to 75 and then to 100 responses for Bird P-603, and to 75, 100, and 125 responses for Bird P-2001. The final experimental stage for both birds was a decrease in parameter values. Table 1 contains a summary of the order of experimental conditions and the number of sessions under each condition for both birds.

The complexity of the situation—two response classes (key pecking and attacking), two component schedules, and seven measures of attack behavior—precluded precise quantitative specification of stability criteria. The birds remained under each experimental condition until no systematic trends in rates of key pecking and in the number of attacks per reinforcement were observed during 10 consecutive sessions. Experimental sessions were conducted six days a week and usually terminated after 60 reinforcers had been delivered. (Occasionally, a session was terminated early to prevent serious injury to the target.)

Table 1

The Order of Experimental Conditions

Bird P-603		*Bird P-2001*	
Condition	*Sessions*	*Condition*	*Sessions*
I. *mult* FR 50 VR 50	36	I. *mult* FR 50 VR 50	27
II. *mult* FR 75 VR 75	51	II. *mult* FR 75 VR 75	50
III. *mult* FR 100 VR 100	34	III. *mult* FR 100 VR 100	15
IV. *mult* FR 50 VR 50	40	IV. *mult* FR 125 VR 125	16
		V. *mult* FR 75 VR 75	43

RESULTS

Figure 1 shows representative cumulative records for Bird P-603 under two parameter values of the multiple schedule. In each case the key-peck record is presented above the attack record. Key pecking occurred at high consistent rates during the VR component, with occasional brief post-reinforcement pauses. During the FR component, key pecking similarly occurred at high rates with higher frequencies and durations of post-reinforcement pauses. In both components, attack occurred only during the post-reinforcement pauses. Thus, bursts of key pecking alternated with bursts of attacking. The total number of attacks was greater during the FR components than during the VR components. For example,

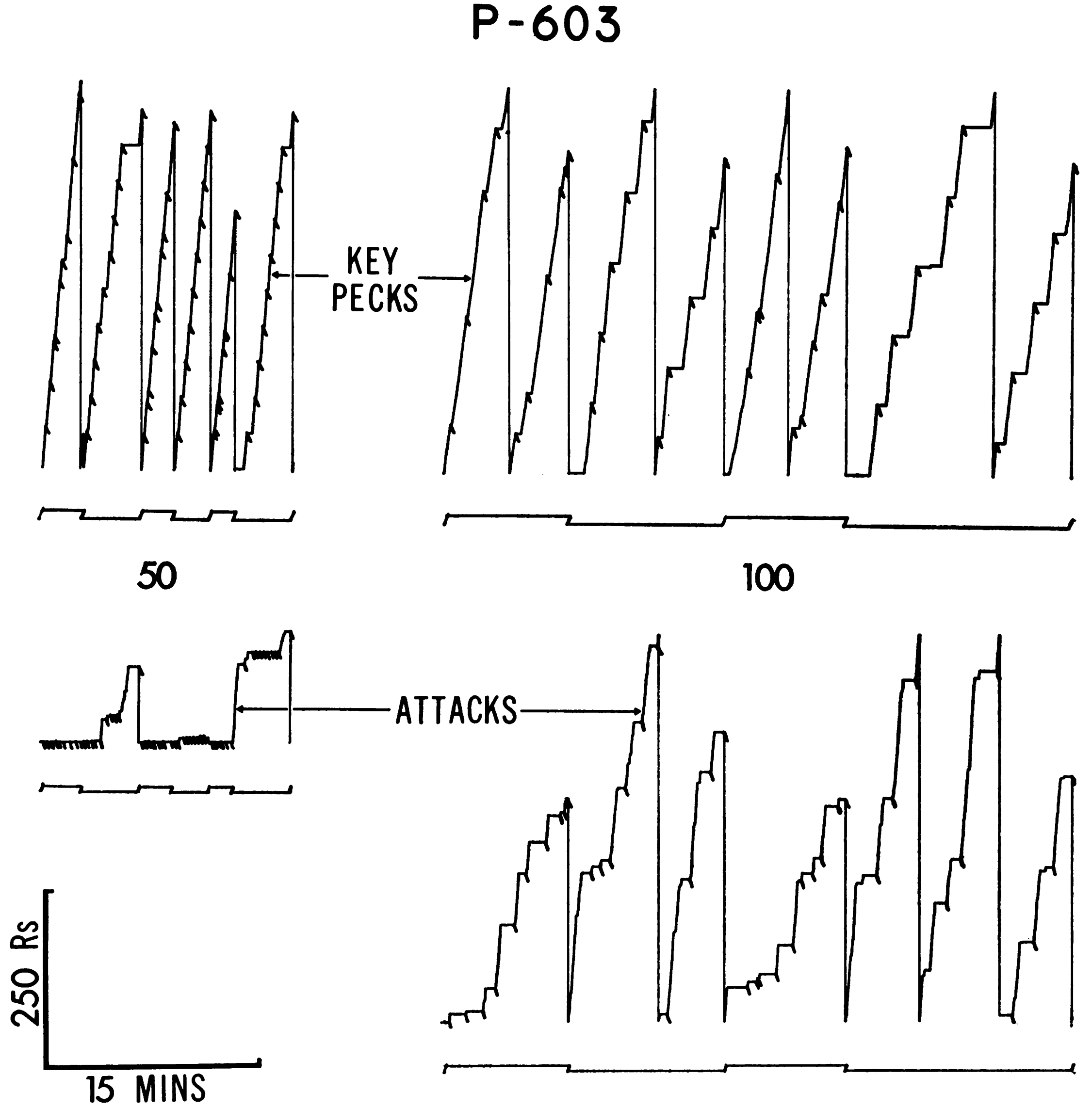

Fig. 1. Representative cumulative records for Bird P-603 at *mult* FR 50 VR 50, and at *mult* FR 100 VR 100. At each value the key-peck record is presented above the attack record. Each upward step of the response pen indicates the occurrence of one key peck or one attack, respectively, in the two records. Reinforcements are indicated by the oblique pips of the response pen in both records. The vertical position of the event pen shows which component was in effect. When the event pen was up, the VR component was in effect; when the pen was down, the FR component was in effect. Both recorders ran continuously except when food was presented. The response pens reset after each 500 responses, or when components changed.

in the session shown under *mult* FR 100 VR 100, approximately 320 attacks were recorded during the first block of 10 reinforcements under VR 100. More than 1000 attacks were then emitted during the subsequent block of 10 reinforcements under FR 100. This cycle of differential frequencies of attack during VR 100 and FR 100 was repeated throughout the session and is representative of Bird P-603's performance throughout the experiment. A greater number of attacks occurred in both components during *mult* FR 100 VR 100 than during *mult* FR 50 VR 50.

Similar results were obtained with Bird P-2001, except that lower absolute levels of attack occurred throughout the experiment. Key pecking was maintained at high rates during both components, with brief post-reinforcement pauses at all parameter values. Attacks occurred only during the post-reinforcement pauses, were greater in number during the FR components, and were otherwise evenly distributed throughout the sessions.

Figure 2 relates the per cent of reinforcements followed by attack, attacks per reinforcement, rates of key pecking, and rates of reinforcement, to the parameter values of the multiple schedule. Each point represents the mean of the last five sessions at each schedule value. With the two birds, both the conditional probability of attack (per cent of reinforcements followed by attack) and the number of attacks per reinforcement were greater during the FR component than during the VR component at all parameter values. The effects of increasing the parameter values on attacking in both components were less clear. During the FR component, there was a general increase in both measures of attack with both birds. During the VR component, there was a similar increase in both measures of attack with Bird P-603. With Bird P-2001, however, only the conditional-probability measure increased with increases in VR value; the number of attacks per reinforcement increased from VR 50 to VR 75 and then decreased as the schedule value was increased further. With both birds, all other attack measures (average number of attack episodes per reinforcement, attack duration per reinforcement, overall rate of attacks and attack episodes, proportion of time spent attacking, and relative rate of attacks) showed functions similar to those shown in Figure 2 for attacks per reinforcement. That is, there was a direct relationship between these measures and schedule values for Bird P-603 during both components, a direct relationship with Bird P-2001 during the FR component, and a bitonic relationship with Bird P-2001 during the VR component.

During the increases in schedule parameters, the levels of attack usually decreased for one to three sessions at each new value before increasing and stabilizing at the levels shown in Figure 2. The second exposure to *mult* FR 50 VR 50 with Bird P-603 and to *mult* FR 75 VR 75 with Bird P-2001 yielded differences in attack levels between the FR and VR components that were comparable to those obtained during the first exposures to those schedule values. In all cases, the levels of attack decreased from those obtained at the highest schedule values, although the initial levels were not recovered in several cases.

With Bird P-603, both key-peck rates and reinforcement rates decreased monotonically in both components as the parameter values were increased. The second exposure to *mult* FR 50 VR 50 resulted in increases in those rates from the values obtained during *mult* FR 100 VR 100, but both rates stabilized at lower levels than initially obtained during *mult* FR 50 VR 50. With Bird P-2001, the effects were less systematic. Key-peck rates during the VR component generally increased with increases in the VR value, while during the FR component, they increased up to FR 100, and then decreased. Reinforcement rates during the FR component decreased with increases in parameter values, while during the VR component, they decreased sharply from VR 50 to VR 75, and then remained relatively constant across the last three values.

DISCUSSION

The two experimental birds attacked live restrained target birds during both FR and VR components of a multiple schedule of grain reinforcement. Typically, bursts of key pecking—once initiated—were maintained until reinforcement, and bursts of attacking—when they occurred—followed reinforcement. With both birds, all measures of attack were greater during the FR component than during the VR component at each parameter value. Increases in FR value generally increased attack.

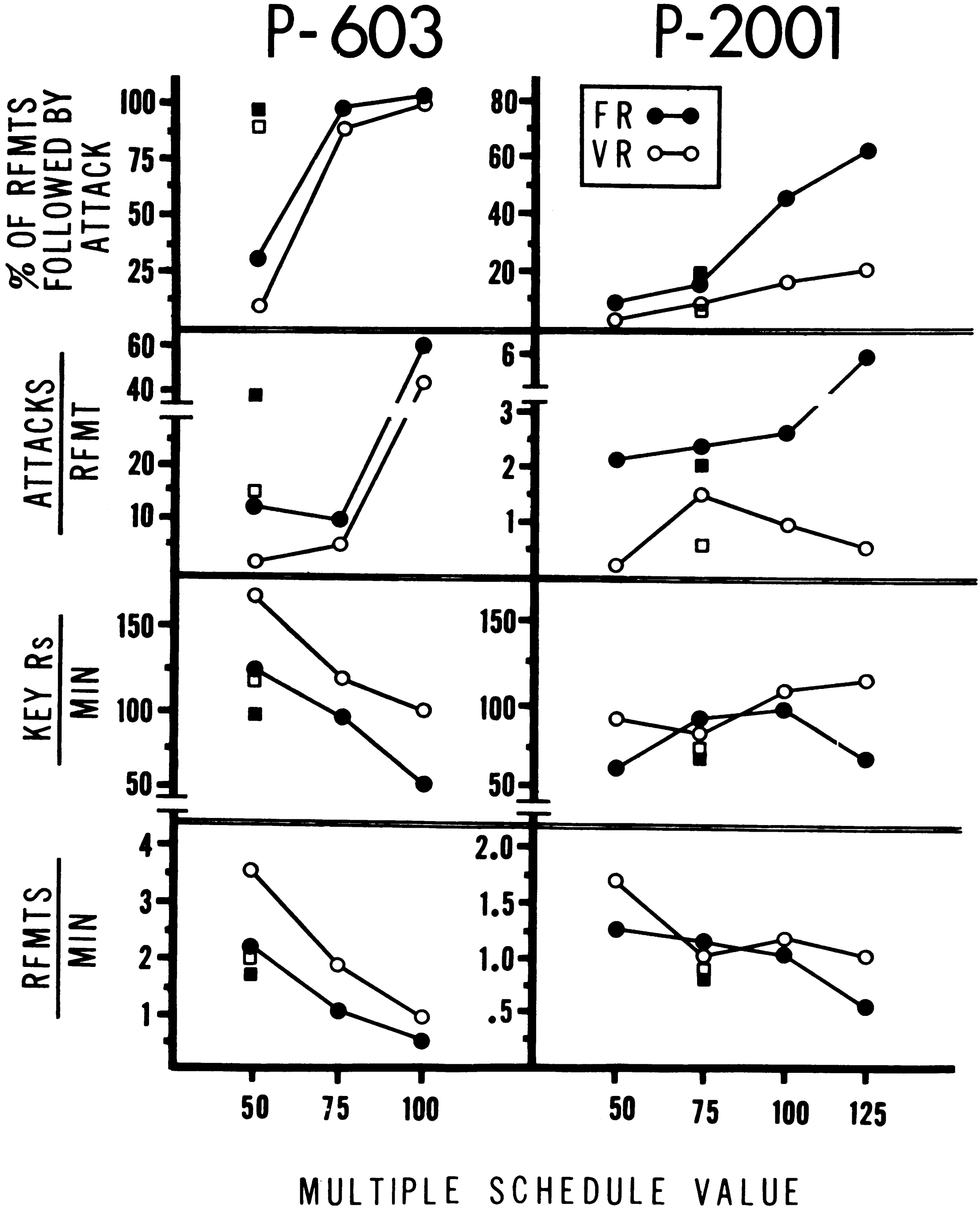

Fig. 2. Last five session means for Birds P-603 and P-2001. From top to bottom, each graph represents the conditional probability of attack (per cent of reinforcement followed by at least one attack), absolute number of attacks (attacks per reinforcement), rate of key pecking (key pecks per minute), and rate of reinforcement (reinforcements per minute), plotted as a function of the parameter value of the multiple schedule. Square symbols represent the second exposure to a schedule value.

Increases in VR value produced different results with the two birds. With Bird P-603, increasing the VR value also increased all measures of attack. With Bird P-2001, however, only the conditional-probability measure showed an increasing function; all other measures revealed an inverted U-shaped function relating attacks to VR value. Considerations of these results can conveniently be made within the contexts of several theoretical frameworks from which induced attack has been viewed. These frameworks include the notion of "aversiveness" of positive reinforcement schedules (Azrin *et al.*, 1966; Hutchinson *et al.*, 1968), the classification of induced attack as a form of "adjunctive behavior" (Falk, 1969, 1971, 1972), and also the analysis of induced attack as a form of "interim activities" (Staddon and Simmelhag, 1971).

The notion of aversive aspects of schedules of positive reinforcement was suggested by Azrin *et al.* (1966) in providing an account of extinction-induced aggression. In relating those results to previous experiments demonstrating escape from schedules of positive reinforcement (Azrin, 1961; Appel, 1963; Thompson, 1964, 1965; Zimmerman and Ferster, 1964), the suggestion was offered that periods of extinction (including periods of zero reinforcement probability in intermittent schedules) are aversive. This basic position was further extended by Hutchinson *et al.* (1968) in suggesting the existence of a direct relationship between the response requirements of ratio schedules and the magnitude of aversiveness. This interpretation is supported by experiments showing that pigeons, humans, and rats will attack targets during periods of extinction (Azrin *et al.*, 1966; Kelly and Hake, 1970; Thompson and Bloom, 1966) and by those suggesting that the levels of induced attack increase with increases in FR values (Flory, 1969*a;* Hutchinson *et al.*, 1968; Knutson, 1970; Lyon and Turner, 1972). The present results, also supporting this interpretation, include the increasing function relating all measures of attack to FR value, the same function obtained with Bird P-603 during the VR component, and the systematic differences between the FR and VR components in all measures of attack. It is more difficult to view the bitonic functions obtained with Bird P-2001 during the VR component as being supportive of this general notion of schedule aversiveness. The bitonic function is, however, central to the framework outlined by Falk (1969, 1971, 1972).

Noting many similarities among a variety of behaviors induced by intermittent schedules, Falk (1971) proposed that they be considered as a broad class of behaviors that resemble displacement activities and that may be termed "adjunctive". These varied behaviors include drinking (polydipsia), air licking, wood chewing, escape from schedules of positive reinforcement, and attack. As schedule-induced phenomena, these topographically dissimilar behaviors share many commonalities. The most important of these, insofar as the present results are concerned, is that an inverted U-shaped function is suggested to relate various magnitude or frequency measures of adjunctive behaviors to parameter values of reinforcement schedules. The inclusion of schedule-induced attack as an adjunctive behavior is supported by the bitonic functions obtained by Flory (1969*b*) and Cohen and Looney (1973). Flory (1969*b*) related rate of attack against a taxidermically prepared target to the duration of a fixed-time schedule, while Cohen and Looney (1973) related rate of induced mirror pecking to FR value. The bitonic functions obtained with Bird P-2001 during the VR schedule in the present experiment similarly support the inclusion of induced attack into the broad class of adjunctive behavior. The increasing functions obtained in the present experiment may reflect the ascending limb of a bitonic function; the descending limb might have been revealed by further increases in parameter values, as suggested by Falk (1971) and by Cohen and Looney (1973). Unfortunately, further increases in schedule values appeared to be precluded by the high levels of attack that were occurring at the maximum values (*e.g.*, over 3000 attacks per session with Bird P-603 at *mult* FR 100 VR 100), and by the possibility that these levels would increase, resulting in serious injury to the target birds.

Both Falk (1971) and Cohen and Looney (1973) suggested that reinforcement frequency is the major variable controlling the levels of induced attack across schedule parameters. Certain aspects of the present results suggest that contingencies of reinforcement other than reinforcement frequency are also important in determining the levels of induced attack. These results were obtained within the same subject, Bird P-2001, both within sessions and between experimental stages. First, comparable reinforcement frequencies within a component at different schedule values (*e.g.*, VR 75 to VR 125) resulted in different levels of attack at each value. Second, comparable reinforcement frequencies between components at a given parameter value (*e.g.*, 75) resulted in different levels of attack between components. Third, comparable reinforcement frequencies within and between the two components resulted in opposite directions of change between the components when the parameter values were increased from 75 to 100. Neither the absolute levels of induced attack nor the shape of the function across a range of schedule values was necessarily related to reinforcement frequency as a single controlling variable. Both the response requirements of a schedule and the type of schedule (*e.g.*, fixed *versus* variable ratio) are also important determinants. Additional support for the importance of response requirements in controlling levels of induced attack is provided by an experiment in which the lever pressing of rats was reinforced with brain stimulation. The number of attacks directed against frogs was greater during FR schedules than during conditions in which the lever was removed and reinforcement was presented at matching frequencies (Huston and DeSisto, 1971).

The most recent framework for viewing induced behaviors is within the context of a comprehensive analysis of the Law of Effect (Staddon and Simmelhag, 1971). Based in part upon experiments with response-independent fixed-time (FT) and variable-time (VT) schedules, a variety of behaviors were classified as being either "terminal activities" or "interim activities". Terminal activities are those that occur immediately before reinforcement (*e.g.*, key pecking in response-dependent schedules); interim activities are those that occur just after reinforcement, including those behaviors that Falk (1971) classified as adjunctive. Three aspects of Staddon and Simmelhag's treatise are especially relevant to the present results and to issues raised by them: (1) comparisons between fixed and variable schedule parameters; (2) the shape of the function relating levels of adjunctive behaviors to schedule parameters; and (3) the selection of dependent-variable measures.

Staddon and Simmelhag (1971) recorded a variety of interim and terminal activities (*e.g.*, pecking, orienting toward magazine wall, wing flapping, preening, *etc.*) during both fixed-time (FT 12-sec) and variable-time (VT 8-sec) schedules. Similar to the present results with induced attack, fewer interim activities occurred during the VT schedule, and they occupied less time than during the FT schedule. In terms employed in describing interactions between concurrent operants, both experiments suggest that fixed schedules generate more changeovers from terminal to interim activities than do variable schedules. Experiments with concurrent operants may shed light on the variables controlling these differences. Sherman and Thomas (1968), for example, examined changeovers from FR components to VR components using a switching-key procedure. Pigeons showed a preference for VR, even when the mean VR response requirement was greater than the FR requirement. The presence of occasional short ratios in the VR component was shown to be a powerful variable in controlling changeovers to that component. Preference for the VR schedule was greater than would be predicted on the basis of reinforcement rates. In the present experiment the occasional short ratios during the VR component may have similarly controlled the lower probabilities of switching to the concurrently available response class (attacking), as compared with the higher probabilities of switching to attack during the FR component.

The second point of contact between the present results and the issues discussed by Staddon and Simmelhag pertains to the shape of the function that is suggested to relate interim or adjunctive activities to schedule parameters. In contrast to the direct increasing relationship suggested by Hutchinson *et al.* (1968) and the inverted U-shaped function suggested by Falk (1969, 1971, 1972), Staddon and Simmelhag (1971, *p.* 37) suggested that interim activities are inversely related to schedule parameters. There are several possible reasons for these differences among predictions made from the various theoretical positions and for similar differences in experimental results. First, the bitonic function suggested by Falk (1969, 1971, 1972) incorporates both the direct relationship proposed by Hutchinson *et al.* (1968) and the inverse relationship proposed by Staddon and Simmelhag (1971). The obtaining of only increasing functions relating induced behaviors to schedule values may reflect a failure to sample schedule values sufficiently large to generate the descending limb. Similarly, the obtaining of only decreasing functions may reflect failures to sample sufficiently small schedule values. Other possible reasons for these discrepancies among theoretical positions and among results both within and between experiments, are discussed below within the context of problems of measurement.

Efforts to relate levels of induced behaviors to schedule parameters are complicated by the fact that many measures, both direct and derived, of the various behaviors are possible. Perhaps because it is generally agreed that induced behaviors are neither reflexive nor operant in nature (*e.g.*, Brown and Flory, 1972; Falk, 1971; Staddon and Simmelhag, 1971), there has been little discussion of the relative importance of individual measures. Most experiments have reported a single measure or two directly related measures, and the selection of measures has varied widely among the different experiments. There has been little analysis of relationships among measures. Staddon and Simmelhag (1971) proposed that the overall rate of adjunctive behavior is a better measure of the tendency to engage in that behavior than is, for example, absolute frequency. Neither the basis for that judgement nor the sense in which rate is a "better" measure was fully elaborated. Some features of the present results exemplify several of the problems involved in comparing results between experiments as well as those involved in interpreting results within a single experiment when a variety of measures are employed. Again, the ubiquitous P-2001 provides the data of interest. As the VR schedule was increased in value from 50 to 125, there was a systematic increase in the per cent of reinforcements followed by at least one attack. In contrast, the number of attacks per reinforcement (and all other measures) increased up to VR 75 and then decreased as the schedule value was increased. This decreasing function from VR 75 to VR 125 with these measures, concomitantly with the increasing function between these values with the conditional-probability measure, indicates that while the bird attacked following an increasing percentage of stimulus presentations, there was a decrease in the number of attacks comprising each bout. These results highlight the fact that the various measures need not covary, and they suggest that general terms such as "amounts" or "levels" be used with caution.

In conclusion, various theoretical frameworks from which to view induced attack have been proposed (Azrin *et al.*, 1966; Falk, 1969, 1971, 1972; Hutchinson *et al.*, 1968; Staddon and Simmelhag, 1971). These positions suggest different functions relating schedule-induced behaviors to schedule values, and each of these functions has been shown across a number of experiments. Disparities among both experimental results and theoretical predictions may be due, in some cases, to the ranges of schedule values examined, and/or to the use of different measures of the induced behaviors. Further studies of induced attack during ratio schedules should extend the values of the schedules employed, and further studies relating induced attack to schedule values in general should examine the interrelationships among a variety of measures. Only after the systematic relationships, or the lack of them, have been uncovered will it be possible to determine the form of the function that best relates induced attack to schedule parameters, to determine the variables controlling these functions, and to answer questions pertaining to a variety of general issues raised within the different theoretical contexts.

REFERENCES

Appel, J. B. Aversive aspects of a schedule of positive reinforcement. *Journal of the Experimental Analysis of Behavior,* 1963, **6,** 423-428.

Azrin, N. H. Time-out from positive reinforcement. *Science,* 1961, **133,** 382-383.

Azrin, N. H., Hutchinson, R. R., and Hake, D. F. Extinction-induced aggression. *Journal of the Experimental Analysis of Behavior,* 1966, **9,** 191-204.

Brown, T. G. and Flory, R. K. Schedule-induced escape from fixed-interval reinforcement. *Journal of the Experimental Analysis of Behavior,* 1972, **17,** 395-403.

Cherek, D. R. and Heistad, G. T. Fixed-interval induced aggression. *Psychonomic Science,* 1971, **25,** 7-8.

Cherek, D. R. and Pickens, R. Schedule-induced aggression as a function of fixed-ratio value. *Journal of the Experimental Analysis of Behavior,* 1970, **14,** 309-311.

Cohen, P. S. and Looney, T. A. Schedule-induced mirror responding in the pigeon. *Journal of the Experimental Analysis of Behavior,* 1973, **19,** 395-408.

DeWeese, J., Webbe, F. M., and Malagodi, E. F. *Schedule-induced aggression using live target pigeons.* Presented at the meeting of the Southeastern Psychological Association, Atlanta, April, 1972.

Dove, L. D., Rashotte, M. E., and Katz, H. N. Development and maintenance of attack in pigeons during variable-interval reinforcement of key pecking. *Journal of the Experimental Analysis of Behavior,* 1974, **21.**

Falk, J. L. Conditions producing psychogenic polydipsia in animals. *Annals of the New York Academy of Sciences,* 1969, **157,** 569-593.

Falk, J. L. *The nature and determinants of adjunctive behavior.* In R. M. Gilbert and J. D. Keehn (Eds.), *Schedule effects: drugs, drinking, and aggression.* Toronto: U. of Toronto Press, 1972. Pp. 148-173.

Falk, J. L. A theoretical review: the nature and determinants of adjunctive behavior. *Physiology and Behavior,* 1971, **6,** 577-588.

Ferster, G. B. and Skinner, B. F. *Schedules of reinforcement.* New York: Appleton-Century-Crofts, 1957.

Fleshler, M. and Hoffman, H. S. A progression for generating variable-interval schedules. *Journal of the Experimental Analysis of Behavior,* 1962, **5,** 529-530.

Flory, R. K. Attack behavior in a multiple fixed-ratio schedule of reinforcement. *Psychonomic Science,* 1969, **16,** 156-157. (*a*)

Flory, R. Attack behavior as a function of minimum inter-food interval. *Journal of the Experimental Analysis of Behavior,* 1969, **12,** 825-828. (*b*)

Gentry, W. D. Fixed-ratio schedule-induced aggression. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 813-817.

Huston, J. P. and DeSisto, M. J. Interspecies aggression during fixed-ratio hypothalamic self-stimulation in rats. *Physiology and Behavior,* 1971, **7,** 353-357.

Hutchinson, R. R., Azrin, N. H., and Hunt, G. M. Attack produced by intermittent reinforcement of a concurrent operant response. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 489-495.

Kelly, J. F. and Hake, D. F. An extinction-induced increase in an aggressive response with humans. *Journal of the Experimental Analysis of Behavior,* 1970, **14,** 153-164.

Knutson, J. F. Aggression during the fixed-ratio and extinction components of a multiple schedule of reinforcement. *Journal of the Experimental Analysis of Behavior,* 1970, **13,** 221-231.

Knutson, J. F. and Kleinknecht, R. A. Attack during differential reinforcement of a low rate of responding. *Psychonomic Science,* 1970, **19,** 289-290.

Lyon, D. O. and Turner, L. Adjunctive attack and displacement preening in the pigeon as a function of the ratio requirement for reinforcement. *The Psychological Record,* 1972, **22,** 509-514.

Richards, R. W. and Rilling, M. Aversive aspects of a fixed-interval schedule of food reinforcement. *Journal of the Experimental Analysis of Behavior,* 1972, **17,** 405-411.

Sherman, J. A. and Thomas, J. R. Some factors controlling preference between fixed-ratio and variable-ratio schedules of reinforcement. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 689-702.

Staddon, J. E. R. and Simmelhag, V. L. The "superstition" experiment: a reexamination of its implications for the principles of adaptive behavior. *Psychological Review,* 1971, **78,** 3-43.

Thompson, D. M. Escape from S^D associated with fixed-ratio reinforcement. *Journal of the Experimental Analysis of Behavior,* 1964, **7,** 1-8.

Thompson, D. M. Time-out from fixed-ratio requirement: a systematic replication. *Psychonomic Science,* 1965, **2,** 109-110.

Thompson, T. and Bloom, W. Aggressive behavior and extinction-induced response-rate increase. *Psychonomic Science,* 1966, **5,** 235-236.

Zimmerman, J. and Ferster, C. B. Some notes on time-out from positive reinforcement. *Journal of the Experimental Analysis of Behavior,* 1964, **7,** 13-19.

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