Effect of different parameters of shock on tonic immobility

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Four separate experiments were conducted with chickens to explore the effects of various parameters of electric shock on tonic immobility. Immobilizing subjects at varying times after the receipt of shock affected the duration of immobility only after delays of over 15 min. Duration of shock affected immobility differently, depending upon whether alternating current or continuous direct current was used. The effects of continuous dc, pulsating dc, and ac shock were also examined. The results were discussed in terms of shock onset-offset characteristics being an important consideration.

Tonic immobility is represented by a state of profound catatonic-like unresponsiveness which follows brief exposure to physical restraint. Although the exact mechanisms underlying tonic immobility remain obscure, the duration of the reaction has proven directionally sensitive to manipulations designed to affect fear (Gallup, 1974). Exposure to aversive events prior to induction reliably increases duration of immobility, while handling, taming, and tranquilizer ingestion result in diminished reactions.

A brief shock given a few seconds before the onset of tonic immobility has been shown to prolong the reaction in chickens (Gallup, Creekmore, & Hill, 1970), and the stronger the shock the longer the immobility response (Gallup, 1973; Gallup, Nash, Potter, & Donegan, 1970). Shock applied via leads tied to the subject's legs seems more effective than grid shock (Maser, Gallup, & Barnhill, 1973), and exposure to inescapable shock has a more potent long-term effect on tonic immobility than escapable shock (Maser & Gallup, 1974).

The robust effects of shock on tonic immobility raise several questions with methodological and theoretical implications. For example, how long do the effects of a single shock last? Does the duration of shock make a difference? And, finally, do alternating and direct-current shock sources produce equivalent effects? The present study attempts to examine these issues as they relate to immobility in chickens.

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EXPERIMENT I

The first study was designed to determine how long the effects of shock last. The time between receipt of shock and onset of tonic immobility was studied.

Method

The subjects were 70 Production Red chicks (*Gallus gallus*), obtained from a Mississippi hatchery at 1 day of age. The chicks were housed in commercial brooders and given continuous access to Purina Chick Chow (Growena) and water. The photoperiod in effect during rearing was 14 h of artificial light per day.

A Foringer constant-current dc shock generator (Model 1154-M11) was used; duration of shock was controlled with a Hunter decade interval timer (Model 11-C). Time between receipt of shock and onset of immobility was monitored by a stopwatch, as was the duration of the ensuing immobility response. Animals were tested in a three-sided (.61 x .61 x .50 m) wooden induction box mounted on a table. This arrangement eliminated extraneous visual cues.

At 21 days of age, all chicks were given 4 days of habituation training. Habituation consisted of manually restraining a bird on its right side for 15 sec in the induction box. The duration of each immobility episode was terminated after about 30 sec by gentle prodding. Each bird was given five inductions per day, with a 60-sec intertrial interval. During each period of immobility, the experimenter sat quietly on a chair about .9 m away and avoided making direct eye contact with the subject. Large plywood boxes, provided with ventilation holes and food, were used to transport the subjects and as pre- and posttest holding boxes located outside the testing room.

On the day after the last habituation trial, subjects were tested. Order of experimental treatments were determined from a table of random permutations. Immediately prior to testing, the chick's feet and legs were dipped into a mild saline solution; a bare wire leading from one of the two terminals on the shock generator, via the interval timer, was wrapped around each leg. While being gently held by the experimenter, the subject then received a 2-sec, 3.5-mA dc shock. Following shock termination and lead removal, the bird was restrained immediately or at 2.5, 5, 10, 15, 60, or 240 min after the receipt of shock. The animal was held on its right side for

Figure 1. Duration of immobility as a function of the time delay between shock offset and immobility onset.

15 sec. Duration of immobility was measured from the time manual restraint ended until the bird rose to its feet. If a chick did not show immobility after the first induction, it was given successive 15-sec inductions, using a 15-sec intertrial interval, until immobility was obtained or until five inductions had been administered, in which case a duration of zero was recorded.

Results

Figure 1 shows that the effects of a single shock last for a considerable period of time and only begin to diminish after about 15 min. For purposes of analysis, the duration of immobility data in seconds were normalized, using a $\log_{10}$ transformation. A one-way analysis of variance, computed on the transformed data, revealed a significant effect of time since receipt of shock, $F(6,63) = 4.80$, $p < .001$. A Duncan's multiple range test showed that subjects in the 240-min delay group remained immobile for significantly ($p < .05$) shorter periods of time than those in the 0-, 2.5-, 5-, 10-, 15-, and 60-min delay groups. None of the other group comparisons were significant.

The effect of time since shock on the number of inductions needed to elicit immobility is presented in Table 1. Analysis of variance on the induction data was significant, $F(6,63) = 6.72$, $p < .001$. A Duncan's multiple range test revealed that the required number of inductions was greater ($p < .05$) for the 240-min delay condition than for all other groups. The 60-min delay condition required significantly more inductions than the 0-, 2.5-, and both the 10- and 15-min delay conditions.

EXPERIMENT II¹

The first experiment showed that the effect of shock on immobility remained pronounced for a considerable period of time after the receipt of shock.

Previous research (Gallup et al., 1970b) has shown that strong shock potentiates tonic immobility more than weak shock. The second study examined the effect of shocks of constant intensity but different duration.

Method

The subjects were 45 Production Red chickens (*Gallus gallus*). The apparatus and procedure were identical to those of Experiment I, except that all subjects were tested immediately after shock termination. Subjects received a 3.5-mA dc shock of .25, 1.0, 2.0, 5.0, or 10.0 sec duration, depending upon treatment designation.

Results

A U-shaped function, relating the effect of different durations of dc shock, is illustrated in Figure 2. Brief shock appeared to potentiate immobility more than shocks of intermediate duration. The duration of immobility data were normalized via a $\log_{10}$ transformation and analyzed, using a one-way analysis of variance. The overall effect of shock duration was significant, $F(4,40) = 4.71$, $p < .004$. A Duncan's multiple range test showed that the 2.0-sec shock condition resulted in significantly ($p < .05$) shorter durations of immobility compared to both the .25- and 10-sec shock conditions. In addition, the 1.0-sec shock condition resulted in significantly shorter immobility durations compared to the 10-sec shock condition.

Analysis of the induction data failed to reveal a significant shock duration effect.

EXPERIMENT III

The effects of brief, as opposed to intermediate, dc shock durations in Experiment II fit in with the idea that the effectiveness of dc shock is based on the temporal spacing between onset and offset: with longer duration shock, the less the recruitment and the less aversive the shock. Since a pulsating dc shock provides for a series of shock onsets and offsets, an attempt was made to contrive a pulsating dc shock source to compare with continuous dc shock at an intermediate shock duration. Steps were also taken to

Table 1
Means and Standard Deviations of the Number of Inductions Needed to Elicit Immobility as a Function of Time Since Shock (Minutes)

Time Since Shock	Number of Inductions	
	Mean	SD
.0	1.20	.63
2.5	1.70	1.25
5.0	2.20	1.48
10.0	1.90	1.45
15.0	1.90	1.37
60.0	3.30	1.89
240.0	4.40	.97

examine the effects of ac shock, since Muenzinger and Walz (1932) have shown that pulsating shock, whether dc or normal cycling ac, tends to be more aversive than continuous shock.

Method

The subjects were 40 Production Red chickens (*Gallus gallus*), purchased at 2 days of age from a hatchery in Iowa and maintained as in the previous two experiments.

A constant-current shock source with provisions for 60-Hz ac, 120-Hz pulsating dc, and continuous dc outputs was built to specifications provided by Stewart and Campbell (1970).

At 10 days of age, the birds were divided randomly into four squads of 10 each. At 12 days of age, the chicks were given 3 days² of habituation training following the procedure used in Experiment I. On the day after the last habituation trial, the subjects received a 2-sec, 3.0-mA shock of the appropriate type (ac, pulsating dc, continuous dc, or no shock), depending upon random treatment designation. Following shock termination, the birds were immediately restrained for 15 sec.

Results

The effect of different types of electric shock on both duration of immobility and number of inductions is presented in Table 2. A $\log_{10}$ transformation was performed on the raw scores. Analysis of variance showed shock type to be

Table 2
Means and Standard Deviations of Immobility Duration (Seconds) and Number of Inductions Needed to Elicit Immobility as a Function of Different Types of Electric Shock

Shock Type	Duration of Immobility		Number of Inductions	
	Mean	SD	Mean	SD
Control	56.61	86.41	1.70	1.49
Continuous dc	162.67	180.41	1.50	1.27
Pulsating dc	513.21	530.73	1.00	.00
ac	329.21	172.01	1.40	.52

significant, $F(3,32) = 6.18$, $p < .002$. A Duncan's multiple range test indicated that both ac shock and pulsating dc shock potentiated the duration of immobility significantly ($p < .05$) compared to the no-shock control group. There were no other group differences. Also, analysis of variance on the number of inductions needed to produce immobility showed no significant effects.

EXPERIMENT IV

This study was designed to investigate the effects of different durations of ac shock on immobility.

Method

Forty Production Red chickens (*Gallus gallus*) were purchased, maintained, and handled as in Experiment III. Except for the test condition, the procedure followed was identical to that in Experiment II.

On the day after the last habituation trial, the subjects received a 3.5-mA ac shock of .25, 1.0, 2.0, 5.0, or 10.0 sec duration, depending upon random treatment designation. Eight birds were tested at each of the different shock durations.

Results

The effect of ac shock duration on immobility time is depicted in Figure 2; generally, birds receiving the same shock intensity for longer durations remained immobile for longer periods of time. Analysis of variance computed on the transformed ($\log_{10}$) duration data yielded a significant main effect, $F(4,30) = 4.79$, $p < .004$. Duncan's test showed that the .25-sec shock produced shorter durations of immobility compared to both the 5.0- and 10.0-sec conditions ($p < .05$). The 1.0-sec shock condition produced significantly shorter reactions than the 10-sec condition, and the 5- and 10-sec shocks resulted in longer immobility periods than the 2.0-sec condition.

Analysis of variance computed on the induction data showed no significant effects.

DISCUSSION

Experiment I failed to reveal any tendency for fear to incubate with time since shock, as suggested by Denny and Ditchman (1962) in their explanation of the "Kamin effect." Rather, the effects of shock on tonic immobility remain pronounced at least until 15 min

Figure 2. Duration of immobility as a function of the duration of both ac shock (Experiment IV) and continuous dc shock (Experiment II).

after the receipt of shock, and only then become attenuated with longer delays.

The effect of shock duration on immobility appears to be a function of the type of shock used. A U-shaped function relating durations of continuous dc shock and duration of immobility was found in Experiment II; Experiment IV showed that a more monotonic function holds for varying durations of ac shock. Since the aversiveness of a given intensity of dc stimulation is primarily due to its onset and offset, the dc duration data could be viewed as resulting from the delay of two transients: with longer delays (longer shock duration), there is less recruitment; consequently, the less aversive shock results in shorter immobility duration times. With 5- and 10-sec dc shock durations, the duration of immobility increased, suggesting that these shock durations were more aversive than the 2-sec dc shock. This could be due to a breakdown in subject resistance at such long durations, resulting in increasingly intense stimulation. Consistent with this interpretation, the more linear-like ac function is probably due to the fact that for a given current intensity ac shock provides for many repetitive shock onsets and offsets.

Although the differences in Experiment II between the effects of ac and pulsating dc shock compared to continuous dc shock were not statistically significant, the data lend support to the notion that, for a given shock intensity, pulsating shock (dc or normal cycling ac) tends to be more aversive than continuous shock.

Taken together, the results of all four experiments show that different dimensions of electric shock can have substantial effects on tonic immobility, and in the light of previous research (e.g., Gallup et al. 1970a, b) implicate immobility duration as a sensitive index of shock. However, number of inductions proved to be less reliably related to different parameters of shock.

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NOTES

1. This experiment has been included to provide information for researchers in this area who use continuous dc shock. Since dc stimulation is mainly effective at onset and offset, with longer shock durations subjects might receive unpredictable stimulation due to either poor electrode contact or to changes in subject resistance as a result of moving about. However, such unpredictable stimulation in the present study was reduced, since while being shocked the birds were restricted from moving about, and electrode contact was maximized by wrapping the legs with bare shock leads.

2. Unpublished data from our laboratory has shown that 3 habituation training days are as effective as 4.

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