Grid vs subcutaneously delivered shock in escape schedules with guinea pigs

JAMSHID KHALILI¹ and CARL CHENEY, UTAH STATE
UNIVERSITY, Logan, Utah 84321

Guinea pigs were trained by use of titrated negative-reinforcement procedures to escape electric shock on ratio schedules. With one group of Ss, shock was delivered through the grid floor of the chamber. Another group had electrodes implanted subcutaneously, closing a circuit between the back of the neck and near the tail bone. The subcutaneous group was also run with grid-shock escape. Results indicate that grid-delivered shock is more effective and efficient than is shock delivered through implanted electrodes.

Although grid-delivered shock is a convenient method of presenting aversive stimuli to animals, the procedure has not produced consistent and/or long-lasting effects. There are a great many technical difficulties involved in the administration of foot shock through a grid floor to a freely moving rat, e.g., polarity scrambling, current density, arcing, fecal-produced shorts and insulation, and resistance changes. There is also the problem of unauthorized escape, especially by the rat, which may balance on one grid rod, lie on its back, or carry out some other escape maneuver. A logical step in attempting to overcome these problems is to attach electrodes. With rats, however, few, if any, reliable techniques have been developed for using implanted or attached electrodes (Dinsmoor, 1966). A number of reliable systems have been developed for delivering shock to pigeons by means of electrodes held in place with a harness (Hoffman, 1960) or implanted surgically (Azrin, 1959). Rats wear out, bite, or pull off any aversive shock attachments, and electrodes are eventually rejected by the animal's tissue. In spite of the mass of available behavioral data, and the dictates of tradition, rats may not be the Ss of preference for escape research.

It was partly due to these problems that we began using guinea pigs. Dutch and Brown (1968) suggest that guinea pigs are difficult animals to use in behavioral research. This may, in fact, be the case when using food or water reinforcement. However, these animals have proven to be excellent Ss for studies using intracranial stimulation (Burnstein & Wolff, 1967) or grid-shock escape (Khalili & Cheney, 1969). They have also been used as Ss with licking (Alvord, 1968) and vocalizing² as the operants of interest.

Guinea pigs used in the laboratory weigh up to 1,000 g, and this large size somewhat restricts their maneuverability within the shock chamber. They are also much less adept than rats at manipulating objects with their forepaws. Most frequently, barpress responses are accomplished with the chin or snout.

In spite of the success that we have had using grid shock with guinea pigs (Khalili & Daley, 1968; Khalili & Cheney, 1969), there is some justification for attempting the applied-electrode procedure. For example, the exact parameters of shock could more nearly be ascertained and manipulated with implanted electrodes. In the research reported here, an initial attempt was made to systematically differentiate grid-shock from implanted-electrode performance on escape schedules with the same animal. Guinea pigs were implanted with subcutaneous electrodes, and the behavioral differences between shock delivered subcutaneously and grid shock were determined.

METHOD

Ten adult guinea pigs were originally selected for this study. Each was surgically prepared with subcutaneously implanted electrodes prior to training. All were allowed free access to food and water in their individual home cages between the 50-min daily sessions.

Each S was anesthetized by sodium pentobarbital, and subcutaneous electrodes were implanted. Each electrode (manufactured by Plastic Products) was 8 cm long, with the insulation removed from 3 cm at the tip. Each lead was inserted in one side of the animal over the rib cage by means of a small incision between the shoulders, through the connective tissue immediately under the skin, and over the platysma and trapezius muscles. Electrodes were mounted on a pedestal attached to the skull with dental cement.

For the other electrode pole, a 1-in. piece of stainless-steel wire, 1/32 in. in diam, was shaped in the form of a semicircle with a sharp end and carefully inserted under the lower end of the tail bone. When the wire was properly situated under the bone, the end was brought out through the skin; a crimped connector was used to hold the two ends together and to provide a grip for the alligator clip on the chamber electrode lead.

All Ss were run in the same Grason-Stadler small-animal operant-conditioning chamber. A Grason-Stadler (Model E1064GS) shock generator-scrambler provided shock to the chamber grid, walls, and bar. Subcutaneous shock was delivered with the same shock generator by bypassing the scrambler. The operant chamber was housed in a sound-attenuation chamber equipped with houselight and fan. Standard electromechanical control equipment was used to program and record contingencies.

Effective intensity was determined behaviorally and set at 1.0 mA for grid-shock animals and at 2.7 mA for subcutaneous Ss. Shock level was adjusted upward until activity was elicited. The Ss' resistance, using the surgical procedure cited above, was approximately 400 ohms. Approximately 3 mW passed through the animal.

Five grid Ss were autoshaped to press a bar that terminated shock for 30 sec. The other five also received autoshaping but were shocked through subcutaneous electrodes. Hand-shaping was employed with frequent modifications and innovations in an attempt to develop escape barpressing with subcutaneously delivered shock. None of the animals learned to press with this type of training. At this point, the electrode-shock guinea pigs were switched to grid shock, and within one autoshaping session, these animals pressed the bar shortly after the shock onset following a 30-sec time-out (TO). This behavior was similar to that of the other grid-trained animals.

Following a single continuous-reinforcement session, all guinea pigs were put on a fixed-ratio-20 (FR20) schedule, with a titrated reinforcement procedure in effect (Khalili, Daley, & Cheney, 1969). The procedure involved reinforcing the first 19 responses with progressively shorter TOs until the schedule became straight FR20, with one 30-sec TO being contingent upon only the 20th response. The shorter TOs refer to "titrated reinforcement." A sample series of TO decreases between sessions was: FR20 TR 10-sec, FR20 TR 5-sec, FR20 TR 3-sec, FR20 TR 1-sec,

Fig. 1. Cumulative records, showing typical acquisition of FR20 escape behavior with subcutaneous shock and subsequent maintenance for 42 sessions. Downward displacement of response pen indicates a 30-sec time-out (TO) from shock.

FR20 TR 0.5-sec, FR20 TR 0-sec (which was the final schedule of 20 responses, and one 30-sec TO).

Subcutaneous animals were provided with two sessions of FR20 TR 10-sec with grid shock, then abruptly transferred to electrode-delivered shock. The remaining TR steps were completed with subcutaneous shock. Transitions from FR20 upward to FR40 and then to FR60 were abrupt whenever criterion was reached on the lower schedule. Criterion was determined by inspection of cumulative records, with an added requirement that 3 consecutive days of consistent responding occur with 95% of the response latencies within 2 sec of shock onset and with 90% of the possible reinforcement opportunities having been obtained. The latter requirement was employed in the overall criterion because the sessions were based upon a fixed time interval and not on the fixed number of ratio runs. Therefore, sessions with long pauses did not satisfy the stability criterion.

Fig. 2. Representative cumulative records, showing transitions from FR20 to FR40 and then to FR60 with subcutaneous shock.

Fig. 3. Cumulative records illustrating transition from FR20 escape to FR40 to FR60 to FR80 with grid-shock. Stability is demonstrated at each level.

RESULTS

Two Ss, 09 and K5, died in the chamber while undergoing subcutaneous shock early in training. (This has not occurred with any of about 50 grid-shock guinea pigs run to date.) The cause of death is unclear, but it was probably the result of inappropriate electrical connections and/or current shorts.

None of the implanted-electrode guinea pigs were successfully trained to escape by barpressing without first having been exposed to grid-shock escape training. Shock initially delivered via the implanted electrodes appeared to elicit "freezing" reactions that were incompatible with behaviors that approximated lever operation. However, after two or three grid-shock training sessions, transition to escape from implanted-electrode shock occurred readily in all Ss.

Figure 1 shows sample cumulative records of L6 for Sessions 2 through 42 in which a titrated negative-reinforcement procedure was used in training. This animal was trained, of course, with grid shock for one autoshaping session and for two subsequent grid sessions. Session 3 (Fig. 1) was the second session in which shock was delivered via implanted electrodes. The first session was the shaping attempt early in the S's training. The schedule at this point was FR20 TR 10-sec; that is, the schedule included 10 sec of escape for each of 19 consecutive responses and 30 sec of escape for the 20th response. Session 42 (Fig. 1) illustrates the maintenance of escape behavior with implanted shock electrodes on FR20 TR 0-sec. This was the 31st session, with parameters at FR20 TR 0-sec. Stability criterion was met at Session 11.

Figure 2 shows a representative record of transitions from FR20 to FR40 and then to FR60 with subcutaneous shock. At FR60, performance breaks down; at this point, the animal was returned to FR20 TR 0-sec, with shock delivered through the grid. Transition up to FR80, with the same animal on grid shock, is shown in Fig. 3, with relatively stable performance maintained at these parameters. Stable and long-term performance has been obtained at these parameters and at higher ones in other experiments.

When grid-shock records of transition from FR20 to FR40, FR60, and FR80 are examined, they simply show that development of FR80 performance on the grid is possible with a short history or shock-escape training (as was not the case in Fig. 3).

The failure to obtain consistent FR60 TR 0-sec performance with subcutaneous shock may have been a function of local infection or scar-tissue formation at the electrode site. However, each animal was carefully examined for these conditions, and

shock intensities were adjusted. We are convinced that neither of these possibilities accounts for the loss of performance, although they cannot be ruled out completely. We are inclined to believe that subcutaneous shock is less efficient in maintaining high ratios for the same reason that we were unable to develop responding initially—subcutaneous shock elicits very little movement, and the respondents are somewhat incompatible with barpressing.

DISCUSSION

The results indicate that titrated reinforcement procedures can be used to quickly and easily train guinea pigs to press a lever and escape electric grid shock. Also, with guinea pig Ss, grid-delivered shock is more effective and efficient than is shock delivered through implanted electrodes. Although we were unable to obtain initial escape responding with implanted electrodes, transition and maintenance were easily possible once the performance was established using grid shock. Performance at FR20 TR 0-sec and at FR40 TR 0-sec was indistinguishable between grid- and subcutaneous-shock animals. However, we have been unable to go beyond FR40 TR 0-sec with subcutaneous shock and sustain performance for comparable periods of time. This feature did not appear to be a peculiarity of the animal since, by switching to grid-shock escape, performance could be obtained and sustained within the same S.

There appears to be no necessity for using implanted electrodes to deliver continuous shock when using guinea pigs in escape experiments. In fact, there are several obvious disadvantages: Electrodes require surgical implantation involving time and material expense; animals sometimes die from subcutaneous shock; initial escape training is difficult (if not impossible); and performance is not easily sustained at high FR requirements.

We can only speculate as to why we have been unable to

develop escape lever pressing initially. It appears that the delivery of continuous shock, at a variety of intensities, by means of subcutaneous electrodes, does not elicit sufficient movement to enable the E to negatively reinforce and shape approximations to barpressing. Just the opposite kind of response is elicited. It is clear, in any case, that it is much easier to develop escape lever pressing "automatically" with grid-delivered shock.

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NOTES

1. Now at North Dakota State University, Fargo, N. Dak. 58102
2. Daley, M. F., & Wolff, P. Personal communication, 1968.