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THE OPPORTUNITY FOR AGGRESSION AS AN OPERANT REINFORCER DURING AVERSIVE STIMULATION[1]

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Squirrel monkeys were provided with a chain-pulling response which produced an inanimate object that could be attacked. In the absence of pain-shock, little or no chain-pulling occurred. When pain-shocks were delivered, chain-pulling responses increased. The chain-pulling response was successively reinforced, extinguished, reinforced, and again extinguished by presenting or withdrawing the opportunity to attack as the reinforcing event. Aggression appears to be a distinctive motivational state which is produced by aversive stimulation and which can be used to condition and maintain new behavior.

Aggression between animals results from many factors such as territoriality, competition over food, defense against an intruder, and endocrine changes (Scott, 1958). Aggression also results from sudden foot-shock presented to paired rats (Ulrich and Azrin, 1962).

Two major problems have existed in the experimental analysis of this fighting phenomenon in rats: (1) the reliance upon a human observer to record the occurrence of an attack; and (2) the somewhat equivocal nature of the attack since physical injury was inflicted only occasionally. Arbitrary decisions were required as to which behaviors were aggressive and which were not. It was later found that obvious physical injury was produced when other species were used, such as paired monkeys (Azrin, Hutchinson, and Hake, 1963). The equivocal nature of the response was eliminated but the very viciousness of the attack behavior between monkeys made repeated measurement impossible. The still later finding (Azrin, Hutchinson, and Sallery, 1964) that monkeys would attack inanimate objects, simplified the problem of measuring the attack objectively and made it possible to obtain repeated measurement of the attack. A mechanical switch was attached to the cord by which the inanimate object was suspended in such a way as to produce a closure of the switch contacts when the monkey pulled the object to its mouth, thereby providing an objective record of the attack. The critical feature of this method was that an additional response was required: the ball had to be pulled as a prerequisite for attack to occur. A still better method would be to utilize a response requirement that was not a component part of the attack response, the nature of the response being dictated by methodological considerations rather than by the nature of the attack behavior. This objective of utilizing an arbitrary response to measure a motivational state is, of course, the same objective that has led to the use of bar-presses, chain-pulls, and panel-presses to measure the strength of motivational states as diverse as hunger and thirst (Skinner, 1938), imprinting (Peterson, 1960), escape (Dinsmoor and Hughes, 1956), avoidance (Sidman, 1953), and intracranial reinforcement (Olds and Milner, 1954). Among other advantages, the use of an arbitrary response also makes it possible to apply a common measure to various motivational states that otherwise are manifested by quite dissimilar behavior patterns. The present experiment attempts to ascertain whether an arbitrary response can be acquired by means of operant reinforcement when the opportunity to attack is utilized as the reinforcing event for that response.

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METHOD

The general procedure in the present study was to use tail-shock to induce aggression in monkeys. An inanimate object was used as the object-of-attack.

Subjects

Five experimentally naive male squirrel monkeys served. Three other monkeys were discontinued: one because of an unusual adaptation to the shock which resulted in large intrasession changes in the probability of attack, and two because of the low probability of attack (<.10) against the inanimate object. This failure to elicit attack consistently from an occasional monkey has been noted previously (Azrin, Hutchinson, and Hake, 1963). Since the monkeys were not raised in captivity, many of their characteristics that are not completely known may have been contributing factors. For example, Hutchinson, Azrin, and Ulrich (in press) found that with rats, age, social isolation, and hormonal development were contributing factors for the existence of shock-elicited attack. The weights of the five subjects in the present study ranged from 570 to 870 g, with an average weight of 740 g. During the experiments, subjects were individually housed in cages in which food and water were continuously available.

Apparatus

The experimental chamber (see Fig. 1) measured 10 by 6 by 23 in. high and included a special chair (Hake and Azrin, 1963) which held the monkey in a loosely restrained position while allowing the delivery of pain-shock through tail-electrodes. The chamber was enclosed in a sound-attenuating enclosure that contained a one-way mirror. The tail-shock was delivered at an intensity of 400 v ac from the secondary of a transformer and through a 10 K ohm series resistor that stabilized the current flow. Each shock was 100 msec in duration.

The top of the inner chamber had an opening through which a canvas-covered ball, 2 in. in diameter, could be lowered by activating a motor. The ball could be similarly recovered through the opening by reversing the motor. "Reinforcement" as used here refers to the lowering of the ball through the opening to a distance of 4 in. from the ceiling where it remained for a duration of about 2 sec. At the end of the 2-sec period, the ball was automatically withdrawn through the opening. While the ball was in the lowered position, the monkey could grasp the ball and bring it to its mouth because of the flexible cord by which the ball was suspended. The cord (by which the ball was suspended) was attached to a microswitch, thereby providing closure of the switch contacts when the monkey pulled the ball to its mouth. This switch closure required a minimum of 80 g of force.

The manipulanda for the conditioned response were two chains suspended through separate openings in the ceiling from two individual microswitches. The manipulandum on the right of the monkey is designated as R_R and that on the left as R_L. Both chains extended a distance of 4 in. from the ceiling, sufficient to enable the monkey to grasp the chain easily, yet not long enough to be disturbed by the subjects' casual movements. The two chains were 4.5 in. apart and were deliberately made physically different to increase the likelihood that subjects would discriminate between them. One of the manipulanda consisted of a simple bead chain; the other consisted of a bead chain enclosed in a narrow 0.25-in. diameter metal tube. Bead chain was used rather than the usual projecting bar or lever to reduce the subject's tendency to attack the manipulandum upon the delivery of the pain-shock. A pull exceeding 20 g was necessary to activate either switch; a response was defined as closure of the switch for a duration of about 0.5 sec. Maintained closure of this switch in excess of 0.5 sec counted as only one response. To be counted as a second response, the chain had to be released and pulled a second time. The 0.5-sec requirement was imposed to eliminate the possibility of counting as responses any momentary closures of the switch that resulted from random movements of the monkey. An important aspect of the apparatus, as mentioned earlier in Azrin *et al.* (1964), is that there be no projecting objects in the chamber that could be attacked easily other than the intended object-of-attack, which was the ball. All of the walls, as well as the waistlock which restrained the monkey, were constructed of micarta, the hard smooth surface of which effectively discouraged any biting attacks. The left section of Fig. 1 is a photograph of a monkey responding to R_R.

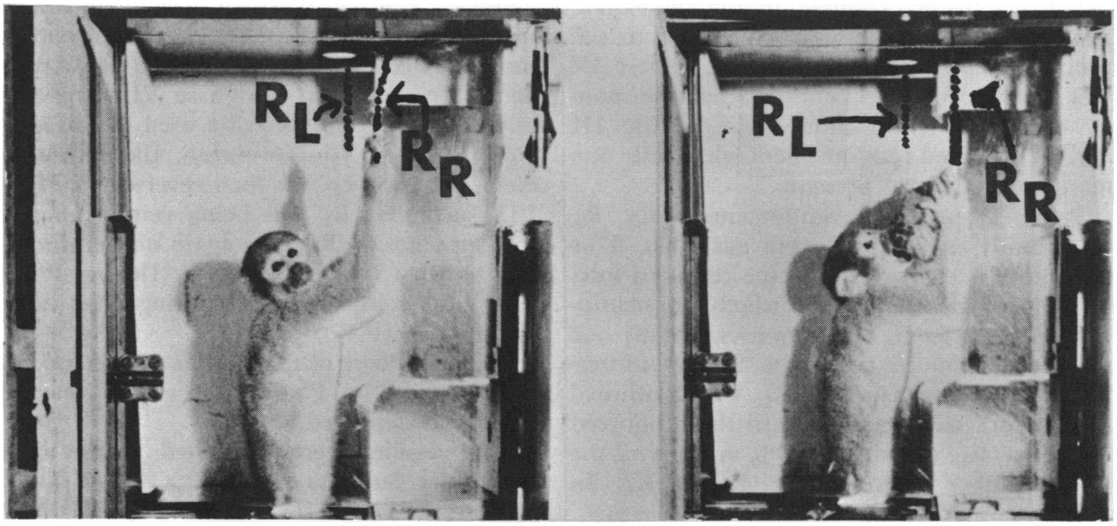

Fig. 1. Left photograph: Squirrel monkey pulling on the R_R manipulandum. Right photograph: attack on ball which has just been lowered as a result of a response on the R_R manipulandum.

The right section of Fig. 1 is a photograph of the subject attacking the lowered ball after having just produced the ball by pulling the chain.

Procedure

Table 1 outlines the experimental procedure. In Phase I, subjects were seated in the experimental chamber for 30 min. The tail was restrained in the electrode assembly, but no shock was delivered. The ball was in a lowered position for the entire 30-min session. The purpose of this phase was to ascertain the frequency of attack against the ball when no shock was delivered. Biting and grabbing of the ball by the monkey was recorded (1) automatically by means of the microswitch that was connected to the ball and (2) manually by an observer through direct observation.

Phase II was identical to Phase I except that the brief tail-shocks were delivered every 15 sec for a total of 25 shocks. The purpose of Phase II was to ascertain whether attack would result against the ball upon the delivery of tail-shock when the ball was continuously present. This procedure was identical to that of a previous study (Azrin *et al.*, 1964).

During Phase III, only R_R was available. The brief shocks were delivered at regular intervals of 15 sec for a total of 120 shocks during the 30-min session. The ball could be lowered only by pulling the chain. Phase III attempted to ascertain whether the response of pulling R_R would be learned if that response were followed by the reinforcement of having the ball lowered for 2 sec.

In Phase IV, manipulandum R_L was available and R_R was absent. A closure of the R_L

Table 1

Phase	*Shock condition*	*Reinforcement schedule (Availability of ball)*	*Manipulandum Availability*
I	no shock	Continuously present	None
II	shock every 15 secs	Continuously present	None
III	shock every 15 secs	$R_R \rightarrow$ reinforcement	R_R
IV	shock every 15 secs	$R_L \rightarrow$ reinforcement	R_L
V	shock every 15 secs	$R_L \rightarrow$ reinforcement	R_L, R_R
VI	shock every 15 secs	$R_R \rightarrow$ reinforcement	R_L, R_R
VII	shock every 15 secs	$R_L \rightarrow$ reinforcement	R_L, R_R
VIII[a]	shock every 15 secs	$R_R \rightarrow$ reinforcement	R_L, R_R
IX	no shock	$R_R \rightarrow$ reinforcement	R_L, R_R

[a]This Phase omitted for one subject.

switch for 0.5 sec resulted in the immediate lowering of the ball for 2 sec similar to the procedures used in reinforcing R_R. Phase IV was designed to determine whether the monkey could also be conditioned to R_L. Phases III and IV provided reinforcement when only one manipulandum was present.

Phase V provided reinforcement for R_L when both R_R and R_L were available. This procedure is comparable to the common food reinforcement procedure in which two manipulanda are present, but responses on only one manipulandum result in the food reinforcement. Reinforcement on R_L was continued during successive sessions until the reinforced responses, R_L, constituted 80% or more of the total number of responses, $R_L + R_R$. In Phase VI, the reinforcement was discontinued for R_L and provided for R_R, thereby reversing the reinforcement contingencies. The number of sessions provided on Phase VI was determined by the same criterion used in Phase V. Upon reaching this criterion, the reinforcement contingency was then reversed in Phase VII, such that R_L was being reinforced and the responses on R_R were again nonreinforced just as they were in Phase V. During Phase VIII the reinforcement contingencies were again reversed.

The last Phase of the experiment, Phase IX, was identical to Phase VIII except that no shock was delivered.

The sessions were scheduled at the same time daily, Sundays excluded.

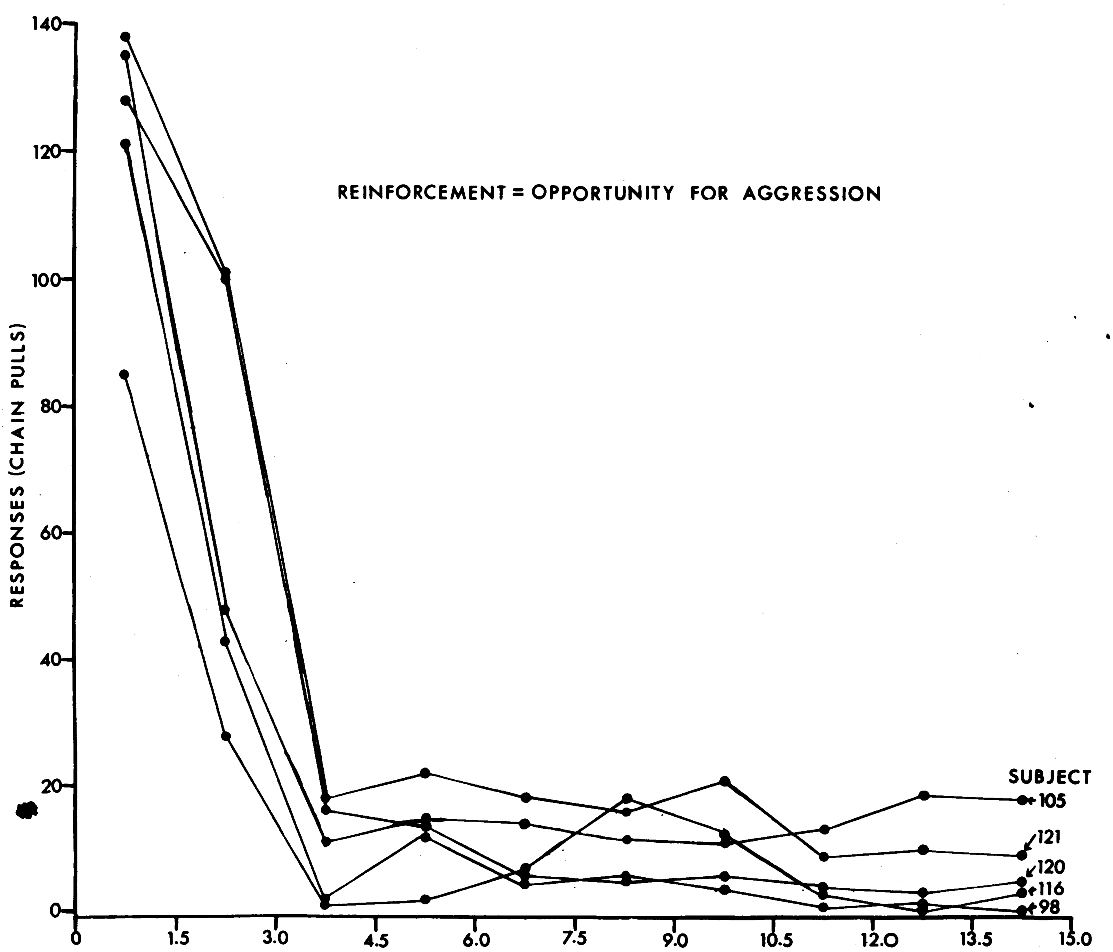

Fig. 2. The number of chain-pulling responses as a function of time since the delivery of shock. The 15-sec period between shock deliveries was divided into 10 intervals of 1.5 sec. Each data point is the number of chain-pulling responses that occurred during each 1.5-sec class interval during one session.

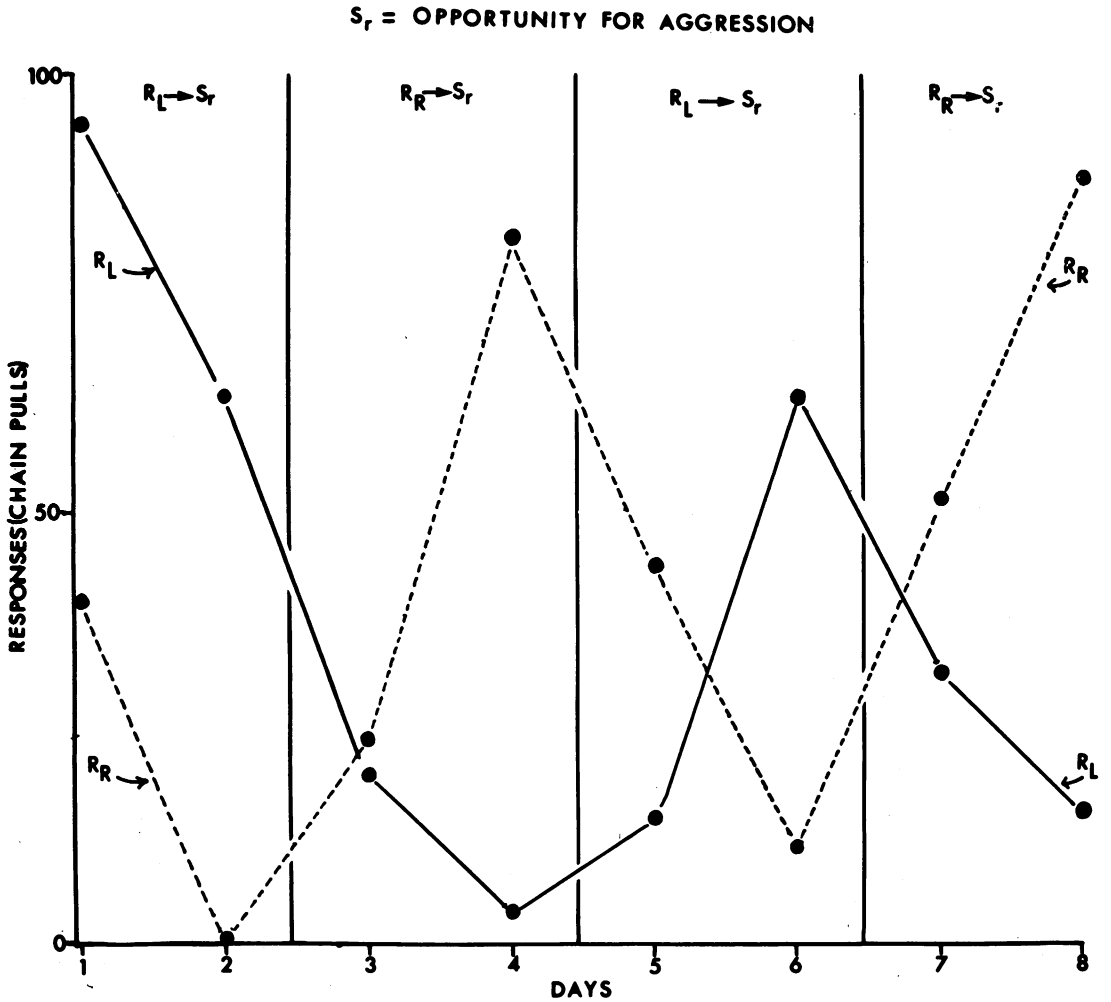

Fig. 3. Reversal of the reinforcement contingency for one subject. The dotted line designates responses on the left chain (R_L); the solid line designates responses on the right chain (R_R). Each data point represents the number of responses per day. The reinforcement contingency was reversed at the point designated by the narrow vertical lines.

RESULTS

Little or no attack occurred toward the continuously present ball in Phase I when no shocks were delivered. Three subjects did bite or manipulate the ball during the first few minutes of the 30-min session, but by the end of 5 min, visual observations revealed no further contact.

When the shocks were delivered to the monkeys in Phase II while the ball was in the lowered position, attack occurred consistently and immediately after each delivery of the pain-shock. Only the first few shocks failed to elicit attack against the ball since the initial reaction of the monkey to the shock was typically a scrambling escape-like behavior frequently accompanied by unsuccessful attempts to bite or attack the walls of the chamber. By the 10th shock, however, each subject vigorously bit the lowered ball immediately upon the delivery of every pain-shock. This consistent elicitation of attack against an inanimate object by pain-shock is in agreement with previous results utilizing the same procedure (Azrin *et al.*, 1964).

When the availability of the ball was made contingent on the chain-pull (Phases III and IV), the chain-pulling responses occurred consistently after each shock. Figure 2 shows the temporal distribution of the R_L responses during Phase IV when an R_L response resulted in the delivery of the reinforcement (ball lowered). It can be seen that the R_L responses were emitted primarily within the first 3.0 sec after the shock delivery. All subjects averaged at least one chain-pulling response for each of the 120 shocks. The results (not shown) for Phase III showed a similar temporal distribution of the R_R responses.

When both manipulanda were present (Phases V-VIII) the monkey responded to that chain which produced the ball. Figure 3 shows the typical day-by-day results when the reinforcement was successively changed from R_L to R_R back to R_L then back to R_R. The frequency of each response increased when reinforcement was provided for that response and decreased when reinforcement was provided for the other response. The acquisition of the reinforced response and extinction of the nonreinforced response usually occurred within two or three sessions for the other four subjects as well as for the subject depicted in Fig. 3.

All subjects showed this increase in frequency of the particular response that resulted in the availability of the object-of-attack, and a decrease in the frequency of the response that did not result in the availability of the object of attack. This is shown in Fig. 4, which compares the nonreinforced with the reinforced chain-pulling responses for each of the five subjects. The data is presented in terms of the percentage of chain-pulling responses and is based on the final day of reinforcement for Phases V, VI, VII, and VIII that preceded

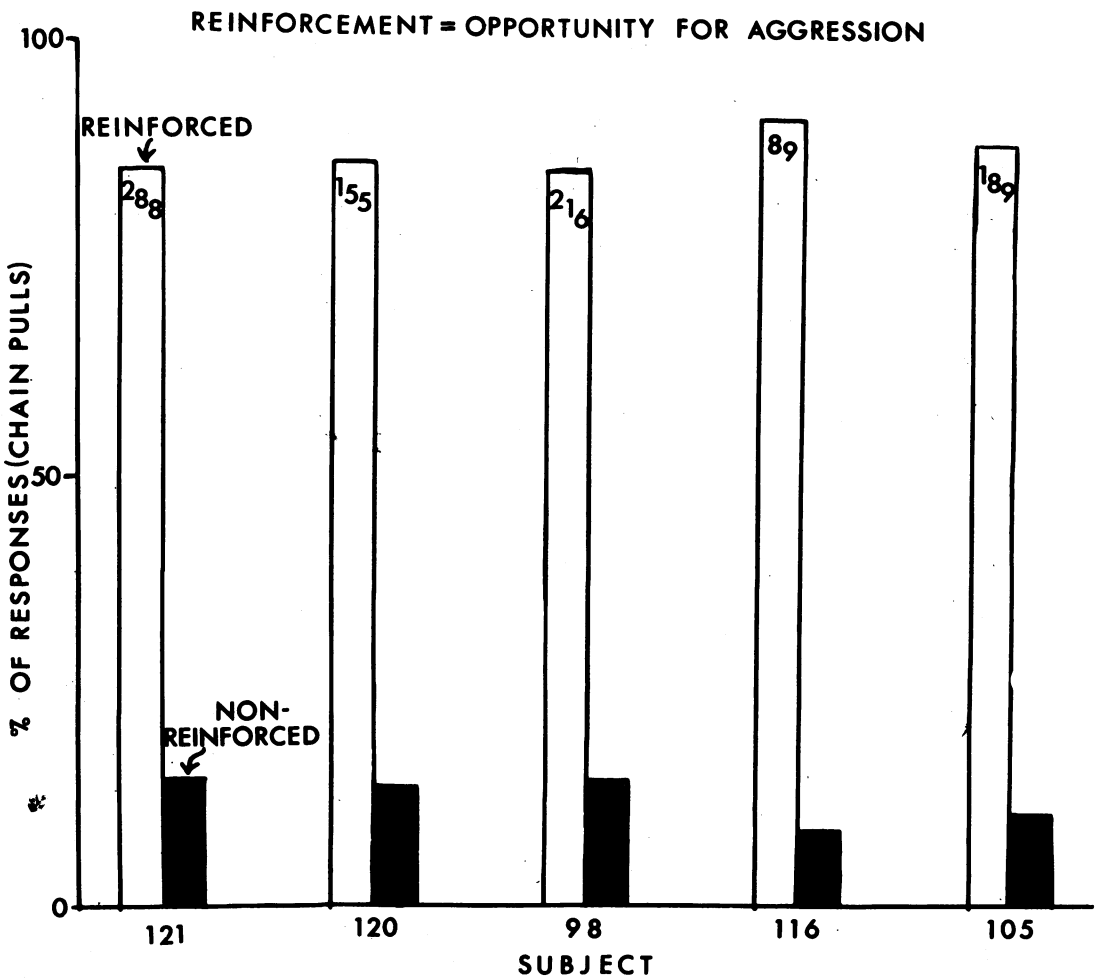

Fig. 4. The average number and percentage of reinforced and nonreinforced chain-pulling responses for each subject. The R_L and R_R responses were combined. The absolute number of reinforced responses is presented at the top portion of the white bar.

the reversal of the reinforcement contingencies. Each of the scores is based on four sessions (three sessions for one subject). It can be seen that for all subjects, over 85% of the chain-pulling responses were emitted on the chain that resulted in the delivery of the object-of-attack. The absolute number of responses emitted is indicated for each of the subjects.

Figure 5 compares the number of R_L responses emitted in the presence of shock with the number emitted in the absence of shock.

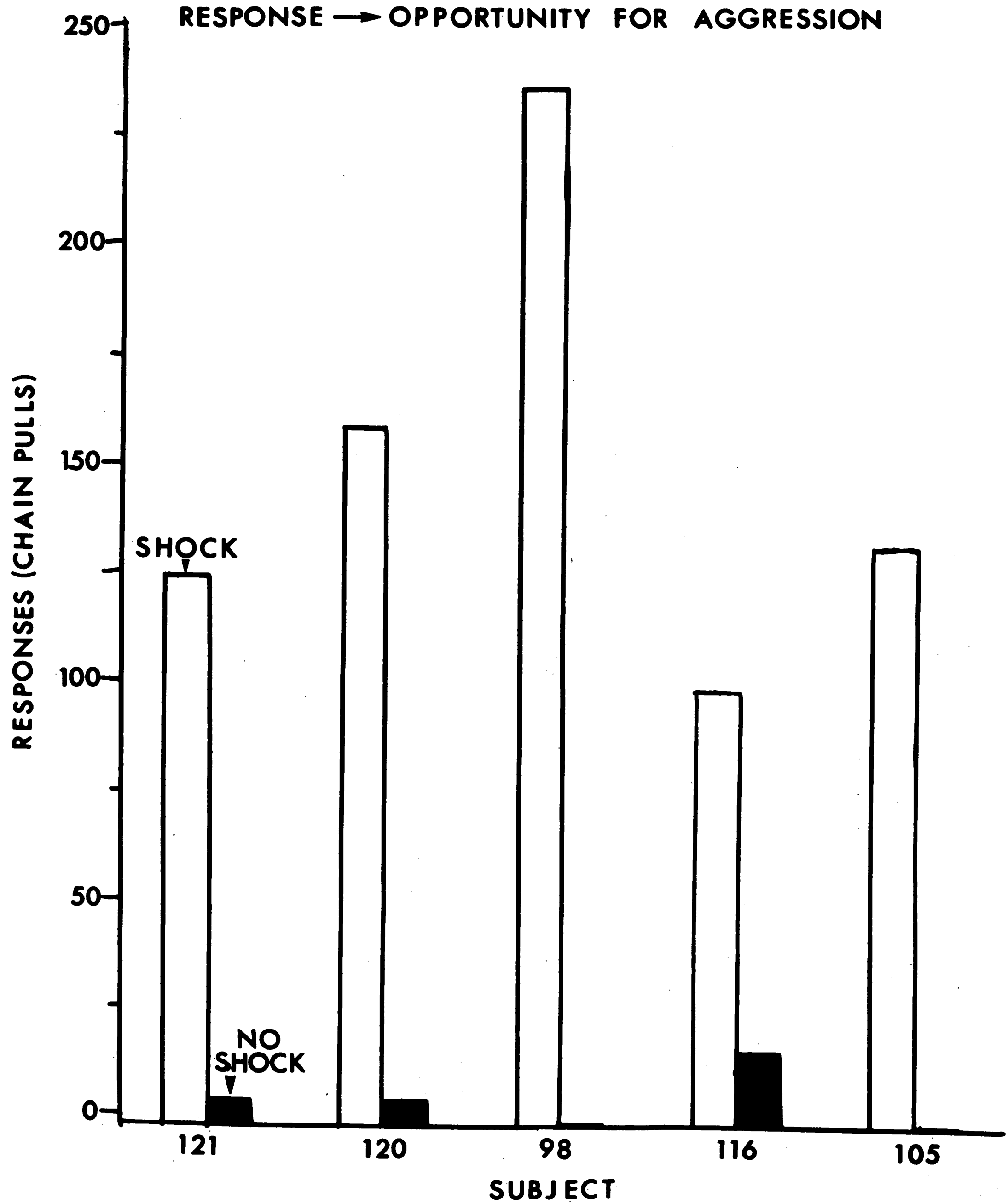

Fig. 5. Chain-pulling responses for each subject in the presence and absence of shock. Each bar designates the responses for one day.

The white bar for each subject designates the number of R_L responses during the last session of Phase VIII, when the shocks were being presented every 15 sec. The solid bar designates the number of R_L responses during the single session of Phase IX when shock was not delivered. The R_L responses produced the ball under both conditions. It can be seen that the number of responses in the absence of shock was zero for subjects S98 and S105, and near-zero for the other three. Of the R_L responses that did occur in the absence of shock, all were emitted during the first 5 min of the 30-min session.

In the present procedure, reinforcement for a chain-pulling response was arranged by making an object-of-attack available for 2 sec. The question may be asked as to whether attack did indeed occur upon each presentation of the object of attack. An answer was attempted by taking two different measures of attack behavior. The first of these measures has already been described: a microswitch was attached to the cord by which the ball was suspended, so that the switch closure automatically registered on the recording equipment whenever the monkey pulled the object of attack toward its mouth. A second measure was obtained by visually observing each of the monkeys for 300 presentations of the object-of-attack during the course of the experiment. Each of these presentations resulted from a chain-pull. Figure 6 presents for each of the subjects the number of attacks as measured by these two different methods of recording. The horizontal dotted line shows the total number of presentations (300) of the object of attack. The stippled bar shows the number of attacks as measured by the closure of the microswitch to which the object-of-attack was attached. No more than one attack was considered to have occurred during a given pres-

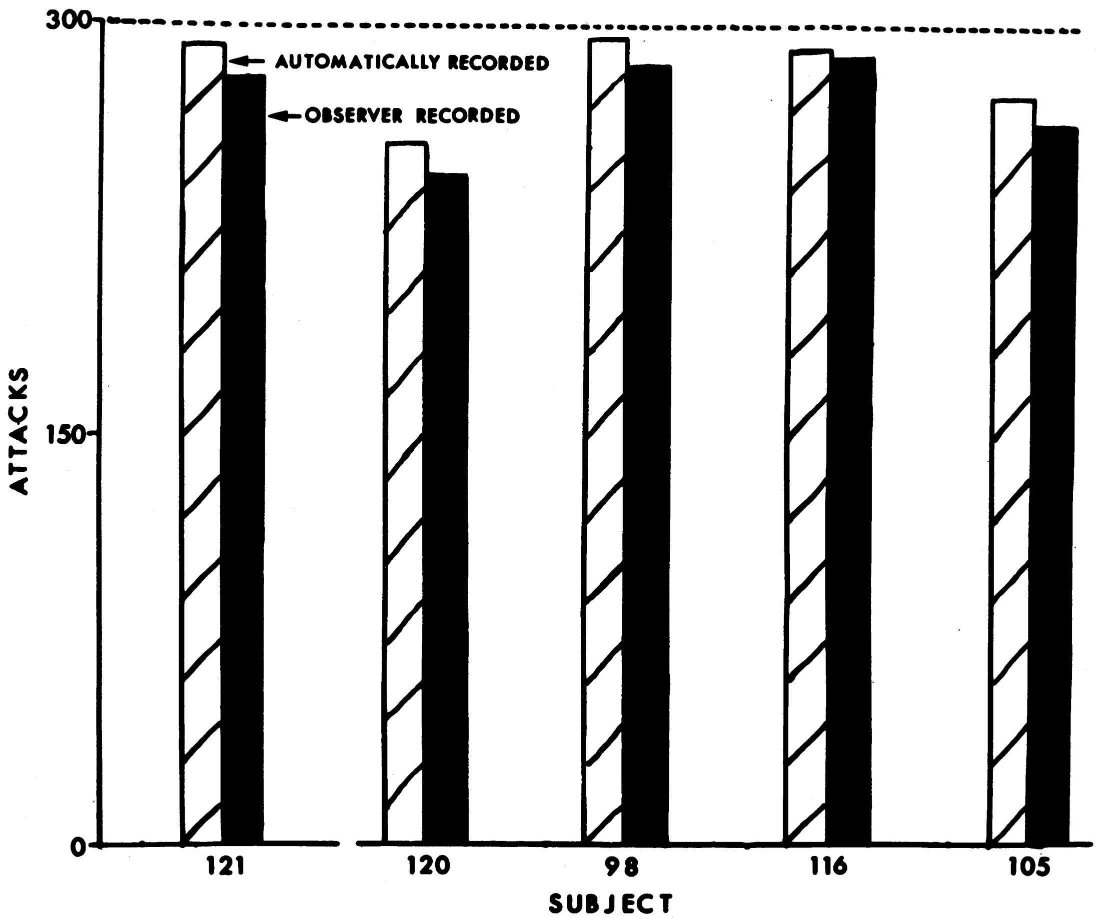

Fig. 6. Comparison of two measures of attack based on 300 opportunities for attack.

entation of the object-of-attack even though the switch may have repeatedly closed and opened during that presentation. Thus, the number of attacks as measured by the closure of the switch could not exceed the number of presentations of the object-of-attack. It can be seen that the number of attacks as measured by the closure of the switch corresponds very closely to the number of presentations of the object-of-attack. For three of these subjects, the correspondence was almost perfect: a closure of the switch resulted on 97% or more of the presentations of the object-of-attack. The correspondence for the other two was fairly close: 85% and 91%. The corespondence between the observer-noted attack (solid bar) and the automatic switch-recorded attack (stippled bar) is again very close, differing by no more than 5% for any subject. The observer-recorded attacks also correspond closely with the number of opportunities for attack: the greatest discrepancy is for S120, about 15%, but less than 10% for the other four subjects.

DISCUSSION

The present findings confirmed the results of previous studies (Azrin *et al.*, 1964) in demonstrating the existence of attack against inanimate objects as a result of aversive stimulation. Little or no attack was seen in the present study when the object-of-attack was continuously available but no shock was presented. On the other hand, attack was consistently elicited toward the continuously available object-of-attack when shocks were presented. Similarly, the chain-pulling responses dropped to a zero level in the absence of shock, but increased to a high level when the shocks were being delivered. Thus, it appears that the delivery of shock was necessary to produce aggression as measured either by the actual biting of the object-of-attack or by the frequency of the chain-pulling responses that produced the object-of-attack. The successful conditioning of the chain-pulling response offers a way to quantify the strength of aggression-motivation without the need to adapt the recording apparatus to the perhaps unique mode of attack (biting, grabbing, slapping, "threatening") that happens to be utilized by a particular animal or a particular species at a given moment.

Stimulus change appeared to contribute little to the occurrence of the chain-pulling response: a near zero level of chain-pulling was obtained in Phase IX when the response produced the ball but no shocks were delivered.

The chain-pulling response did not appear to be the result of a blind attack by the monkey upon the chain following the delivery of a shock since responses occurred almost exclusively only on that chain, which was followed by an operant consequence. It seems, therefore, that the principal source of strength of the chain-pulling response was the operant consequence of allowing an opportunity to attack the inanimate object.

It seems useful to consider aggression as a distinctive motivational state in the same loose sense in which it is useful to consider hunger or food deprivation as a distinctive motivational state. The opportunity to attack appears to be a reinforcement for a subject exposed to aversive stimulation in the same general sense that the opportunity to eat is a reinforcement for a subject that has been deprived of food. A new response was acquired and extinguished by arranging the opportunity to attack as a consequence for that response; similarly, new responses have been acquired and eliminated or extinguished by arranging the opportunity for eating. An obvious difference between aggression motivation and hunger motivation appears to be the relative brevity of the aggressive motivation. The aggressive tendencies reached a high level during the period immediately after the shock, falling off rapidly thereafter in contrast with hunger motivation, which persists for long periods of time. However, this difference between aggression and hunger motivation may be only apparent and may derive primarily from the technical difficulty of maintaining a continuing state of aversive stimulation in a manner fairly comparable to the maintenance of a continuing state of food deprivation. Some support for this suggestion was obtained in previous studies. When continuous footshock was provided for short durations (Azrin, Ulrich, Hutchinson, and Norman, 1964) attack was observed for a major part of the duration of the shock delivery, being interrupted primarily by the competing motor reactions elicited by the shock. It appears that shock creates a motivational state in which the opportunity to attack is a reinforcing event for the duration of stimulation and for a brief period after the cessation of stimulation.

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