IV. SOME PHYSIOLOGICAL CONSEQUENCES OF FRUSTRATION

QUIN F. CURTIS Ohio State University

It was Pavlov¹ who first recognized that persistent abnormalities of behavior could be produced in animals as a consequence of a controlled laboratory procedure. One of the experiments of his laboratory in particular has been frequently quoted and has determined the direction of much which has been done since. A dog was trained by the conditioned reflex method to discriminate between different visual patterns; the presentation of a circle of light was always followed by food, while the appearance of an ellipse whose axes bore the ratio of 2:1 was never so rewarded. To the dog, the circle soon became a conditioned stimulus to salivation, while the ellipse acquired the negative property of inhibiting salivation.

When the ellipse was caused to become more and more nearly circular, the dog continued to make perfect discriminations until the ratio of the axes had become 8:9. Now after several weeks of imperfect discrimination of the two, the dog's behavior suffered a sudden change. The differentiation of circle from ellipse broke down completely, and he became negative to all stimuli. As training continued, this negative behavior passed over into continual excitement, so that the dog, which had formerly stood quietly on his bench, now was constantly struggling and howling. Careful retraining on the easier discriminations of circle from ellipse required more time than had the original training on the same problem. When the difficult differentiation was again attempted, the animal quickly broke down as before, and training had to be abandoned.

The theory of cortical action by which Pavlov accounts for the enduring disturbance engendered by this experiment does not concern us, but simply the fact that some features of this experimental technique of frustration strained the dog's nervous system to the breaking point.

¹I. P. Pavlov, Lectures on conditioned reflexes (New York, 1928).

In the extensive researches of Liddell and his associates upon the conditioned behavior of sheep and swine, the features of Pavlov's method which are productive of nervous strain have been further delimited. The general method is similar to Pavlov's: the animal is induced to submit to the restriction of a harness which limits his freedom of locomotion, and to remain alert and quiet except when responding to stimulation. The response utilized with the sheep is a delayed motor reflex based on application of a mild electric shock to the foreleg. In the trained normal sheep, this stimulus evokes a brisk flexion of the leg, but no tantrum or observable "emotional" behavior.

Some of the factors which Anderson and Liddell² have shown are likely to damage the nervous system in the sheep are:

1. The necessity of inhibiting or restraining a conditioned response beyond the animal's capacity to do so. This has been accomplished in two ways. (1) A conditioned reflex with a moderate delay of 5 seconds between onset of the signal and application of the shock may be elicited too frequently or with insufficient rest interval between tests. (2) An excessively long delay (30 seconds) between onset of signal and application of shock may be required, straining the capacity of the sheep to withhold response.

2. Confusion of positive and negative stimuli. For example, a positive reaction to a metronome beating at 120 ticks a minute was well established; then a series of slower rates (50, 60, 72, 84, 92) were made negative by presenting them without the shock. After these differentiations were established, a special daily test presented the whole gamut of rates in turn, the positive rate (120) being interposed between each of the negatives. After a few weeks of this procedure, the animal gradually became negative to all rates. When the positive rate alone was presented for a few weeks, the positive response returned in exaggeratd form, and was extended to all the negative rates, even those which had formerly been easiest to discriminate. Several factors were probably operating here: (1) the animal was required to make delicate auditory discriminations, and (2) the number of successive discriminations and the total time consumed in the daily tests may have been excessive.

3. Alternation of excitation and inhibition. An attempt was made to establish in the sheep a rhythmic alternation between excitation and inhibition—action and restraint. The sheep was pre-

² O. D. Anderson and H. S. Liddell, Observations on experimental neurosis in sheep, Arch. Neurol. & Psychiat., 1935, 34, 330-354.

sented at 7-minute intervals with alternate auditory stimuli (pure tones) one of which was reinforced by shock, the other not. Unfortunately, as the animal always responded positively to both tones, there was never any evidence that he could discriminate between them. Neurotic behavior began to appear within a few weeks. After a rest, he was trained to react to a buzzer followed by shock, with rest intervals of 7 minutes. The neurosis remained unchanged. Anderson and Liddell believe that the regular temporal alternation of positive and negative stimuli places heavy strain on the animal's nervous system.

The interesting fact for our purposes is that whatever the means of inducing the neurosis, the manifestations of it are remarkably constant. These manifestations may be characterized in at least three ways: (1) The behavior changes, in the sheep at least, are permanent, enduring for the life of the individual. (2) They are new, and do not except superficially resemble a regression to an earlier habit-pattern. (3) They involve not only the animal's overt adjustments to the environment, i.e., his response to a conditioned signal, but many of his homeostatic physiological relationships such as the speed and regularity of the pulse and of respiration.

The gross changes which occur in the behavior of the sheep in the laboratory situation have been described earlier.³ The sheep, previously co-operative, becomes refractory and resists being taken to the laboratory and harnessed in the Pavlov frame. The breakdown is usually initiated by an inhibitory phase, in which conditioned responses are for a time suppressed. If training is continued, the animal passes over into an excitable phase, where conditioned reflexes are more violent than normal, and positive responses are given to stimuli that were formerly negative, discrimination between stimuli having completely broken down. During the interval of several minutes between stimulations, the animal cannot maintain its former state of alert quiet, but exhibits at frequent and irregular intervals spontaneous tic-like movements of the reaction limb which Anderson compares to the fidgeting of a nervous child. This is probably the most characteristic overt manifestation of the neurosis in the sheep.

There are also significant and enduring differences in the relatively intrinsic functions of respiration and heart action. The

⁸ Anderson and Liddell, op. cit.; ^{(H.} S. Liddell, W. T. James and O. D. Anderson, The comparative physiology of the conditioned motor reflex, Compar. Psychol. Monog., 1934, 11, No. 1.

respiration of the neurotic sheep as compared to the normal is irregular, rapid, and may be punctuated by gasps or breath-holding.⁴ Of five pigs studied,⁵ one which developed a sleep-like state of complete inhibition for a time exhibited during this period a characteristic "bumpy" form of respiration which could be used to identify this animal's records. Sutherland and Wolfe, and others, have pointed out that the spirograms of neurotic patients show peculiarities which serve to "fingerprint" the individual.

Differences between normal and neurotic animals may be demonstrated during the barn and field life of the pig or sheep as well as in the laboratory situation. The diurnal activity cycle of normal and neurotic sheep was studied by recording the 24-hour gross activity upon scale platforms. Records show that the activity of the normal sheep is greatest during the day, rising to a peak at feeding time, but ceasing almost completely for an hour or so at a stretch during the night. The neurotic animal's record, on the other hand, shows bursts of activity spaced a few minutes apart during most of the day and night. It is as though the day's total store of energy was frittered away in over-responding to an endless succession of slight stimuli. This is reminiscent of the already mentioned inability of the neurotic sheep to inhibit or reserve his defensive leg reactions until the significant time for action arrives.

A 24-hour sampling of the pulse rate also shows a distinction between the normal and neurotic sheep. The neurotic heart exhibits greater variability of rate, both day and night, than the normal.

Some evidence that the behavior traits of the neurotic sheep make a clinical entity is to be inferred from their constancy in the cases observed, and from the action of drugs. Liddell, Anderson, Kotyuka, and Hartman⁶ showed that subcutaneous injections of adrenalin had the effect of depressing the conditioned leg flexions in anticipation of the shock, while increasing the sheep's irritability during the rest interval, as measured by the spontaneous movements of the reaction limb. Extract of adrenal cortex, on the other hand. had the reverse effect, quieting the sheep during the rest interval and increasing the vigor of the conditioned response to the signal.

⁴ Anderson and Liddell, op. cit., p. 17. ⁵ Q. F. Curtis, The experimental neurosis in the pig, reported at Minneapolis meeting of American Psychological Association, 1937; G. F. Sutherland, Experi-mental neurosis in swine, reported at International Physiological Congress, Zurich, 1938. ⁶ H. S. Liddell, O. D. Anderson, E. Kotyuka and F. A. Hartman, Effect of extract of adrenal cortex on experimental neurosis in sheep, Arch. Neurol. & Psychiat., 1935, 34, 973.

Its effect in this respect was to make the neurotic sheep resemble the normal.

A type of behavior seen in the conditioned response situation which seems to me to bear on the nature of conflict is what I should call the dissociated activity of reaction systems. It has been pointed out by Pavlov and others that the conditioned response can only artificially be considered a unitary segment of behavior. The conditioned behavior of the dog toward a food stimulus, for example, is a complex of which the behavior of the salivary gland is a very small part, selected for analysis because its behavior is so simple; it can only secrete or fail to secrete. But the dog's total behavior also includes such items as orienting movements of the head and body, changes of galvanic skin resistance, approach to the food, snapping and eating, gastric flow, and appropriate adjustments of cardiac and respiratory activity.

These segments of behavior have the appearance of an integrated, mutually dependent whole when the mature conditioned response is examined. The entire animal seems to be co-ordinated toward one end or "purpose." But when the conditioned reaction is in process of formation or is being disrupted by extinction or inhibition, the picture of integration is not so complete. In the formation of the conditioned response, the individual reflexes appear in order, and in extinction, disappear roughly in reverse order.⁷ Moreover, when the conditioned response is disrupted, as by the inhibiting agents of a "conflict" situation, there may be a splitting or *dissociation* of these behavior segments into elements which may even work at cross-purposes to one another. For example, a dog may salivate at the presentation of a signal meaning food, but fail to make the motor response which would bring his head to the food dish.

In a paper reported before this group last fall, I described how a pig, faced with a conflict situation (i.e., approach or withdrawal from the apple-box) would, at a certain stage of training preceding the breakdown, execute a part of both responses, figuratively tearing himself apart in the middle.

I consider it possible that the "conflict" here may consist in the dissociation from a larger pattern of part-reactions which are evoked simultaneously by an equivocal stimulus. May not a more adequate sampling of the many processes of the body reveal deepseated disharmonies fundamental to an experimental understanding of the conflict problem?

⁷ Liddell, James, and Anderson, op. cit.

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