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Effects of Insulin Shock on Behavior and Conditioned Reflex Action in the Well Trained Sheep.*

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Insulin shock has radically, and perhaps permanently, altered the behavior of a sheep whose conditioned reflexes and general behavior have been studied for 7 years. During the year preceding the insulin experiment the conditioned motor reflex had gradually failed (Fig. 1-A) although the sheep remained quiet and alert during the 20-minute test period. The sheep was started on 10 units of insulin and the daily dose was increased by 10 to 15 units until coma and convulsions occurred. First signs of coma were observed at 160 units but dosage was carried to 280 units in an effort to secure typical shock phenomena. Convulsions were induced on 7 successive days.

No discrepancies in the results as given below for a typical day were observed. Insulin is given to the fasting sheep at 9 A. M.; in 5 hours it is standing with head drooping, lips twitching, and must be carried into the testing laboratory. It is placed upon the observation platform with great difficulty. When in the testing frame the sheep is induced to stand but soon slowly sinks. After a few minutes it rises and stands for a few minutes, then sinks again. When standing, the head gradually droops, the eyelids close; then suddenly the head is raised and the eyes are opened. This sequence is repeated many times throughout the first part of the observation period.

At this time the heart rate is normal or below normal (80-60); breathing is labored and noisy. The animal is now tested. It not only shows no conditioned motor (defensive) reflex but fails to respond to any outside stimulus. In an effort to show what is happening to the animal at all times, the conditioning test (sound of buzzer for 10 seconds followed by shock to the left foreleg) is repeated at the usual 5-minute intervals in the coma, the recovery period, and for some time after. After about an hour of fairly

* The expenses of this investigation were defrayed in part by a grant from the Josiah Macy, Jr., Foundation.

severe convulsions glucose is administered by mouth. In about 30-40 minutes the animal becomes more alert. It stands, eyes open, head no longer drooping, and repeated head movements are seen. At this time the sheep shows evidence of beginning hyperexcitability.

In the intervals between conditioning tests the sheep which for-

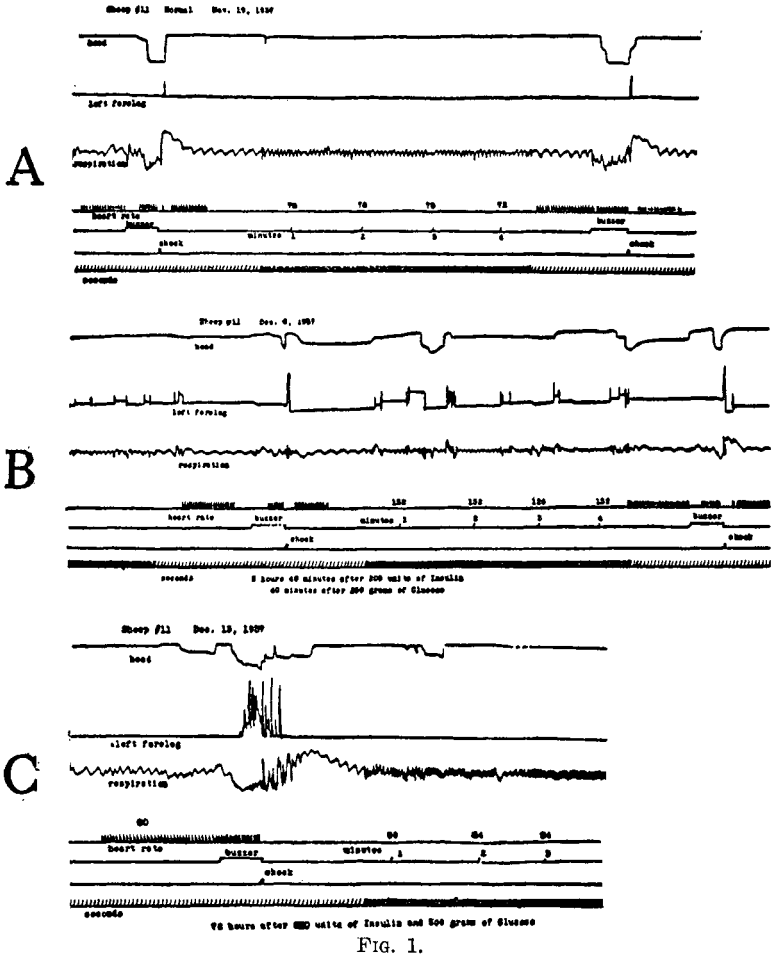

FIG. 1.

In each record, reading from top to bottom: head movement, foreleg movement, respiration, heart rate, signal, shock, time in seconds.

A. A graphic record of the behavior of a normal sheep. Note the absence of the conditioned foreleg movement to the buzzer. The animal is perfectly quiet in the interval between the two buzzer tests.

B. A record of the behavioral reactions of the same animal a short time after insulin shock. Note that the animal shows frequent restless movements in the interval between the two conditioned stimuli. Contrast this record with that of A.

C. A record of the behavior of this animal 3 days after the series of insulin shocks. Note the extreme vigor of the conditioned reflex elicited by the buzzer (conditioned) stimulation.

merly stood without movement now exhibits spontaneous flexion movements of the reaction leg (left foreleg). These occur with great frequency and are accompanied by an increase in respiration and pulse rate as observed in experimental neurosis (Fig. 1-B). The defensive reaction of the limb to shock (in abeyance during coma) shortly manifests itself.

About an hour after the glucose administration, signs of overactivity are still quite evident. The *conditioned reflex which has been almost entirely absent for one year now reappears with abnormal vigor.* The *interval leg movements* decrease in frequency as the tests continue and the amplitude of the conditioned movements (*i. e.,* during buzzer signal) increases as they decrease (Fig. 1-C). At about 5 P. M. the sheep is returned to its pen and fed. Pulse and respiration are approximately normal.

In the recovery period from each of the 7 insulin shocks the movements of the reaction limb (left foreleg) in the rest intervals between signals appeared for the first time in the history of this animal and occurred at times with a frequency as high as 6 per minute. Such movements have been observed only in animals exhibiting experimental neurosis. On each occasion the number of such movements gradually decreased and as this occurred the conditioned reflex reappeared. The latter at times attained a value as high as 420 mm as determined by Fick's work adder. Such a conditioned reaction was by far the most vigorous one the sheep had ever given. In the tests made during the period from the last insulin dose on December 12th to the present, March 5th (2½ months) the conditioned responses showed an average magnitude of 185 mm which notably exceeds the average figure for 6 years preceding the experiment (150 mm) and is more than 4 times as great as during the immediately preceding year (39 mm). At present the interval leg movements appear but rarely.