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Reduction of General Activity in Male Albino Rats from Electro-Convulsive Shock.

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The use of electro-convulsive shock for the treatment of functional psychoses and certain other abnormal mental states is now widespread. Although its use appears to be well justified on clinical grounds, there is no wholly satisfactory explanation of the physiological changes through which the benefits are effected.[1] It seems probable, therefore, that many types of animal experiments will be needed to supplement human investigations in defining and, ultimately, explaining both the immediate and distant effects of electro-convulsive shock, at the psychobiological level.

Many investigators have noted a reduction in exploratory activity and rate of locomotion of rats in various learning situations, following the administration of electro-convulsive shock. Some of these reports are still unpublished;[2,3] others are summarized by Stainbrook in his recent review.[4] Consideration of these data led Stone[5] to conduct a small-scale study of the effects of electro-convulsive shock on the daily voluntary activity of 6 female rats, housed in the Slonaker-type of activity drum. He found consistent, temporary reductions of activity after shock. The present report is a continuation of this earlier study. Its main objective is to gather confirmatory data from which to make a more reliable estimate of the concurrent effects of electro-convulsive shock on the voluntary activity of male rats than was possible in the preliminary study on females.

Procedure. The convulsive shock was given by applying a 50 milliamperes, alternating current for 0.2 second through electrodes clipped on the ears of the rat. This consistently resulted in a grand mal seizure which started with a generalized tonic contraction of the entire body and then gradually passed into the clonic phase after about 10 seconds. The total period of the seizure proper was between 20 and 30 seconds. In the main, the typical syndrome and its most common variants were like those described in some detail by Golub and Morgan.[6]

The study began with 15 well-tamed males, approximately 70 days old. No shock was administered during the first 25 days of the study as it was desired that the animals become thoroughly adapted to their drums and the routine of handling before the introduction of shocks. From the first day and thereafter each animal was removed from its drum once daily and manipulated as much as would be necessary later on when shocks were to be administered. While the rat was out of the drum the experimenter replenished the supply of food and water, so that a surplus of these was available at all times. As a regular routine each rat was returned to the floor of the drum, ready for activity, whether or not he had been shocked.

Following the 25-day period, in which each rat tended to establish a characteristic level of daily activity, the first electro-convulsive shock was given. One seizure was induced daily in each rat on 5 consecutive days. This course was followed by a 5-day period in which no shock was given. Then followed (1) 2 additional 5-day periods of shock, alternating with 5-day periods of no shock, (2) one 5-day period of pseudo-shock, in which all manipulations except passage of the current occurred, and (3) a 20-day recovery period without

1 Kalinowsky, L. B., and Hoch, P. H., *Shock Treatments and Other Somatic Procedures in Psychiatry*, New York, Grune & Stratton, 1946.

2 Horowitz, M. W., and Stone, C. P., *J. Comp. Psychol.*, 1946, in press.

3 Stone, C. P., and Poplin, Betty, *J. Comp. Psychol.*, 1946, in press.

4 Stainbrook, E., *Psychol. Bull.*, 1946, **43**, 21.

5 Stone, C. P., PROC. SOC. EXP. BIOL. AND MED., 1946, **61**, 150.

6 Golub, L. M., and Morgan, C. T., *J. Comp. Psychol.*, 1945, **38**, 239.

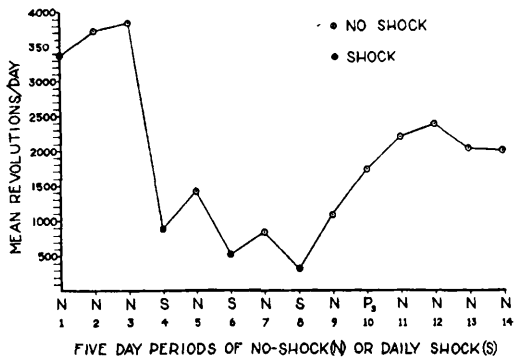

FIG. 1.
Activity of 13 male albino rats in revolving drums, based on the means for 5-day periods. In periods 4, 6, and 8 the rats received a daily electro-convulsive shock.

shock or pseudo-shock. Altogether there were 15 convulsive seizures, spread over a period of 25 days. Two of the rats were eliminated during the experiment. One died, we believe, from a disturbance of the respiratory mechanism. The other became paralyzed in the posterior third of the body, possibly, (but not certainly) from a spinal injury incurred at the time of shock.

Results. The records for the first 10 days of preliminary running were discarded because of the excessive variability of individuals while becoming adapted to the procedures. As shown in Fig. 1, 5-day periods have been numbered serially from 1 to 14. For each period the mean number of drum revolutions per rat per day has been calculated. The significances of differences between group means for the 5-day periods were calculated by use of the conventional small sample technic.

The mean level of activity during the first shock period (number 4) is significantly lower than that of the preshock periods 1, 2 and 3 ($P<0.01$). The same is true of shock periods 6 and 8. The mean of shock period 6 is significantly lower than the mean for no-shock period 5 ($P<0.01$); and the mean of shock period 8 is significantly lower than the means of no-shock periods 5 and 7. Thus, it is clear that the voluntary activity of the group is significantly reduced by 5 daily electro-convulsive shocks whether one considers the level of preshock activity or the levels reached in the intervening no-shock periods.

From period 4 to 8 there is a cumulative downward trend. Its consistency suggests that we have here a real cumulative effect, although the statistical significance of successive differences is less clear-cut than those referred to above (for the differences between periods 4 and 6, $P<0.05$; for periods 6 and 8, $P<0.10$; and for periods 4 and 8, $P<0.02$). In this experiment no rat was consistently hyperactive upon being returned to the drum after being shocked. Indeed, there was much less running on the part of all during the next 6 to 10 hours than had characterized their behavior at comparable times in the preshock period.

The period of pseudo-shock (number 10) is noteworthy because it is attended by a rise rather than a drop in activity. This would seem to indicate that the period was a constituent part of the course of recovery and that the convulsive shock was the essential cause of reduced activity during the periods of shock.

For the last 4 periods of no-shock the mean level of activity is fairly consistent, but lower than that of the preshock periods. Although a few rats were notably hyperactive, more of them were hypoactive, as compared with their preshock records. The net effect is a reduction of the combined mean value for periods 11, 12, 13 and 14 as compared with that of preshock periods 1, 2 and 3 ($P<0.05$). Possibly full recovery of some of the animals had not yet been achieved at the termination of our experiment, 30 days after the last shock. However, we are not warranted in drawing this conclusion without further appraisal of the natural reduction in activity of male rats during the 5th month of age. According to Richter,[7] the mean begins to decline between the 3rd and 4th month. If this should hold for our animals also, it is possible that a part or all of the drop in means for periods 11 to 14, as compared with periods 1 to 3, is due to the natural age decline in drum activity.

Finally, a word of caution should be urged against hasty assumption that specific factors accounting for reduction in drum activity, as

[7] Richter, C. P., *Comp. Psychol. Monog.*, 1922, **1**, pp. 55.

herein described, and the curtailment of exploration and increase of time scores as reported by others[4] are identical in kind. The literature is replete with examples showing that one and the same end-result in terms of reduction of level of activity may be the consequence of many diverse factors. Through factor analysis, van Steenberg[8] found that only a small fraction of the reliability of drum scores can be accounted for by a factor which is common to these and to other performances in mazes, problem boxes, and other tests. Thus, further analyses are needed before one may safely assume that the partial inactivation of rats in the activity drum is effected by the same factors as those which interfere with the exploratory tendency and the increase in time scores on learning tasks.

Summary. A series of daily electro-convulsive shocks in 13 male rats, for 5-day periods, significantly reduced concurrent activity as compared with (1) preshock activity, (2) 5-day periods of no-shock, interposed between periods of shock, and (3) the post-shock recovery period. There is a cumulative effect of successive periods of shock. The mean level of activity reached during the post-shock period of 30 days was significantly lower than that of the preshock period. Whether this difference was due to natural decline of activity with age or to lingering effects of electro-convulsive shock was not determined.

[8] van Steenberg, N. J. F., *Psychometrika*, 1939, **4**, 179.

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A Second Motor Nerve System to Frog Skeletal Muscle.

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The existence in skeletal muscle of special tonus mechanisms—particular nerve or muscle fibres or contractile elements—has often been proposed and as often been discarded. Tasaki and Mizutani[1] recently reported that stimulation of small diameter nerve fibres could initiate slow contractions in frog muscles. It appears that no electrical investigation of this problem has yet been made, nor have the structures giving slow contractions been identified. The present investigation following Tasaki and Mizutani's study clearly demonstrates a separate neuromuscular system which may well be involved in tonus and contracture and which has been missed because of the much greater action of the well-known twitch system. This latter has been eliminated (a) by progressive pressure block or galvanic block applied to the frog's sciatic below the point of stimulation following Leksell[2] (the large fibres failing sooner) and then observing various leg muscles, or (b) by cutting all but the desired fibre[1] in a small nerve (about 10 fibres) to an isolated toe muscle (extensor longus digiti IV., 15 mm long, 40 to 60 fibres) observed under the microscope.

As compared with the usual motor nerve fibres, those here active are of smaller diameter, higher threshold, greater resistance to pressure or polarization block and slower conduction. They are probably not autonomic, since they may be larger than 5 micra. A single impulse in one evokes a barely visible movement of an attached small muscle, repeated impulses at 3 to 4 a second give a small local shortening and at 20 to 50 a strong slow local contraction appears and in some preparations an occasional fully-propagated

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[1] Tasaki, I., and Mizutani, K., *Jap. J. Med. Sciences*, 1944, **10**, 237.

[2] Leksell, L., *Acta Physiol. Scand.*, 1945, **10**, suppl. 31, 84.