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AN AUTOMATIC METHOD FOR THE STUDY OF AGGRESSION IN SQUIRREL MONKEYS[1]

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Experimental analysis of aggressive behavior in infrahuman species has become increasingly sophisticated in recent years. Many early studies relied upon visual observation of naturally occurring aggressive behavior in the normal environment (see review by Tinbergen, 1951). Gradually, more of the research came to rely upon the more controlled environment provided by laboratory test chambers (Scott and Fredericson, 1951). To isolate further the precise variables controlling aggression, more recent studies have attempted to produce aggression experimentally in the laboratory (Ulrich and Azrin, 1962). In all the research, however, the objective definition and measurement of aggressive behavior has been one of the most difficult problems. Several investigations have constructed scales to be used as guides during the task of reporting visual observations of aggression (Davis, 1935; Hall and Klein, 1942; Ulrich and Azrin, 1962). These efforts are time consuming, depend upon broad categories, and are subject to errors of compromise and interpretation.

Azrin, Hutchinson, and Sallery (1964) found that electric shock would elicit aggression toward inanimate objects as well as other live animals. It thus became feasible to design a restricted non-social environment to study elicited biting attack against an inanimate object. In the method developed, squirrel monkeys were seated in a restraining chair and electric pain-shocks were delivered to the tail. A terrycloth-covered tennis ball was suspended from a cable attached to a microswitch. The animal could reach up, grasp the tennis ball, pull it to its mouth, and bite it. Pulling the ball closed the microswitch, which recorded an aggressive episode.

Several difficulties were discovered in this method. The first problem was reliability. A subject would frequently pull the ball but would not bite or make any other mouth contact with it. Thus, a biting episode was recorded when none had occurred. This situation forced the experimenters to monitor the recording process and biting behavior continuously. Secondly, the recorded duration of biting behavior was not directly related to duration of actual episodes of biting. The method could thus determine the existence or non-existence of attack but could not measure frequency, duration or intensity.

In the present paper, a method is described whereby frequency, duration, and intensity of biting attack responses may be measured and recorded directly with a much greater degree of sensitivity and reliability.

Method and Procedure

Figure 1 shows the general apparatus. As in earlier experiments, squirrel monkeys were seated in a restraining chair equipped with tail-electrodes (Hake and Azrin, 1963). Directly in front of the subject's face and mounted to the front panel by two supporting rods was a 5 in. length of rubber hose "A". The hose formed part of a sealed pneumatic system. Pressure exerted upon the surface of the hose increased the air pressure within the hose, this change being transmitted via a hollow passage through one of the support arms to a pneumatic switch outside the experimental chamber. The two parts of this system will be referred to as the bite sensor assembly (that part located within the chamber) and the biting transducer assembly (that part outside the test chamber). Additional restraint was provided by a movable neck yoke "B", hinged at

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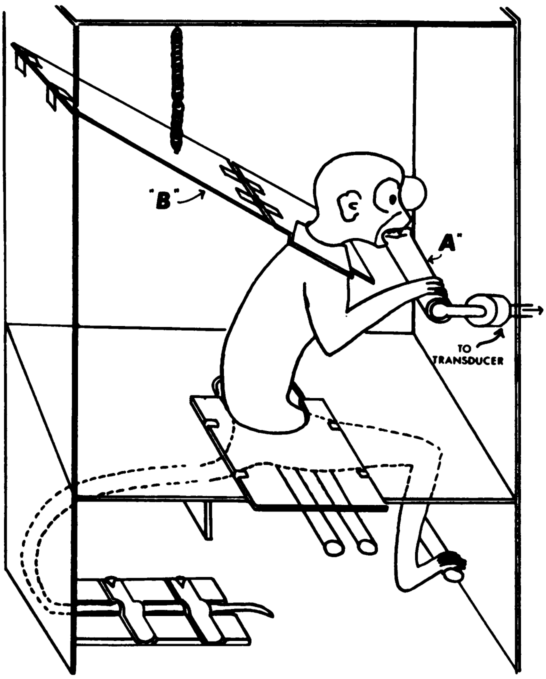

Fig. 1. Diagram of the general method (A) Bite Sensor and (B) hinged neck yoke.

two points to permit bending of the neck. A spring attached to the neck yoke counterbalanced the weight that would otherwise rest on the subject's shoulders. The purpose of the neck yoke was to insure orientation and proximity of the subject's head to the rubber hose.

Bite Sensor Assembly

Figure 2 shows a detailed schematic of the bite sensor assembly. The biting sensor is a piece of pure gum rubber, general purpose pressure-vacuum laboratory hose (E. H. Sargent and Co., Catalogue No. S-73515, size F). Its outer diameter is 5/8 in. and the wall thickness is 1/8 in. The ends of the hose were forced over 1/2-in. diameter brass nipples, which were soldered at right angles to the 1/4-in. brass hose supports. These hose supports were long enough to allow the hose assembly to be moved toward or away from the monkey's face. One of the support arms was drilled out to permit transmission of pressure changes to the biting transducer.

Biting Transducer Assembly

Figure 3 shows the biting transducer assembly. A short length of rubber hose (arrow)

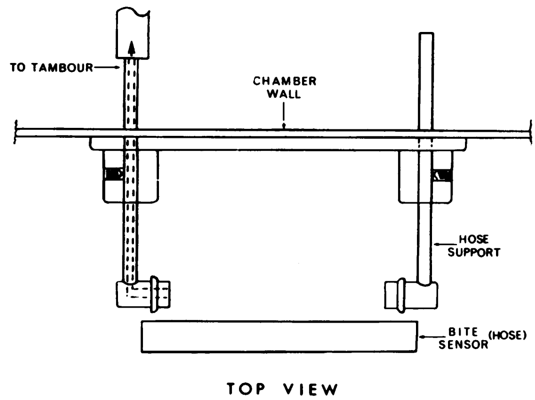

Fig. 2. Diagram of the bite sensor assembly.

extending from the hollow bite sensor support-arm connects directly to a tambour outside the chamber. A relay contact was cemented to the center of the tambour head. This relay contact served as a common of the biting transducer switch. Counterpoised above this relay contact was another relay contact serving as normally open for the biting transducer switch. Increased pressure in the pneumatic system distended the tambour head causing the relay contacts to close. The biting pressure required to close the contacts was dependent upon the spacing between contacts. Contact spacing and, thus, sensitivity of the unit was controlled by a micrometer movement, *i.e.*, "Sensitivity Control", as shown in Fig. 3.

A branch pneumatic circuit was connected to a 0-60 mm Hg pressure gauge (Marshalltown Manufacturing, Inc.). The entire pneumatic system was mounted on a micarta panel attached to the outside of the chamber wall, providing easy access for adjustment between

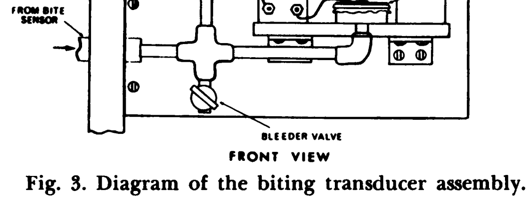

Fig. 3. Diagram of the biting transducer assembly.

experimental sessions. An indicator lamp placed adjacent to the gauge on the panel was connected in series with the switch contacts and a source of 28 v. This feature allowed immediate monitoring of the sensitivity setting and convenient adjustment to any other force requirement before the start of an experiment. A bleeder valve was provided in the pneumatic system to insure that pressure could be equalized after, for example, inserting a new piece of biting hose in the chamber.

To insure that the biting sensor would not be accidentally punctured, a subject's two upper and two lower canine teeth were routinely clipped off flush with the first premolars before testing started. This required less than 1 min and was accomplished with a pair of hog tooth nippers (chrome plated diagonal cutters). The process did not cause the subject more discomfort than from the temporary restraint involved, as the tooth nerve was not exposed. As a further precaution, the bite sensor hose was replaced after each 50 hr of experimental use.

Performance Characteristics

Initial experiments determined the most appropriate adjustment of the apparatus for sensitive and reliable recording of biting behavior. Subjects were placed in the chamber and periodic shocks were delivered (see Fig. 1) through a 50 K ohm series resistor to tail-electrodes (Hake and Azrin, 1963).

Upon delivery of shock, the subjects would reach out, grasp the bite sensor with both hands, and bite into the hose for several seconds. This behavior appeared to consist of a series of temporally discrete bites, rather than any prolonged masticatory movement.

To assess more accurately the temporal and intensive properties of the biting behavior, a Statham P-23 ac pressure transducer was installed in the pneumatic system. The output of the transducer was amplified and recorded on a Grass Model 7, six-channel polygraph. A second pen simultaneously recorded duration of tambour switch closure. A third pen connected to record response-former output was activated only at the onset of each bite, thereby providing a simplified record of the number or frequency of bites. These tracings were collected for four subjects for a minimum of 500 shocks of various intensities during five 1-hr sessions. Shocks were always 100 msec duration. Figure 4 shows a sample of the data obtained. Each bite produced a fairly discrete change in pressure characterized by a rapid rise and fall time. This allowed a reliable measure of the duration of each bite as seen in the performance of the tambour switch. The response-former record emphasizes the frequency characteristics rather than amplitude or duration of bites.

From the data in Fig. 4, it can be seen that biting varied in intensity, duration, and frequency. It would thus be possible to study any or all of these dimensions of the behavior. If it were desirable to automate recording and analysis of response intensity, the output of the pressure transducer could be coupled to a digital output voltage amplifier and controller device. Alternatively, standard relay and response-former circuitry would be sufficient to record duration or frequency.

Figure 5 presents a sample record of cumulative biting responses from a second subject. Electric shocks of 100 msec duration and 400 v were delivered every 4 min. This data was obtained by connecting the output of the

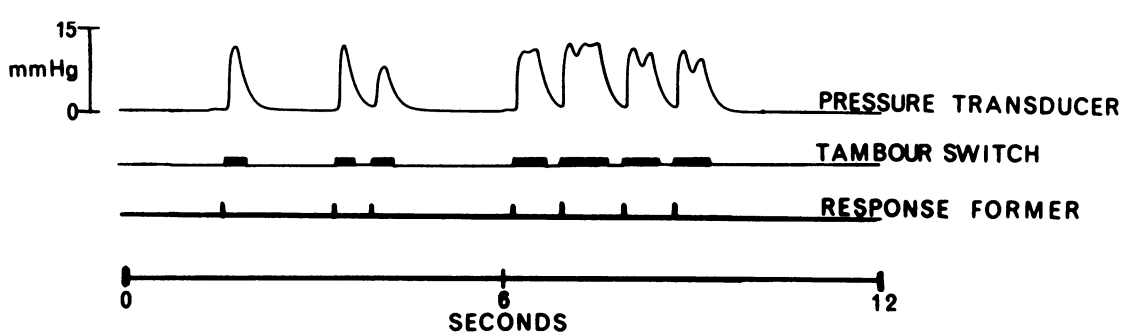

Fig. 4. Sample polygraph records showing biting pressure and action of tambour switch and response pulse former after delivery of a 400 v shock. Shock was delivered at 0 sec.

biting transducer switch to the input of a standard response-former circuit. Each shock produced a series of 20 to 50 biting responses by this subject. Collecting data on frequency of biting in the form of cumulative response records provides an immediate description of performance for the entire session as well as those moment-to-moment changes produced by the electric shock.

Validity and Reliability of the Method

A question which arose early in this research was the extent to which other bodily contact might produce spurious pressure changes and subsequent switch closure. The present method could provide a valid measure of biting only if it could be made sensitive to differences between biting and all other behaviors. Simultaneous records were obtained by the polygraph and a visual observer for 21 1-hr sessions involving over 1000 shock presentations. Analysis revealed a virtually complete separation along the pressure dimension between biting events and grasping or bumping contact with the hose. All observed bites, as evidenced by tooth contact with the bite sensor, produced a pressure of at least 3 mm Hg. On the other hand, all other observed contacts, such as grasping or bumping, produced pressure changes of less than 1 mm Hg. On this basis, the tambour switch was routinely adjusted to close at about 2 mm Hg.

Another question was whether, and to what extent, the method could more reliably record biting than could a human observer. Records were obtained automatically during four 1-hr sessions and compared with the data obtained by a human observer pressing a microswitch for each observed biting response. Although the two sets of data were similar, the observer was unable to respond quickly enough when several bites occurred in rapid succession. He recorded too few bites on some occasions and too many on others as compared to the bite sensor and transducer switch. He was incapable of measuring duration or amplitude of an individual bite.

The method and apparatus described above appears to provide an objective, valid, reliable, and automatic method of sensing and recording biting behavior.

Such a method may offer advantages for the study of aggression and its determinants. As shown above, attack against the hose was elicited by electric shock. In addition, preliminary research indicates that the method may be suitable for the study of aggression produced by extinction or intermittent reinforcement of other operant responses, intracranial stimulation, and reinforcement specifically for attack. The method may also be useful for the study of the effect of drugs and hormones on aggression.

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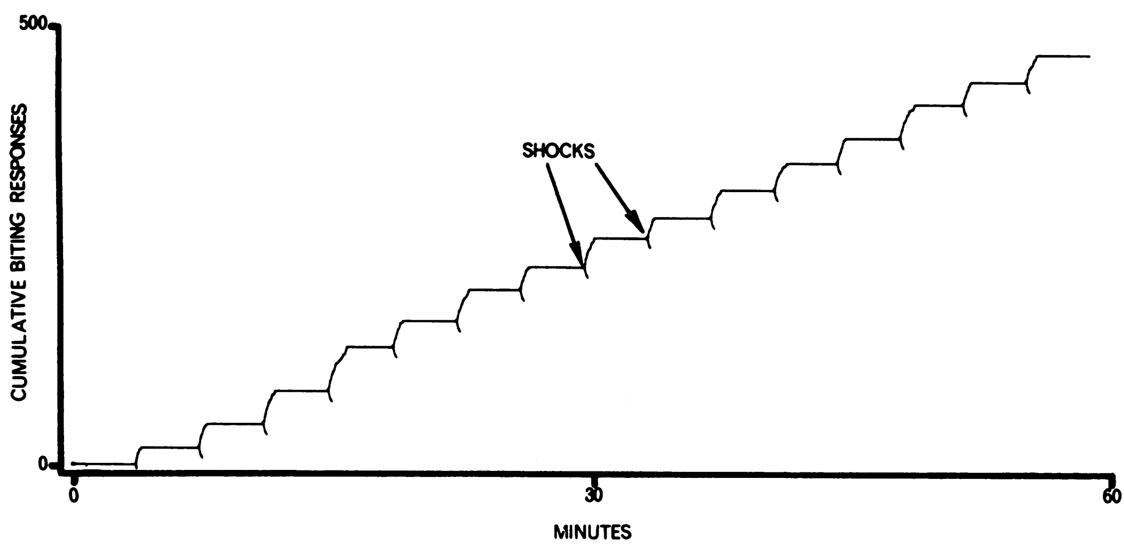

Fig. 5. A sample cumulative record of biting responses obtained using the method described.

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