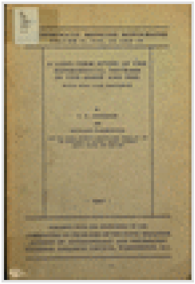

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VOLUME II, NOS. III AND IV

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WITH NINE CASE HISTORIES

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A LONG-TERM STUDY OF THE EXPERIMENTAL NEUROSIS IN THE SHEEP AND DOG

WITH NINE CASE HISTORIES

BY

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AND

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FOREWORD

THE AUTHORS wish here to express their great debt of gratitude to H. S. Liddell, their teacher, co-worker and friend over many years. They wish to extend their thanks to him for many "hunches" about experiments given them during informal conversations in the laboratory, for his keen and critical analysis of the present work as it progressed, and for an equally careful criticism of the exposition of this report. Perhaps the greatest aid of all has been his constant encouragement of the experimenters themselves throughout long, and sometimes completely puzzling experiments—a form of aid far more difficult to describe in words.

The Cornell Behavior Farm has afforded us not only the use of its excellent physical facilities but also the advantages to be derived from an interchange of ideas with various members of the staff of investigators working there, people representing diverse points of view and training but through whose work runs a central idea, namely, an interest in understanding some of the factors which lie at the basis of human and animal behavior. Among this group of workers we are especially appreciative of the helpful information and advice of our medical colleagues, Dr. G. F. Sutherland and Dr. J. A. Rose, on clinical matters relating to the psychoneuroses.

We wish also to express our gratitude to Dr. Norman S. Moore, Professor of Clinical Medicine at Cornell University, for his continued interest and cooperation in this work, and especially for his interpretation of the electrocardiograms taken in sheep with experimental neurosis.

The expenses of the investigation at the Cornell Behavior Farm were in part defrayed by generous grants from the Sage Research Fund and the Heckscher Research Fund of Cornell University. Further substantial grants were made to H. S. Liddell by the Rockefeller Foundation and the Josiah Macy, Jr., Foundation.

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I. INTRODUCTION

IT IS THE design of the present report to present new material on the experimental neurosis in the sheep and dog which has come to light during the course of long-term investigations of behavior by means of the conditioned reflex method.[1]

The description of the experimental neurosis in the dog, first observed by Pavlov and his associates (*21*) about 1913, is classic, and therefore needs little comment. In conditioned reflex experiments, involving the salivary (food taking) reflex, the dogs were at times called upon to "solve" problems, *e.g.*, to distinguish between one stimulus and another, the one type of signal being reinforced by food, the other type not reinforced. The problems were often beyond the animals' ability to achieve. In such circumstances abnormalities of behavior were noted. Certain animals became markedly excited, while others showed a state of profound inhibition. The disorder was long enduring. It was temporarily improved by rest and by sedative drugs.

Gantt (*9*), continuing and extending the work of Pavlov, has studied a number of cases of "neurotic" behavior in the dog from several aspects. "Conflicts" were produced by the animals' attempts to achieve difficult differentiations of conditioned signals for food. The symptom-complex, involving several physiological systems, was characterized by "defense-reactions—negativism, refusal of food, whining, barking, agitated movements, increased respiration, raucous, forced breathing, frequent uncontrolled micturition, sexual erections." The sexual aspects were specially studied. The disturbance was found to have a marked and constant effect upon the "latent period, duration and type of induced erections and ejaculations; a condition resembling premature ejaculation resulted."

Dworkin (*7*, *8*), has also studied several cases of the disorder in dogs and has paid special attention to its "inhibitory" form. This investigator found a definite improvement in the symptomatology following the administration of sedative drugs. It was interesting that a profound state of inhibition could be supplanted by one of excitation following the drug therapy.

[1] The work upon the sheep was done at the Cornell University Behavior Farm, Ithaca, N.Y., while that upon the dog was carried out in the Department of Anatomy of the Cornell University Medical College, New York City, and at the Cornell Anatomy Farm, Peekskill, N.Y. The cases of experimental neurosis in the dog, reported here, were observed during the course of conditioned reflex experiments of the senior author (O.D.A.) (*4*) associated with the work of Charles R. Stockard upon the genetic and endocrine basis of morphological and behavioral types in the dog.

It is our intention to present here three cases of the experimental neurosis in the dog in order further to elaborate its diverse manifestations. One of the cases presents a previously undescribed manifestation, namely, marked rigidity of the limbs suggestive of decerebrate rigidity.

Although our observations upon the dog have not previously been reported, descriptions of the experimental neurosis in the sheep have, from time to time, come from the laboratories of the Cornell Behavior Farm. The condition was first observed and described in sheep by Liddell and Bayne in 1927 (*16*). Anderson and Liddell (*1*) in 1935 further described its symptoms in sheep and presented case histories which traced its origin and temporal course. Liddell, Anderson, Kotyuka and Hartman (*17*) in 1935 reported upon the effect of extract of the adrenal cortex upon the neurotic behavior. And Anderson, Parmenter and Liddell (*2*) in 1939 described certain cardiovascular manifestations of the disorder.

Six cases of the experimental neurosis in the sheep are here presented. In our analysis of these we shall present hitherto undescribed signs of the disorder in these animals and shall describe new circumstances and procedures which produce and maintain the disturbance, together with certain therapeutic measures which have been taken. The case of a sheep which remained entirely normal under strain is included for comparison with the "neurotics."

The present investigation extends over a period of 12 years. The behavior of the sheep has been studied almost continuously throughout that period; that of the dog has been studied for 4 years. The continuity of the work was essential in order to obtain a case history as complete as possible in each animal with experimental neurosis. And continuity of the more extensive work upon the sheep was achieved by the fact that the two authors have worked at times together and at other times in alternation. Thus, when one of us (O.D.A.), who began the observations presented in this report in 1928, went to New York City in 1932, the other (R.P.), after an interval, continued the work with the sheep at Ithaca. From 1936 to the present writing the authors have worked together on this animal. They have pooled their results of the investigation of the sheep in order to present a temporally continuous picture of the experimental disorder in the animal over the 12 year period. The work upon the dog, extending from 1932 to 1936, was uninterrupted.

In the case of the sheep the observations naturally covered the entire life-span of many individuals, since this is about 10 to 12 years under the best conditions of care. The study of the dogs covered only the mid-portion of their life. They were about 2-3 years old at the beginning of the experiments and were 6-7 years old at the end of the work. Their average life span is about the same as that of the sheep.

It is our intent here to compare directly the disorder in the sheep with that in the dog wherever such direct comparison is possible. Our task in doing this has been rendered easier by the fact that the two animals have been studied under almost exactly the same experimental conditions, by the same experimenter.

The sheep has long been our "standard animal" for the study of the experimental neurosis. And in this paper it will be apparent that the studies upon the sheep are preponderant. The obvious reason for this is that our work with the sheep has been far more extensive than that with the dog, the greater number of cases having been studied in the former animal than in the latter, and for the longer period of time as well.

Since the manifestations of the experimental neurosis were seen by us first in the sheep, our description of these phenomena has naturally pertained to this animal alone. Certain fairly definite symptoms have been observed and described, but the list of these has, as would be expected, been increased considerably by our detailed study of the same disorder in the dog. The dog, with perhaps a more complex neural organization than the sheep, expresses "nervousness" under the same circumstances in a somewhat different manner, and in some cases to a markedly greater degree.

In the long-term analysis of the experimental neurosis the results of the analysis attain a proper meaning when they are presented by means of case histories which cover the chief events in the life of the particular animal in much the same way that medical case histories cover those facts in the human patient's history which conceivably have a bearing upon the illness from which the individual suffers. Presentation of our material in this way provides a proper temporal perspective in which significant happenings in an animal's life may be related one to another and each event assigned its proper value in the progression of happenings which result in the overt expressions of the experimental neurosis, which maintain it over a period of years, or which contribute to its alleviation. It is only by means of such a method of viewing the animal's behavior that we can come to have any clear understanding of the causative factors of the disorder. Such a historical view of the animal is proverbial among the workers in this laboratory. Thus when an experienced investigator is shown a new "case" by a colleague he asks the inevitable questions: "Exactly what procedure have you been using with this animal; How was he behaving previously; Has the procedure been changed in recent months?"

The study of the causative factors which lie at the basis of the disorder is the essential problem of our work. Our principal interest has not been in finding a "cure" for psychoneuroses, nor has our work upon the animals, thus far, been designed to shed light upon those practical problems of the clinical psychiatrist which deal with psychological and social maladjustment in psychoneurotics. These are very important, and indeed pressing, problems, but it has seemed to us best, for the present, to center our studies upon those aspects of the behavior of the total psycho-physiological animal which can be examined by physiological instrumentation. Such an investigation, we believe, should ultimately make a contribution to the study of the psychoneuroses. It may shed light upon equally pressing problems concerned with the organic symptomatology of, for example, the anxiety neurosis, a disorder which the experimental neurosis in the sheep and dog resembles in a number of respects. However, we have no desire to belabor such a resemblance, for it should be borne in mind that this is an investigation of an experimental disorder in *animals*. Therefore our chief concern in this report is the detailed description of certain factors in the history of our animals which are helpful in the analysis of the experimental disorder.

Our concept of animal behavior is extremely broad. In any investigation of the "behavior of the animal as a whole" this is clearly a necessity. In this view many and various behavioral items must be taken into consideration, since many physiological systems are involved in the experimental neurosis. We have accordingly studied certain reactions mainly referable to the neuromuscular system, that is, overt muscular response; certain reactions mainly referable to the autonomic nervous system, *e.g.*, the respiratory and circulatory responses; and, although the chief emphasis of the work has been placed upon the study of these types of reaction, we have not neglected to consider certain psychological states. Regarding the latter, we have always held that statements concerning such states as fear or apprehension, as applying to the animals, are clearly inferences and are nothing more. For indeed we have no precise means of knowing that an animal's state of mind is one of anxiety, although many objective signs may point to the existence of such a state. These indications or signs are remarkably clear under certain circumstances which we shall detail later, and they may be considered coordinate with the evidences of anxiety observed by the psychiatrist in certain psychoneurotic cases, namely, the patient's verbal admission and description of his feelings of anxiety, together with objective signs of the emotional state, such as rapid heart, disturbed respiration, pallor, sweating, and the like.

For convenience and for the sake of orderliness in the exposition of a somewhat diverse body of data, these data will be presented topically. The phenomena discussed under a particular heading are illustrated in detail by reference to one or more of the case histories to be found in the appendix. In a few cases, in order to make a point clear, certain details from the case histories are repeated in the text.

In the discussion we have attempted to answer certain questions regarding the general significance and implications of this work which have been raised, particularly during the past few years, by physiologists, psychologists and psychiatrists, as well as by our students.

II. MANIFESTATIONS OF THE EXPERIMENTAL NEUROSIS

1. General Considerations

Behavior was studied in both sheep and dog chiefly by means of conditioned salivary and motor (defensive) reflexes. In the sheep the conditioned motor reflex alone was used, since the use of the salivary reflexes was impracticable. The sheep almost continuously chews the cud and this causes an almost constant flow of saliva. Conditioned salivation cannot, therefore, be accurately determined. In the dog, both defensive and salivary reactions were used. Of the three dogs whose cases are reported, the conditioned motor response was employed in two and the conditioned salivary response in the third.

The conditioned salivary reflex was measured and recorded according to the classic method of Pavlov. The conditioned motor reflex was studied by a method developed at the Cornell Behavior Farm. The method has been previously described in detail (*1*). The conditioned motor reflex was elicited by various stimuli, chiefly the sound of a metronome or door buzzer which was reinforced by the application of a mild electric shock to a forelimb (the left forelimb in the sheep, the right in the dog). The overt motor response to the signal or shock consisted of defensive flexion movement or movements of this reaction leg accompanied by movements of the head and trunk.

The data which form the basis for the case histories were gathered from three sources. 1) *Kymograph tracings* of the salivary and neuromuscular reactions were taken regularly. Since changes in several physiological functions occur coincidently with these reactions, certain of them were selected as samples for study. Two of these, alterations of respiration and pulse, were recorded simultaneously with the defensive motor responses. Respiration, but not the pulse, was recorded with the salivary reactions. Reactions of other systems, *i.e.*, digestive, urinary and sexual, were noted but were not recorded graphically. In addition, tracings of spontaneous diurnal neuromuscular activity outside the laboratory were taken in the sheep. On occasion respiratory tracings were also obtained on these animals in the barn. 2) *Detailed descriptive notes* of behavior in the laboratory and in the animal quarters (barn, pasture and dog kennels) were regularly taken. These notes described particularly the overt conditioned neuromuscular activities, the general reaction of the animal to other animals, to the experiment and to the experimenter. 3) *Moving pictures and still photographs* were taken in order to illustrate both typical and atypical forms of behavior. Individual frames from the cinematographic films provided an accurate means of analyzing the reactions in detail.

Of 28 sheep studied by the authors, 7 cases of experimental neurosis were observed. Since one of these cases, that of sheep #52, has previously been reported upon in detail (2) it is not included among the present case histories, although it will be referred to in the text. Out of a total of 26 dogs, the 3 cases given here were the only ones observed.

Of the 7 cases in sheep (sheep A, D, J, #7, #8, #11, and #52) 5 cases were classed as "excitatory" (sheep A, D, #8, #11, and #52) and 2 as "inhibitory" (sheep J and #7). Of the three cases in the dog (dogs #868, #881, and #929) 2 were "excitatory" (dogs #868 and #881) and one case vacillated between the "excitatory" and "inhibitory" patterns (dog #929).

The manifestations of the nervous disturbance are remarkably similar in the sheep and dog when the animals are trained according to a similar routine. Thus, when the animal subjects are called upon to distinguish between one conditioned signal and another, the first being reinforced by a shock to the foreleg, the second not being followed by a shock (these signals being presented in alternation with exactly the same interval of time elapsing between them) the neurotic behavior which may be induced by such a procedure is as follows. Frequently hyperexcitability is manifested in both dog and sheep by restlessness, vocalization, micturition, vigorous and wild reactions of defense and offense, and a long enduring, perhaps permanent disturbance of respiration and heightening of the pulse rate. Or, on the other hand, the condition is sometimes manifested in either species by a state of deep inhibition, that is, by mildness and docility, passive stubbornness, weakening or complete disappearance of many defensive and offensive reactions, and markedly variable respiration and pulse; or there appears in some cases a gradual shift from one extreme to the other in the same animal over a period of time. The abnormal manifestations, once they have appeared, are apparently of long duration in both sheep and dog.

Although the above symptoms are in general common to both animals, certain important species differences are observed, as would be expected. These will be pointed out under topics dealing with specific symptoms.

In the sheep, our "standard" animal for the study of the experimental neurosis, the symptom-complex observed in the greater number of cases indicates a state of hyperexcitability. The chief overt manifestations of this state can perhaps best be described by reference to photographs and tracings of typical cases (sheep D and #52, figs. 1 and 2).

The photographs of fig. 1, taken from a moving picture film, show the

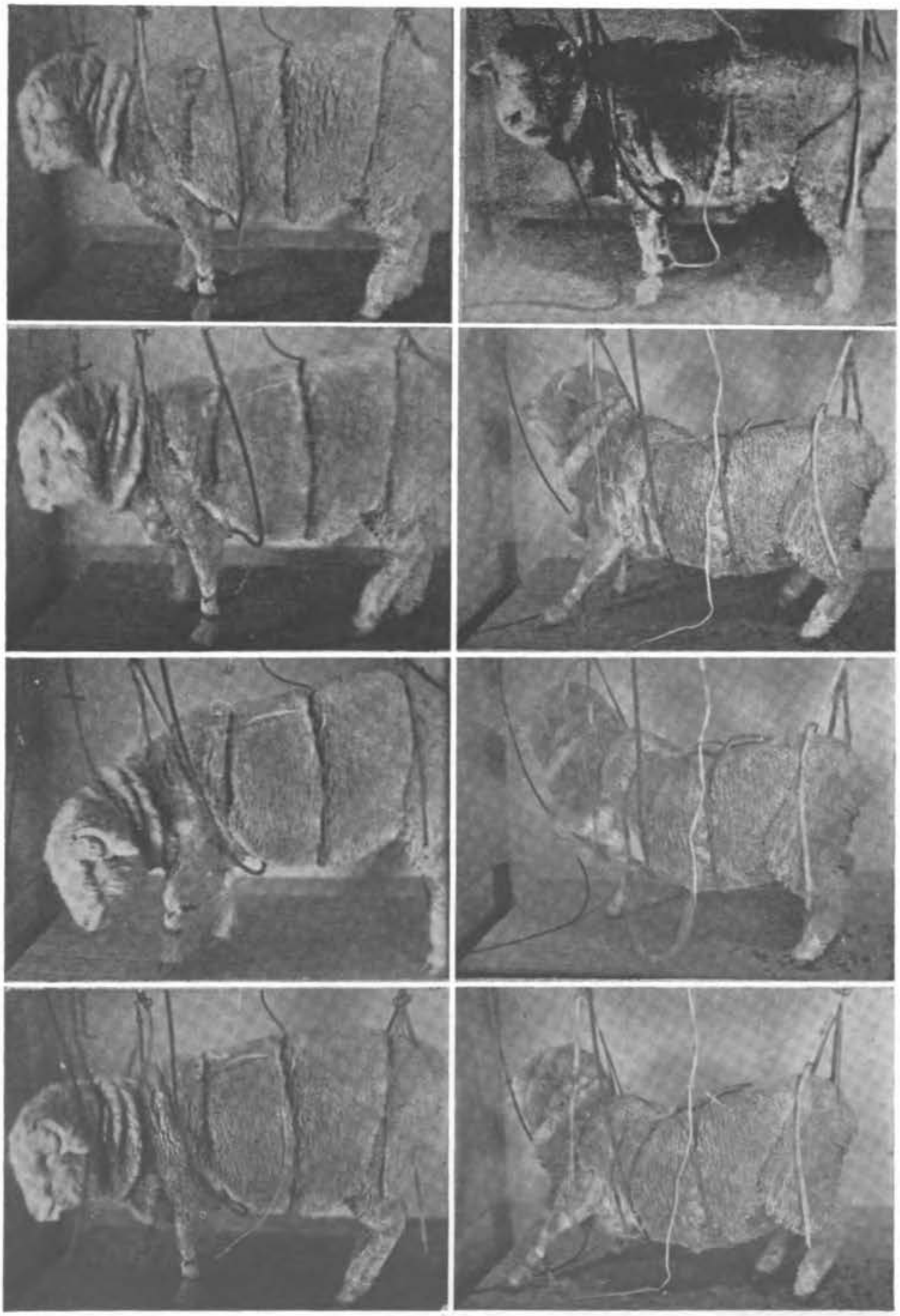


FIG. 1. Photographs showing conditioned motor reactions of a normal and an experimentally neurotic sheep. The normal animal is shown on the left, the neurotic on the right. In each case the top picture shows the animal before the presentation of the conditioned stimulus. Pictures below show the reactions to the sound of a buzzer to be followed by an electric shock to the left forelimb. Note in the normal animal the precise movement of the head and leg. Note in the nervous sheep the distorted posture and diffuse struggling reaction.

conditioned motor reflex in a normal sheep (left) as contrasted with that of a sheep with "experimental neurosis" (right). The reaction of the normal animal to the conditioned signal (buzzer followed by shock) is brisk and consists principally of precise flexion movements of the reaction leg with lowering of the head. This type of reaction, with little variation, may be seen year in and year out. The reaction of the neurotic sheep, on the other hand, is characterized by violent, diffuse struggling which involves all four legs and

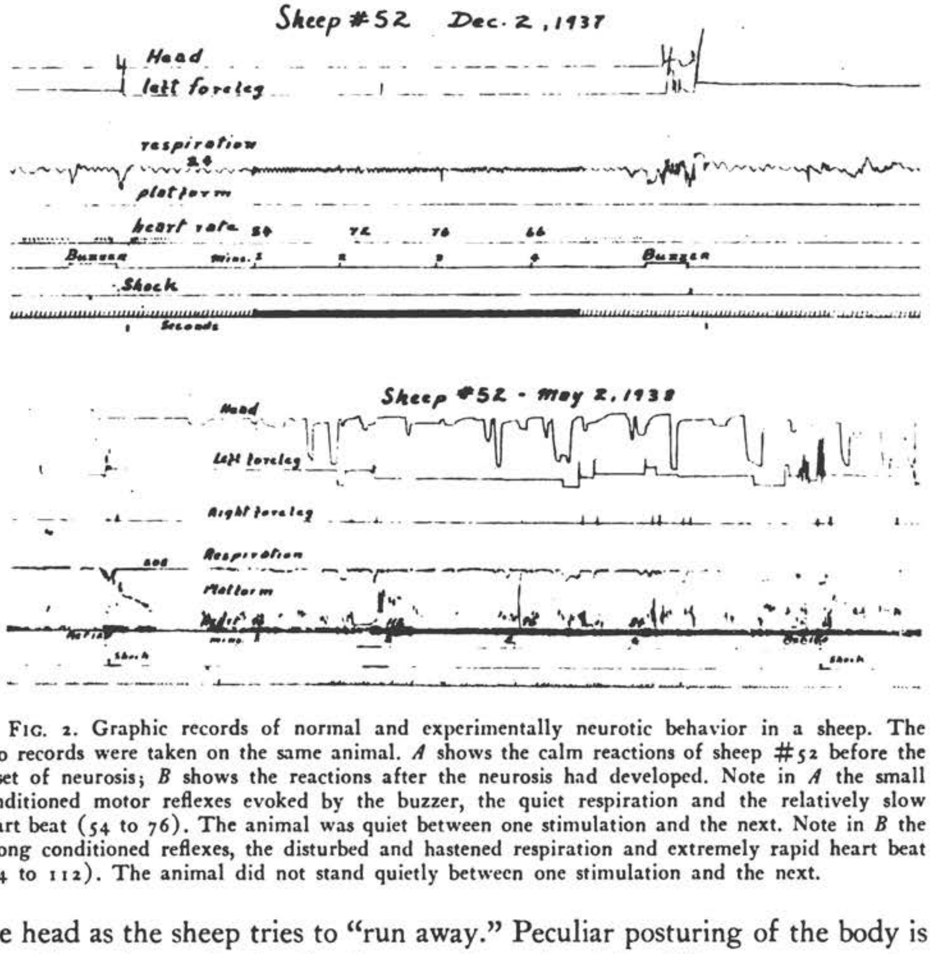


FIG. 2. Graphic records of normal and experimentally neurotic behavior in a sheep. The two records were taken on the same animal. *A* shows the calm reactions of sheep #52 before the onset of neurosis; *B* shows the reactions after the neurosis had developed. Note in *A* the small conditioned motor reflexes evoked by the buzzer, the quiet respiration and the relatively slow heart beat (54 to 76). The animal was quiet between one stimulation and the next. Note in *B* the strong conditioned reflexes, the disturbed and hastened respiration and extremely rapid heart beat (84 to 112). The animal did not stand quietly between one stimulation and the next.

the head as the sheep tries to "run away." Peculiar posturing of the body is sometimes observed as in the photographs at the right of fig. 1.

Graphic records of normal and disturbed responses are shown in fig. 2. The two records were secured from the same sheep at different periods in its life span. The upper tracing shows the reactions before the animal became neurotic; the lower tracing shows the reactions after it had developed the typical symptoms of experimental neurosis. The sheep, at the beginning of the investigation (top record), reacted precisely to the signals (buzzer) and stood quietly in the 5-minute interval between stimuli. The lower tracing of fig. 2, taken about one year later, shows the markedly disturbed behavior *after the sheep had been subjected to a schedule of stimulations given at uniform time intervals and involving a simple metronome differentiation.* Note the vigor of the conditioned reactions; the constant and violent tossing of the head; the restlessness in the interval between stimuli as shown by spontaneous movements of the reaction limb.[2] Contrast the earlier calm breathing and slow heart rate with the rapid, disturbed respiration and extremely rapid heart rate after the neurosis supervened.

2. Manifestations Referable to the Neuromuscular and Autonomic Nervous Systems

1) *Hyperirritability.* One of the most striking expressions of the experimental neurosis in sheep and dogs is the forceful neuromuscular reaction (startle response) elicited by the sudden application of light tactile stimulation or even by a sudden loud noise. This can readily be seen in sheep when they are feeding at a trough in the barn. A light touch upon the back of a normal, calm sheep seldom, if ever, causes any overt response at all, the animal continuing to eat voraciously. The same touch upon the back of a "nervous" sheep will cause it to jump quickly, back away from the food trough and dash past the observer to a remote corner of the barn.

In the nervous dogs a similar mode of behavior can be seen in the kennel run. A loud and unexpected noise frequently causes these animals suddenly to crouch, tremble and urinate or to dash quickly into the dog house. When such dogs are being led on leash from the kennels to the conditioned reflex laboratory, the slightest disturbance along the way, such as the sudden appearance of a stranger or the movement of a piece of paper stirred by the wind or a quick, scraping noise, often causes frantic struggling, sometimes accompanied by yelps as of pain and by trembling and micturition.

The sheep, when brought to the laboratory and placed in the restraining straps in preparation for an experiment, exhibits a phenomenon which has been observed so regularly that it has come to be considered a classic symptom of the experimental neurosis in this animal. When the reaction limb (the left foreleg to which the shock had been applied) is inadvertently touched, the response is immediate and vigorous flexion.

In an extremely tense sheep it is found that the lightest touch with the finger or even with a feather applied near or upon the shaved portion of the limb to which the shock electrode is customarily attached is sufficient to evoke brisk flexion. The movement ranges in intensity from a slight, almost imper-

[2] The reaction limb is the one to which the electric shock is applied in the conditioning tests.

ceptible jerk of the limb to a series of violent movements continuing after withdrawal of the stimulus (after discharge).

It is not necessary that contact be made at the spot where the shock is usually applied. An even more sensitive region appears to be the back of the hoof. The movement of a few hairs at this location often serves as a sufficient stimulus to bring out a vigorous response. This reaction is less easily evoked in body regions remote from the reaction limb. Thus stimulation of the flank or the back only occasionally elicits it, the reaction being weaker than when the leg itself is touched. The skin field, or area in which the response can be elicited, becomes more extensive when the animal is more tense and "nervous" and less extensive with less tension. Thus when motor responses are "manic" a touch upon the contralateral flank causes flexion of the reaction limb, and when the animal is fairly calm, stimulation of the limb itself does not evoke it in every case.

This sensitivity to touch is one of the first symptoms of the onset of neurosis and is one of the most persistent. It is noticed much less frequently, however, when the animal has been given a long rest from the experiment.

We have come to view this sign as one of the most sensitive indicators of the depth of the neurosis. However, we wish to emphasize the fact that this phenomenon is not observed among sheep who exhibit the inhibitory form of the neurosis. It is characteristic only of the hyperexcitable type of the disorder.

This phenomenon was clearly evident in the nervous dogs in experiments on the conditioned motor reflex. The lightest touch upon the reaction limb evoked vigorous flexion of the limb, sometimes accompanied by a yelp as of pain (case of #868, and the case of #929 during the excitatory phase of its disorder). On a few occasions a loud startling noise caused the reaction. In the case of dog #881, in which the salivary response alone was employed, light touch did not evoke defensive limb flexion. It frequently elicited a startle response accompanied by crouching, trembling and sometimes micturition.

The response of the reaction limb to touch is not seen in sheep and dogs classed as "normal."

2) *Over-reaction to stimulation.* In observing the experimentally neurotic sheep in the laboratory as well as in the barn and pasture we are continually struck with the fact that these animals over-react to stimulation. This is shown in a variety of ways. When evidence of tenseness appears, the conditioned motor reaction shows an extremely short latent period; that is, the reaction limb begins to flex almost immediately upon the onset of the signal. On many occasions we have noticed, when using the metronome at 120 beats

per minute as the positive conditioned signal, that the limb flexes at the very first beat of the metronome. From all appearances the animal seems *already set to react before it has cause for reacting;* consequently the conditioned response appears to be instantaneous.

Over-reaction is also seen in the enormous increase of the movements of flexion themselves when the animal is stimulated. In the customary 10 second period of the conditioned stimulation a normal sheep as a rule flexes the reaction limb three or four times before the shock is delivered; while a "nervous" sheep may, during the same time, flex the leg eight or ten times. In the latter case, however, each flexion is of greater vigor than in the normal animal. The total magnitude of the conditioned reflex in the disturbed animal was therefore often more than 100 per cent greater than normal.

Increase in the magnitude of the conditioned motor reflex was analysed statistically in the case of sheep #52 as the animal became more and more nervous during simple differentiation experiments (stimuli at equal intervals of time). During the first month of work the average magnitude of the reflex was 48 mm. in the 10-second periods of stimulation; during the second month it averaged 72 mm.; and during the third month it had increased to a value of 102 mm. A similar increase was observed in all of the cases in sheep in which the experimental neurosis took the excitatory form. This increase was also clearly observed in two cases of the disorder in the dog (dogs #868 and #929). The graphic records of fig. 2 show this phenomenon in sheep.

Not only is there an increase in the vigor of the defensive reaction during stimulation, but the limb movements have frequently been noted to persist as long as one minute after cessation of stimulation and shock. This after-discharge is not confined to the limbs alone but involves tossing movements of the head as well. These were occasionally noted to continue even after the diffuse limb movements had ceased. A similar after-discharge of the motor reaction was often seen in the above two cases in the dog.

Another phenomenon which has been often noted is the flexion of the reaction limb occurring at the instant of cessation of the negative or unreinforced stimulus. This phenomenon has been designated by us in other sections of this report as the "off-reaction."

In the neurotic animal a reaction of the conditioned limb may be elicited by a great variety of stimuli in addition to the conditioned one; in other words, generalization is extremely wide in the tense animals. Scratching on the wall of the experimental chamber, touching the animal with the finger either on the reaction limb or on the body (as reported in a previous section), a distant locomotive whistle, automobile horns, the noise of an airplane overhead, all may evoke motor reactions of one sort or another during an experiment.

In the case of sheep D, whose experimental neurosis was observed over a period of 12 years, a very interesting "posturing" type of conditioned reflex was noted during the years when the experimental neurosis was at its height. The normal animal remains erect when the conditioned reflex is elicited. The neurotic animal, however, habitually adopted a most peculiar posture in which the back was arched, the head raised and turned to one side, the fore-limbs stiffened and extended forward, the hind limbs partially flexed as in a crouch. The flexion movements of the reaction limb were superimposed on this posture. The arched back and elevated head reminded the observer of opisthotonic reactions seen in certain types of convulsive seizure. Fig. 1 contrasts these posturing reactions of sheep D with the responses of a normal animal.

In the dog, over-reaction to the conditioned stimulus is well illustrated by the case of dog #868. During the early phase of the nervous disturbance in this animal the metronome beating at a rate of 120 per minute (reinforced by shock) evoked a most violent and forceful motor reaction. The dog sank slowly to the floor on the first tick of the metronome but immediately bounded to its feet and began to struggle to get out of the harness, biting the straps, the electrode about its ankle, even biting at the platform on which it stood; and this behavior was accompanied by whining, barking, yelping and growling. The motor reactions were so vigorous at times that the dog became almost inextricably entangled in the straps and wires so that he hung head downward from the supporting beam overhead.

Although patterns of over-reaction observed in sheep in response to the conditioning stimulus were often extremely violent, none were as violent as those seen in this dog and in another dog recently studied at the Cornell Behavior Farm.[3] The manic reactions of this latter animal will be described in a later paper. In the over-reaction of the experimental neurosis there is a great deal more vocalization and a more complete disruption of normal postures in the dog than in the sheep. No sheep ever became so entangled in the straps as to hang head downward. The sheep crouches, trembles, breathes stertorously, or lunges repeatedly in efforts to get out of the harness, but the reactions of the extremities are relatively precise and stiff in comparison with the extremely diffuse limb and trunk reactions of the dog.

3) *Restlessness during the experiment (interval activity).* Another manifestation of the experimental neurosis is the extreme restlessness before an experiment is to begin and during the intervals between stimulations. In the sheep this restlessness manifests itself principally in frequent quick movements of the head and reaction limb.

[3] Unpublished experiment of Lewis B. Daniel and O. D. Anderson.

Long observation of our experimental animals has permitted us to judge the moment of an impending spontaneous leg movement very accurately. This judgement is based upon the posture of the animal, particularly the alert position of the head with ears raised as though the sheep were listening. This characteristic pose is shown in fig. 3. In fig. 4 a tracing of the spontaneous movements of the foreleg in an interval between stimulations is shown.

The frequency and distribution of these spontaneous interval movements, particularly those of the reaction leg, offer a means of assaying the level or degree of tension, since it is fairly obvious from examination of our protocols that tension and the number of leg movements are co-variable, that is, the

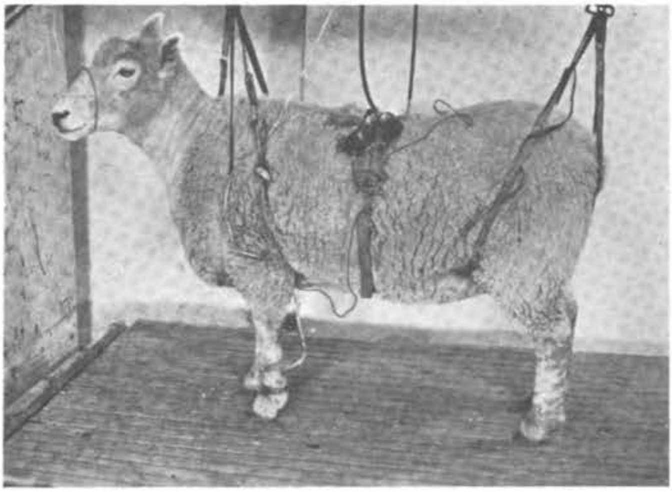


FIG. 3. A photograph showing the typically alert "listening" posture of an experimentally neurotic sheep seen in the intervals between successive conditioned stimuli (reinforced by an electric shock).

more tense the animal the greater the number of spontaneous movements, the less tense the animal the smaller the number of movements.

The temporal course of tension in the constant intervals between stimuli was studied in the case of the experimentally neurotic sheep #8 by determining the number and distribution of the spontaneous leg movements occurring during each interval. For comparative purposes a similar analysis was made in the case of sheep #11, normal at the time of this experiment.

The animals, both castrated males of mixed breed, with the Merino strain predominating, were closely similar in body weight and appearance, and animal #8, at the beginning of this analysis (spring of 1935) had been experimentally neurotic for about five years. The neurosis had supervened as a result of adherence to a rigid daily testing schedule which consisted of 4 stimulations with pure tones, positive stimulation alternating with negative, separated by 3 intervals of exactly 7 minutes each. Animal #11 had shown no signs of the disorder under a similar regimen. In this sheep an occasional spontaneous movement of the reaction leg had been noted to occur in the intervals although such infrequent movements are observed in all of the normal animals.

The experiments covered a period of four months during which there were 37 test periods for each animal. Each day's test lasted for about one hour and consisted of 4 positive conditioned stimuli given at intervals of exactly 7 minutes. Thus during each test period there were three 7-minute rest intervals.

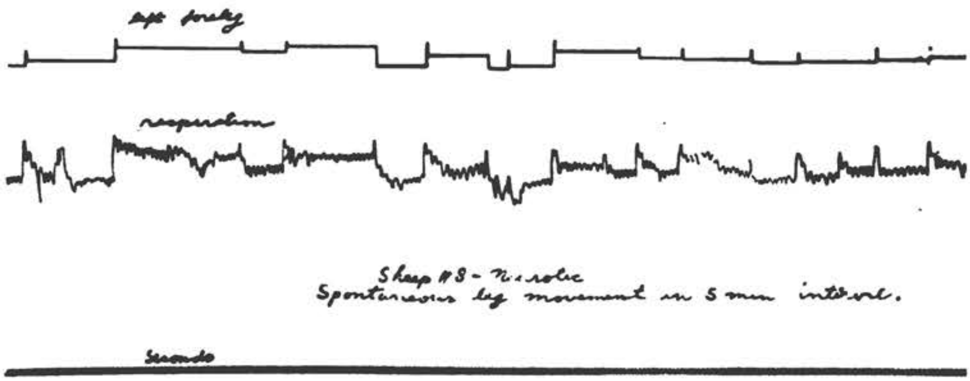


FIG. 4. A graphic record showing the character of the spontaneous movements of the reaction (left) foreleg in neurotic sheep, occurring in the intervals between successive conditioned stimuli. Note that the movements are slight and quickly executed ("tic-like"). Note coincident distortion of the respiratory rhythm.

In order to establish the typical course of tenseness in the animals during these intervals the numbers of leg movements were counted for each of the 7 minutes of rest and were then totalled for the 37 experimental sessions. Each interval was considered separately. The number of movements was summed up for all of the first intervals, all of the second, and all of the third. This was done in order to determine whether tension increased or decreased during the course of a day's session. It had previously been observed that some neurotic sheep became more restless during a day's experiment, showing an increasing number of spontaneous movements in each succeeding interval; while others showed the opposite tendency, that is, decreasing number of movements. We wished here to see whether either trend could be detected. The results are tabulated below.

Consider the first rest period, *i.e.*, the 7 minutes intervening between the first and second stimulations of each test period. For neurotic sheep #8 and normal sheep #11 the spontaneous movements for this rest period during the 37 experiments total as follows:

	Neurotic sheep #8	Normal sheep #11
1st min.	29	5
2nd min.	43	16
3rd min.	73	10
4th min.	98	17
5th min.	123	13
6th min.	158	17
7th min.	153	19
Total for the 37 first intervals	677	97

For the second rest interval the totals are as follows:

	Neurotic sheep #8	Normal sheep #11
1st min.	14	2
2nd min.	26	8
3rd min.	52	10
4th min.	54	10
5th min.	88	18
6th min.	146	13
7th min.	143	8
Total for the 37 second intervals	523	69

For the third rest interval the totals are:

	Neurotic sheep #8	Normal sheep #11
1st min.	29	8
2nd min.	29	9
3rd min.	41	13
4th min.	67	11
5th min.	112	17
6th min.	149	25
7th min.	167	17
Total for the 37 third intervals	594	100

The fact which is immediately apparent from an inspection of the tables is the very great number of interval movements of neurotic animal #8 as compared with #11. The total number of movements for all the intervals in the 37 experiments was 1,794 in the case of the experimentally neurotic sheep #8 and 266 in the case of the normal sheep #11. The method of totalling 37 test periods serves to prevent masking of the true difference in activity between the neurotic and normal animals which might otherwise occur on occasional days of atypical activity.

In both sheep this spontaneous activity rises rapidly during the resting interval and reaches a peak in the 6th and 7th minutes of the interval. It would seem that this peaking of the curve of excitation near the end of the interval between conditioned stimuli is due to accurate timing on the part of the animal. The temporal sense of these animals has been so accurately adjusted to the standard 7 minutes that excitability is relatively low during the early minutes of the interval but increases as the time for the next stimulation approaches. When this stimulation is given it acts upon a neural mechanism which has already reached a high degree of excitability. This may account for the violence of the conditioned motor response in many of our disturbed sheep.

Instances of the animal's ability accurately to time an interval to which it has long been accustomed has been demonstrated before in the course of our experiments. In one case (sheep C) an animal which had been habituated for many years to stimulation separated by intervals averaging one minute became so accurate in timing that when left standing quietly upon the experimental platform without stimulation for a period of 15 or 20 minutes, it held its breath for a few seconds at almost exactly one minute intervals (see fig. 36).

Two other sheep, #9 and #10, whose histories are not given in this report but which had been trained to positive conditioned stimuli separated by exactly 3-minute pauses, similarly showed a maximum number of movements occurring in the second and third minutes of the rest period.

The tables also show, in the nervous sheep, that the greatest number of movements occurred during the first interval (677), the number of the second and third rest periods showing a decline (523 and 594 respectively). In the normal animal the values remained fairly constant.

The fact that even normal sheep become increasingly more tense in the constant waiting interval between two stimulations was demonstrated in another manner. Sheep #11, normal at that time, was again employed. The animal had been trained to react to 4 positive stimulations (tone reinforced by shock) with intervals of exactly 7 minutes between the stimuli for more than one year. A highly stable conditioned motor reflex had been established, very nearly the same magnitude of the reflex being evoked by each stimulation. On a given day the series of tests was begun with the following modification. After the first stimulation, instead of waiting for the accustomed 7 minutes to elapse, the second stimulation was given at the end of one minute and the magnitude of the conditioned reflex was noted. Several weeks later, after the usual routine had been reestablished, a "sampling" was again made

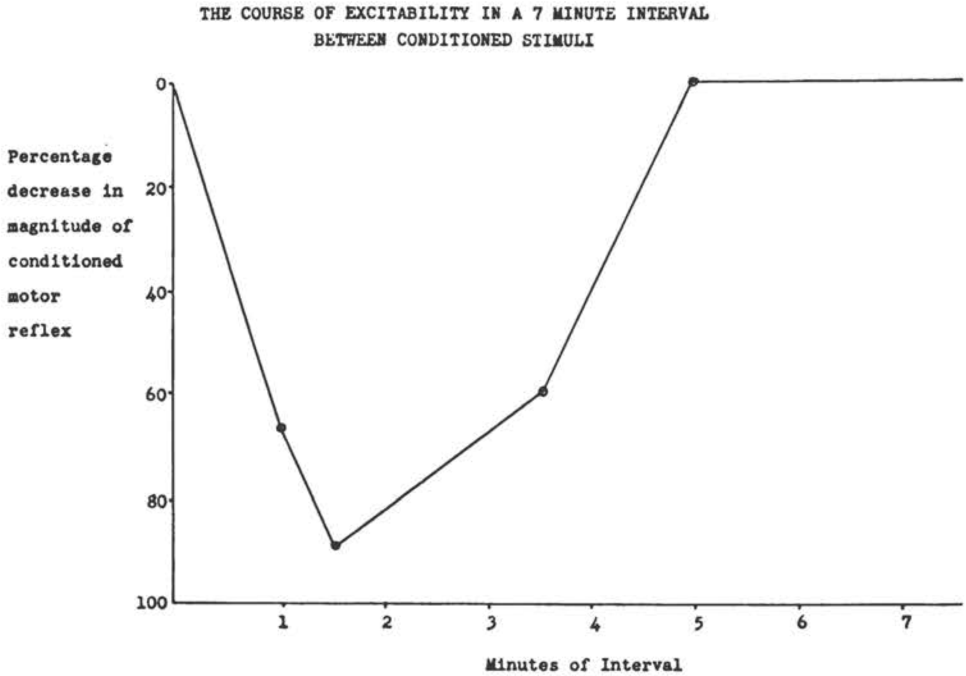


FIG. 5. Graph showing, in a normal sheep, that excitability in a 7-minute interval, to which the animal had become habituated, decreases during the first minutes of the interval and increases during the later minutes as the time for the next conditioned stimulus approaches (the 7th minute). The degree of excitability was here estimated by determining the magnitude of the conditioned motor reflex elicited by the conditioned stimulus presented *occasionally* at various times during the standard interval. That is, on the first occasion it was presented one minute after the preceding stimulus; on the next, one and a half minutes afterward; on the next, three and a half minutes afterward; and on the last, 5 minutes afterward. After each of these tests the animal was rehabituated to the 7-minute rhythm. The magnitude of the reflex decreased then increased in the interval.

but this time the signal was given when one and a half minutes of the 7-minute interval had elapsed. The next "sample" was taken in the middle of the period at three and one-half minutes after the previous stimulation, and the last was taken at the fifth minute. The first "sample" stimulation at one minute resulted in a weak response, the second, at one and a half minutes, in a still weaker reaction, while the third, at three and a half minutes, evoked a response which had partially recovered and the fourth at five minutes, one which was of usual vigor. The numerical values of these reactions when plotted on the same scale yielded the smooth curve shown in fig. 5.

It seems clear, from the above evidence, that under these circumstances the level of excitability or tension varies within the rest interval. Excitability declines immediately following stimulation but increases as the time for the next stimulation approaches.

This observation was confirmed in the dog when a rhythmical mode of stimulation was employed (see cases of dogs #868 and #929). As in the sheep the dogs expressed nervousness in the constant intervals between stimulation by frequent, spontaneous, tic-like, flexing movements of the leg to which the shock was customarily applied. These movements were, however, occasionally somewhat different in character from those observed in the sheep. In dog #929, during the phase of hyperexcitability observed in its neurosis, the foot was raised from the floor and was held in that position as though injured. This partial flexion was observed to occur during the first minute of the 5-minute pause between stimuli and to be held throughout the pause. Brief, tic-like movements of the leg were superimposed upon the partial flexion. They began to appear in the first part of the interval and increased in frequency as the time for the next stimulus drew near.

Interval movements of the reaction limb superimposed upon a continuous, partial flexion were never seen in the sheep, and were only occasionally seen in this dog. The reaction was not observed in dog #868, trained in the same way, although frequent restless movements of the leg appeared. As in dog #929 these movements increased in frequency as the interval advanced.

The more typical movements (in both sheep and dog) take place when the animal is standing erect with all four feet upon the floor (fig. 3). Each movement consists of a slight, brisk flexion of the leg immediately followed by extension, the foot being raised then lowered to the floor. At times the position of the foot is shifted from one point to another.

For a comparison of the spontaneous leg movements in the sheep and dog see the graphic records of fig. 2 (lower tracing) and fig. 9, *B* and *D*. These tracings show the remarkable similarity of the movements in the two animals.

A great variety of spontaneous interval movements was seen in the case of dog #881, trained to react to signals for food instead of for shock. It is of interest at this point to describe these movements in order that they may be compared with those described above which occur in animals trained to react to signals for shock.

Since the case history of dog #881 is reported in detail in the appendix we shall here give only a bare outline of the training of the animal which preceded its experimental neurosis.

A fairly stable conditioned salivary reflex was established to a metronome beating 120 times per minute and followed by food. In each day's experiment four or five stimuli were given at exactly 4-minute intervals. For five or six-months unsuccessful attempts were made to establish a differentiation between the metronome 120 and metronome 50, the latter not being followed by food. The positive and negative stimuli were given alternately and were separated by 4-minute intervals. The conditioned salivary reflex weakened and finally disappeared completely, and the animal became increasingly nervous.

The signs of the experimental neurosis were typical of those seen by Pavlov (*21*) and by Gantt (*9*). The nervousness was characterized principally by marked restlessness and violent negativistic behavior in the intervals between stimuli. During conditioned stimulation the dog stood immobile. When the stimulation had ceased, however, the animal at once began slowly to back away from the food dish (not having eaten the food). When it had backed away as far as the restraining straps would allow the tightening of the straps about the limbs evoked a most violent form of struggling. The dog attempted to withdraw the legs from the straps by threshing them wildly about. This diffuse struggling was often accompanied by attempts to chew the straps through and by soft, continuous whining. When near complete exhaustion the animal would cease struggling and crouch, trembling, to the floor, sometimes urinating continuously for a considerable period of time. The respiration was rapid and shallow and was audible. The pulse rate was very rapid. After the rest the dog often suddenly lunged forward against the straps, climbing upon the food box and biting the wires and tubing attached to it. Such activities were continued throughout each 4-minute interval between stimuli.

On one occasion the dog was induced to stand upon the platform without the usual straps about the legs. We wished to see what it would do following stimulation if given complete freedom of movement. It stood quietly before and during the positive stimulus and paid no attention to the food in the dish. When the stimulation was over it immediately backed away from the food, bounded from the platform and dashed out of the laboratory to stand trembling in a dark corner of the hallway outside. We do not know what element or elements in the experiment induced such striking evidences of fear.

Such behavior was observed for a period of about two years. For photographs and graphic records of these reactions see figs. 6 and 7.

Restlessness in the interval thus involved, in this dog, diffuse and varied movements of the whole body, while in the sheep and dogs (trained with

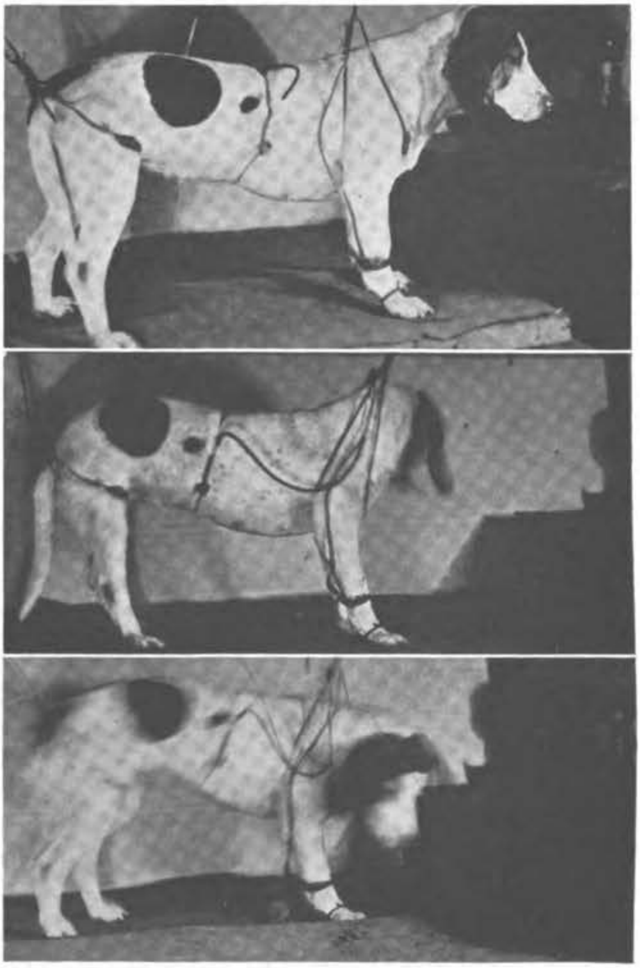


FIG. 6. Photographs showing the course of development of the excitatory experimental neurosis in a dog, #881. In this experiment the electric shock was never employed, the unconditioned stimulus being food. The photograph at the top shows the dog standing quietly on the platform at the beginning of the experiments and before any sign of neurosis had appeared. The next shows the animal attempting to back away from the food dish in the interval between stimuli and after neurosis had developed. The bottom picture illustrates the typical manic struggling reactions which followed upon the cessation of conditioned stimulation.

signal and shock) restlessness consisted, for the most part, of stereotyped, localized movement of a single limb (the reaction leg) accompanied by raising and lowering movements of the head.

It is of interest to note that at no time were the typical, tic-like movements of the reaction leg seen in the animal quarters in either sheep or dogs. General restlessness, including startle reactions, wild running and plunging about, and the like, were, however, noted in both dog and sheep.

4) *Rigidity of the extremities (pseudo-decerebrate rigidity).* A very curious expression of the experimental neurosis was observed in the case of a dog, #929, reported in detail in the appendix. We had attempted without success to establish a differentiation between metronome rates (met. 120, positive and met. 42, negative) in experiments with the conditioned motor reflex. On continuing the experiments for several months a marked state of hyperexcitability became evident, characterized by violent reactions to con-

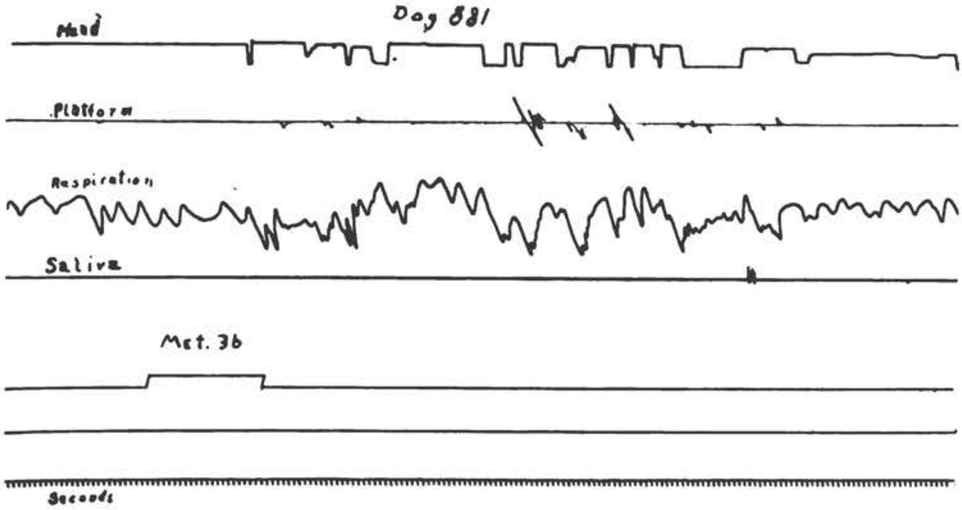


FIG. 7. A graphic record showing the interval struggling activity in the neurotic dog, #881, seen in fig. 6. The activity is here shown by vigorous tossing movements of the head (top line) and by general movements of the animal upon a sensitive pneumatic recording platform. Note that the activity is evoked by a negative (non-reinforced) conditioned stimulus (metronome 36).

ditioned stimulation and to other stimuli as well. The slightest noise often evoked this violent form of behavior. In the uniform intervals between stimuli, spontaneous flexion movements of the limb were noted. This syndrome was considered typical of the hyperexcitable phase of neurotic behavior.

At this point the experiment was abandoned for about a month, and when the animal was returned to the experimental room a marked change in behavior was apparent. The great agitation had been supplanted by complete quiescence. The dog, however, was considered to be *too* quiet. A normal, calm dog, under these same circumstances, would have shown some amount of movement as he stirred about in the harness and looked about the room. This animal showed little or no movement. However, the eyes did move. The posture was abnormal in that the body was crouched, the head held low.

It appeared to us at the time that the animal was simply "afraid" to move.

In tests which followed on this day and on the next he was allowed to stand for periods as long as 22 minutes during which no movement was seen. Since the limbs appeared to be rigid, we applied the usual tests of decerebrate rigidity. With the fingertips pressed against the sole of the foot, resistance to flexion was encountered. This, however, gave way, as we pressed upward, the leg bending slowly until finally a fully flexed position was attained. On withdrawing the hand, the complete flexion was maintained. We then attempted to extend the flexed limb. Slight resistance to extension was noticed.

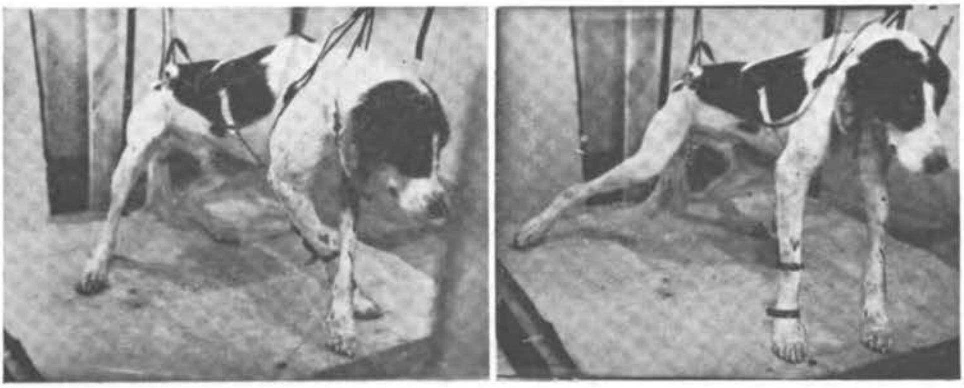


FIG. 8. Photographs of an experimentally neurotic dog, #929, which showed pseudo-decerebrate reactions. The photographs illustrate that the limbs could be passively placed in various abnormal positions. These positions were maintained, and the animal remained immobile over considerable periods of time. The limbs and the neck were rigid and resisted passive flexion or extension. A partial flexion of a limb could be maintained. These phenomena were observed in this dog only during an "inhibitive" phase of its neurosis.

A partial flexion was also maintained. Passive flexion was tried in the case of each of the four limbs, and each responded in the manner just described. The reaction did not center about the reaction leg any more than about the other limbs.

We shifted one of the forepaws behind the other, so that the forelegs were crossed. One of the hind limbs was placed in outward extension. This awkward, abnormal pose was maintained for nearly a half-hour. Fig. 8 shows the abnormal poses of this animal taken when the experimenter placed its limbs in awkward positions.

When conditioned stimuli were applied, they evoked slow, hesitant responses of the reaction limb, in contrast to the violent responses previously noted.

Since the posture and reactions of the animal so strongly suggested those of a decerebrate dog (colleagues who saw the animal thought it was decerebrate) we have referred to the condition as pseudo-decerebrate rigidity.

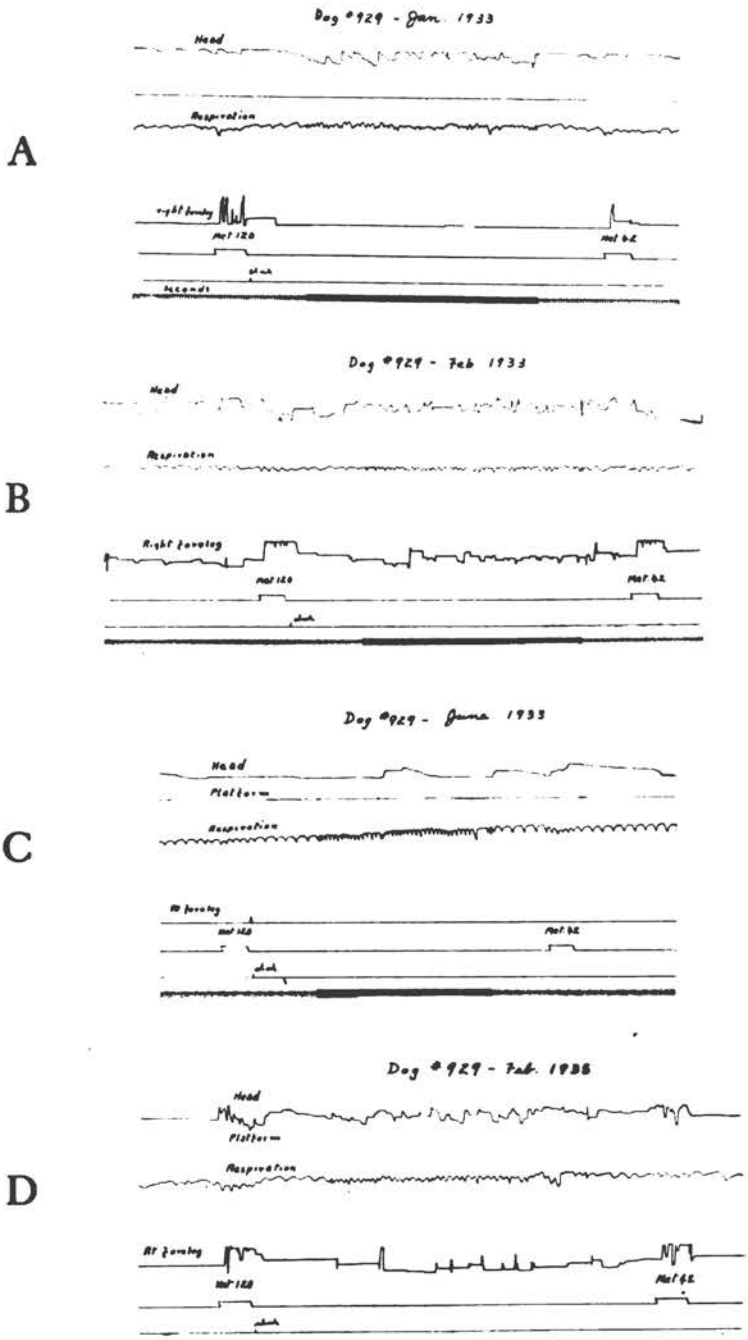


FIG. 9. Graphic records illustrating the course of the development of the experimental neurosis in dog #929, whose abnormal postures are shown in fig. 8. Behavior passed through several phases, from normal (*A*), to hyperexcitability (*B*), to extreme hypoexcitability (*C*), and to hyperexcitability (*D*). The pseudo-decerebrate reactions appeared only during the hypoexcitable phase.

The above described behavior was noted for about one month when the experiments were discontinued. The animal was given a rest of about a year, after which the tests were resumed. No sign of the abnormal immobility was now noticed. The animal stood erect, moving his head about in a normal manner. Abnormal placement of the limbs was not maintained. The passive flexion responses noted earlier, were now no longer present.

The graphic records of fig. 9 show the course of the neurosis in this dog. Several phases are illustrated by typical tracings. Behavior passed from normal to excitatory, to inhibitory, and to excitatory again during the two-year observation period.

Our colleague, G. F. Sutherland, has informed us[4] that he has observed a case in the dog which presented almost exactly the same features as that of dog #929 described above. Marked rigidity of the extremities with general immobility was noted in conditioned reflex experiments on the animal. In addition to rigidity he noted that the eyes were immobile, the animal looking directly ahead in a fixed stare. We did not observe this in our dog. The eyes were directed toward the observer when he was in the room and they followed him as he moved about the room.

Neither our dog nor Sutherland's showed much rigid immobility outside of the experimental setting, although the muscular movements of our animal, when observed in the animal quarters, were, during this inhibitive phase, slowly executed and hesitant. Its walking movements reminded one of slow-motion pictures. When the leash was placed about the dog's neck, preparatory to leading him to the laboratory, he stood motionless. Normal dogs show a variety of movements under this condition and the experimentally neurotic dogs #868 and #881 (and this dog, #929, during the excitable phase of its neurosis) moved vigorously to avoid having the leash attached.

No single instance of this pseudo-decerebrate rigidity was seen in sheep or indeed in any other dog studied.

5) *Immobilization of the reaction limb.* As previously stated, the experimental neurosis in the sheep and dog is not always characterized by an augmentation of neuromuscular activity and reponse. The case of dog #929, just presented, is a good example of the marked inhibition of the neuromuscular system in the disorder. In two of the cases among the sheep, sheep J and #7, a long enduring (apparently permanent) inhibitory state developed which bore some similarity to that of dog #929. We consider these cases in sheep to be representative of a truly inhibitory form of the neurosis, and while it is much rarer in our experience than the excitatory type, its mani-

[4] Personal communication from G. F. Sutherland concerning his unpublished experiments performed at McGill University.

festations are equally striking. We shall here describe the symptoms seen in sheep J and #7.

Experimentally neurotic sheep J, a female, predominantly Shropshire in strain, developed an enduring nervous disturbance while attempting to discriminate between a buzzer reinforced by a shock and a doorbell not reinforced. During early testing (1931-32) this animal showed extensor rigidity

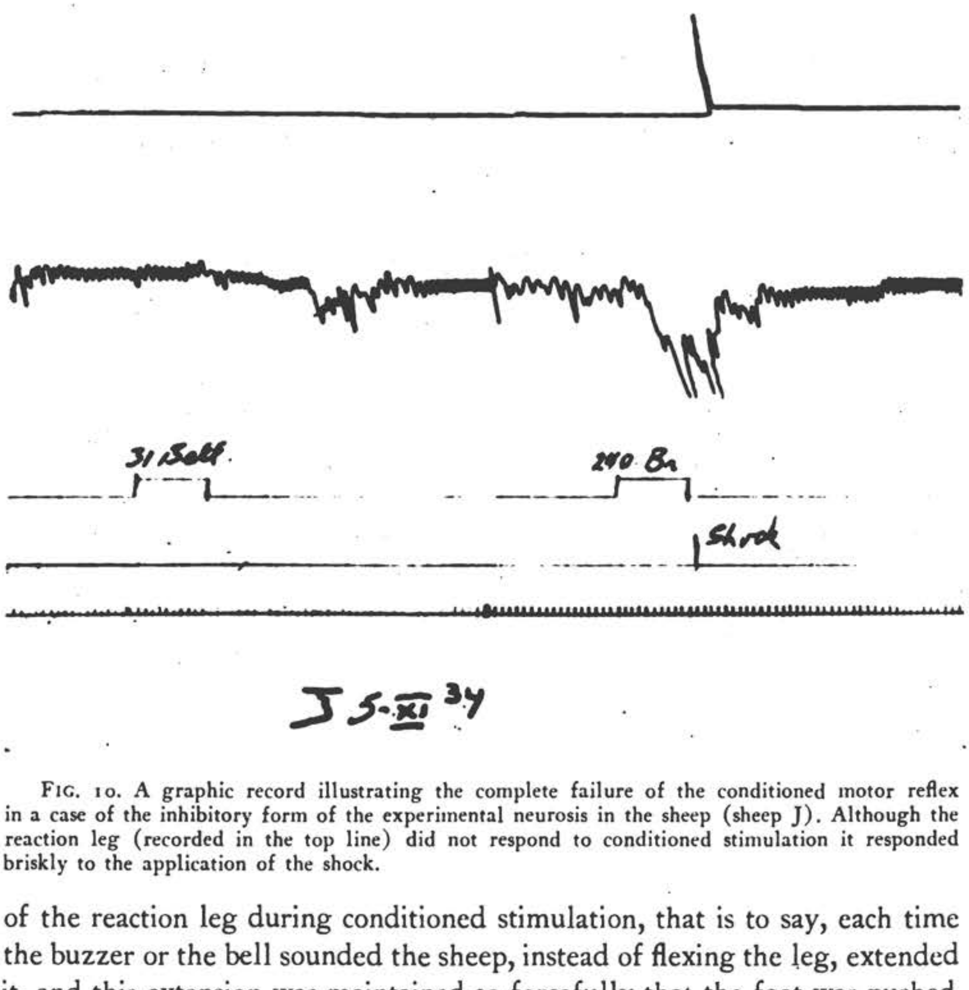


FIG. 10. A graphic record illustrating the complete failure of the conditioned motor reflex in a case of the inhibitory form of the experimental neurosis in the sheep (sheep J). Although the reaction leg (recorded in the top line) did not respond to conditioned stimulation it responded briskly to the application of the shock.

of the reaction leg during conditioned stimulation, that is to say, each time the buzzer or the bell sounded the sheep, instead of flexing the leg, extended it, and this extension was maintained so forcefully that the foot was pushed slowly forward on the floor. The alternate flexion and extension movements of the limb seen in normal sheep during conditioned stimulation were absent. When the shock was delivered to the leg the limb flexed only slightly but the foot was raised to a considerable height from the floor by the action of the shoulder musculature. Such a movement was stiffly executed and the resulting body posture was awkward.

As the observations continued we noted that the sheep, on being stimulated with the buzzer or bell, varied the form of the reaction from time to time. At times both forelimbs were extended so that the forefeet were pushed forward on the floor and this was accompanied by a lowering of the head. The animal stood in this crouched posture throughout each stimulation, neither the head nor the limbs showing any movement. At other times the sheep stood erect during the conditioned stimulation. The reaction leg was extended rigidly. The opposite foreleg and both hind legs showed alternate flexion and extension movements, the whole body pivoting about the immobile and extended reaction limb. Raising and lowering movements of the head accompanied these stamping leg movements. Indeed the whole reaction suggested that the leg to which the shock was applied (left foreleg) had been actually glued to the floor and that the sheep simply could not move it.

It is an interesting fact that in the absence of conditioned defensive movements of the reaction leg the other extremities of the body should, as it were, "take up" that limb's activity. It is as though the usual outlet for the normal response had been closed and the defensive mechanism found its mode of expression through other channels, in this case through action of the head and the other limbs.

The sheep was quiet during the intervals between stimuli, occasionally eating from the pail of oats on the platform.

A graphic record of this behavior is shown in fig. 10, and a photograph of the typical posture of this animal during conditioned stimulation is shown in fig. 11.

Work on this animal was stopped in 1932 and the sheep was not used again in an experiment until 1934, when the same reactions were seen. The experiments were again abandoned for two years and were resumed again in 1936. At this time, during an experiment to test a new technique for producing experimental extinctions and differentiations (*19*) a partial response of the reaction limb had reappeared, and six months later, when the animal was stimulated, unrestrained and free to move about the experimental room, the conditioned response to both positive and negative stimulation was to walk or run away from the location of the signal (*20*).

Two months later, in a series of 3 positive, 1 negative, 1 positive, 1 negative and 3 positive stimulations, in that order, at one minute intervals, discrimination improved and signs of leg "fixation" appeared only once. Two more test periods were given the animal, each consisting of 4 positive stimulations, with exactly 5-minute rest intervals between them. Leg "fixation" seemed to have disappeared, although the conditioned responses were very feeble. The marked inhibitory behavior, observed off and on for five years, was now supplanted by a somewhat more active type of performance under the new conditions. The reactions, however, were far from normal.

In the case of animal #7 we observed a clear-cut, long enduring example of inhibitory neurosis, but of a different type from that of sheep J, just described. The sheep simply stood passively during conditioned stimulation preceding the shock and showed no stiffening of the limbs or crouching as

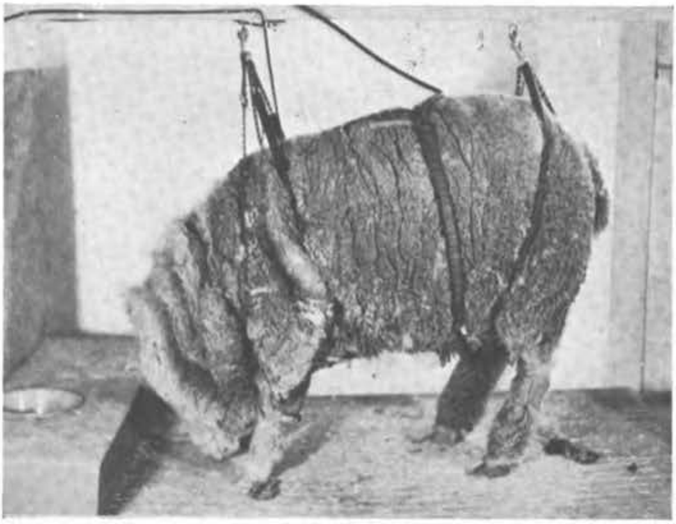


FIG. 11. A photograph illustrating the posture typical of certain of the sheep with the inhibitory form of the experimental neurosis. The above photograph was taken during the presentation of a conditioned stimulus to be followed by shock. Note that the reaction leg, instead of being flexed, is rigidly extended and that the head is held in a low position. Compare the posture of this sheep with the pseudo-decerebrate posture of the dog #929 shown in fig. 8.

seen in sheep J. Sheep #7 had for many years given extremely weak conditioned responses, a fact which we attributed to a wide variety of inhibitory stimulations. (See case history for details.) It had, however, effected discrimination between several groups of stimuli. After two years of rest, work had been resumed with this animal in February 1935, at which time a bell-buzzer differentiation was attempted. Responses from the animal became smaller and smaller, the latent period before movement increasing and coming nearer and nearer to the constant 10 second duration of the conditioned stimulus. Finally, a year later, after it had been given several tests, free to move about in the experimental room and adjoining pen, all conditioned responses of the reaction limb completely disappeared; and during a series of 105 positive stimulations with a metronome in 1937-38 it responded only 11 times with movements of the reaction limb and 5 of these responses were of a magnitude characteristic of its former less inhibited phase. No restlessness in intervals between stimuli was seen at any time. In this animal inhibition had steadily deepened.

It is also of interest that this animal, despite almost complete absence of muscular movement during the test periods, often showed an extremely

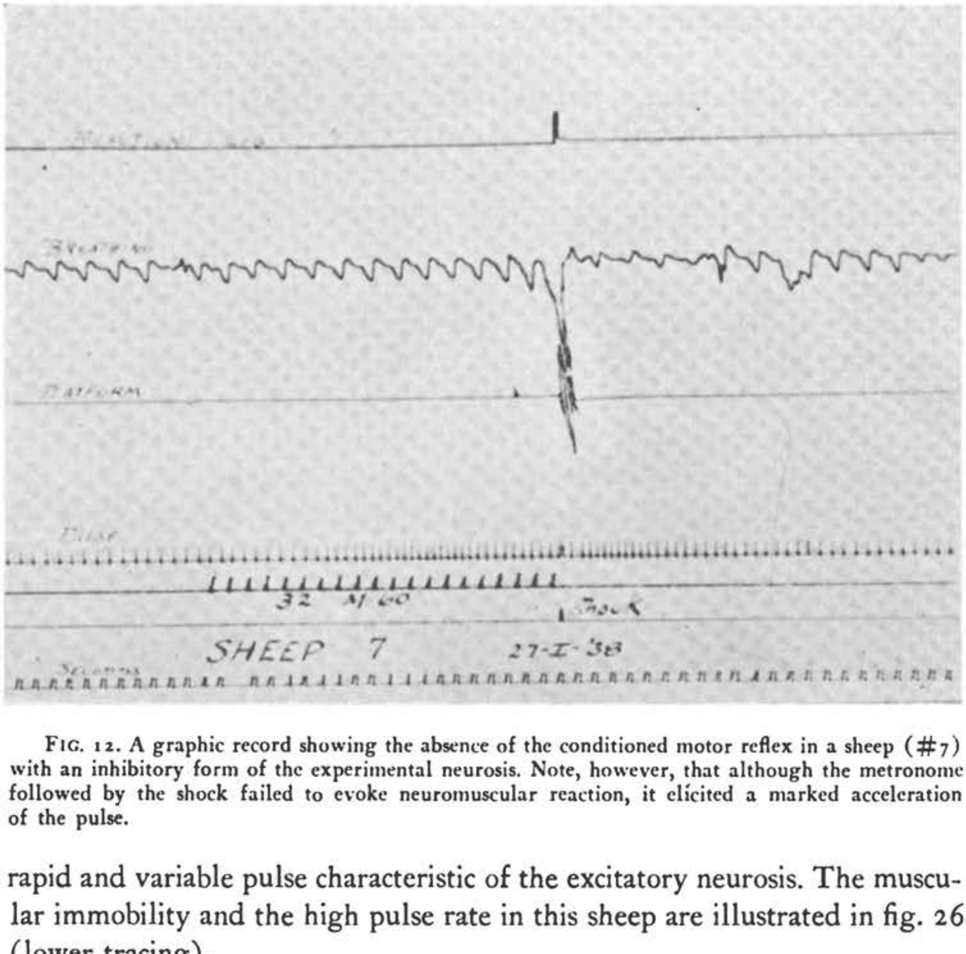


FIG. 12. A graphic record showing the absence of the conditioned motor reflex in a sheep (#7) with an inhibitory form of the experimental neurosis. Note, however, that although the metronome followed by the shock failed to evoke neuromuscular reaction, it elicited a marked acceleration of the pulse.

rapid and variable pulse characteristic of the excitatory neurosis. The muscular immobility and the high pulse rate in this sheep are illustrated in fig. 26 (lower tracing).

During the later period of the disturbance in this animal a curious out-of-stepness between the neuromuscular and the cardiovascular responses to the signal appeared, and this is described in a later section of this paper.

6) *Transfer of the motor reaction pattern.* In certain experimentally neurotic sheep there occurred a transfer or shifting of the habitual motor reaction pattern from one part of the body to another. As stated previously, the con-

ditioned motor reflex and the spontaneous activity during the experiment involved, in the majority of the neurotic sheep, defensive flexion movements principally of the reaction leg to which the shock was delivered (the left foreleg). In one case the reactions shifted spontaneously from the left foreleg to the right foreleg. In another they shifted from the left foreleg to the head and neck. In the latter case the transfer was brought about by a change in the experimental conditions.

The spontaneous transfer was noted in the case of sheep #8. The overt manifestations of the disorder previously shown by this animal in the laboratory consisted of 1) violent movements of the reaction leg each time the conditioned stimuli (tone or buzzer) were presented, and 2) frequent spontaneous movements of this leg in the waiting interval prior to each experiment as well as in each of the intervals between conditioned stimuli (7-minute intervals). These two cardinal symptoms had been observed for more than eight years.

During the ninth year of observation in this old neurotic, however, that component of the syndrome which consisted of spontaneous interval movement shifted altogether from the left to the right foreleg. However, the conditioned signals (and the shock when applied) in every case evoked vigorous defensive movements of the old reaction limb (left foreleg). The movements were observed to cease abruptly after the stimulus and shock had ceased and no motion of this leg was seen in the ensuing interval. When the left leg reactions stopped the interval movements of the right leg began to appear. These were exact duplicates of the type of movements that had formerly been executed by the left limb during rest intervals. They were slight, tic-like, flexing motions and they continued throughout each interval. This transfer remained unaltered for about one year when the observations were terminated by the sudden death of the animal. (The sheep was attacked and killed by dogs.) We have no explanation for this phenomenon. The result itself was interesting and was somewhat surprising in view of the fact that this animal had for so long a time shown an almost unvarying syndrome.

A graphic record illustrating this transfer in sheep #8 is shown in fig. 13. The restlessness in the interval between two stimuli is revealed by frequent movements of the right forelimb instead of the left. Sensitive recording apparatus was attached to both forelegs.

The shifting of restless movements from one limb to another was not observed in any other neurotic sheep. Nor was a single instance of this seen in the dog.

Both the spontaneous limb movements of the rest intervals and the conditioned limb reactions to stimuli may be supplanted entirely by vigorous tossing movements of the head. And any agent which evokes these latter movements can produce this type of transfer.

This phenomenon is well illustrated by an experiment carried out in sheep #52. When the neurosis was at its height we attempted to employ a breathing mask in order to obtain a more adequate respiratory tracing. The sheep was exhibiting characteristic restless movements of the reaction leg, coupled with tossing movements of the head, as it waited for stimulation to begin (fig. 2, lower tracing).

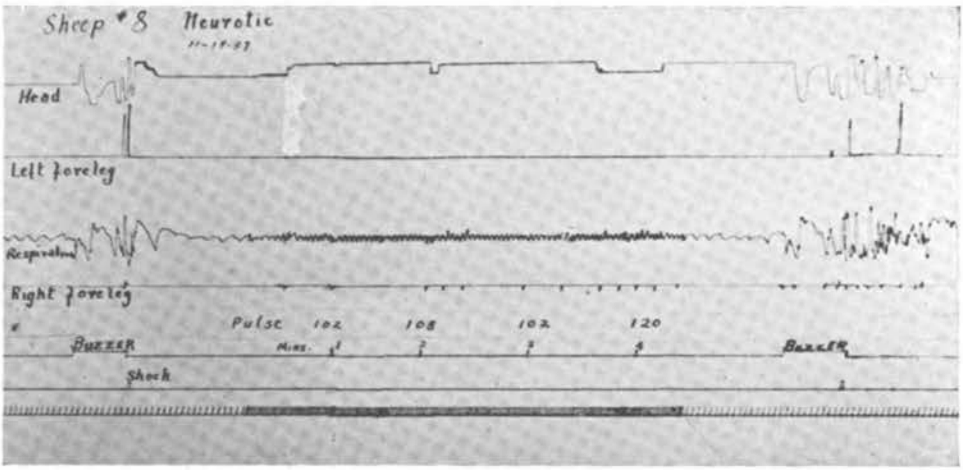


FIG. 13. A graphic record showing the transfer of the neurotic reaction pattern from the reaction (left) foreleg to the right foreleg in sheep #8. This animal had for many years shown tic-like flexion movements of the reaction leg in the intervals between stimuli. The right foreleg now supplanted the left, and these contralateral limb movements may be seen recorded above.

When the breathing mask was fitted over its muzzle the sheep began almost at once to toss its head about violently, knocking the mask against the floor and walls in unsuccessful attempts to get it off. During such activity we noticed that the usual spontaneous leg movements had disappeared altogether and had, as it were, been supplanted by the violent movements of the head. This "transfer" of the reaction from leg to head movement is shown graphically in fig. 14. The photograph of fig. 15 shows the breathing mask in place on the sheep's muzzle.

In subsequent observations on other sheep, in which the mask was used, the head movement supplanted the conditioned limb movement during conditioned stimulation.

Sheep #9, a normal animal, had developed a positive conditioned motor reaction to a door buzzer with electric shock as the reinforcing agent. This animal was presently experimented upon in a series of tests involving a breathing mask which caused it slowly to lose its customary motor response to stimulation and to substitute in its stead a slow swinging of the head from side to side, with the nose just clearing the platform.

In order to determine whether a "feeling of suffocation" was the provocation for these head movements the mask was removed and a loose sponge rubber ring placed around the sheep's nose 4 or 5 inches above the nostrils at a point where it could by no possibility interfere with respiration. The sub-

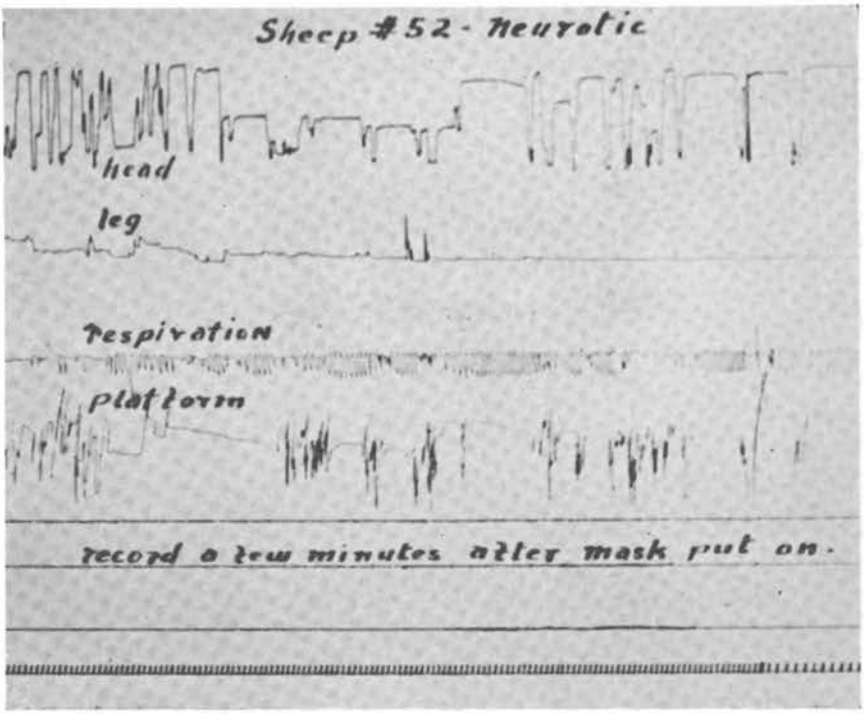


FIG. 14. A graphic record showing the inhibiting effect of a respiratory mask on the usual reactions of the left foreleg (the shocked leg). The normal leg reactions are seen to disappear and to be supplanted by a marked increase in movement of the head as the neurotic sheep attempts to dislodge the mask covering its muzzle.

stitutive reaction remained in full force, the animal tossing the head as vigorously as before, and it was not until the ring was removed that the head movements ceased and the usual conditioned limb reactions reappeared. The experiment with the ring is illustrated graphically in fig. 16.

The example cited above is but one of many observed in this laboratory even among normal as well as neurotic sheep. In fact, in almost every case the breathing mask has acted as a complete inhibitor or powerful modifier of the existing reaction pattern and its use has therefore largely been given up in this work. This is unfortunate since it alone of the devices we have tried gives a true respiratory tracing, unmodified by the artifacts of abdominal muscular movements, all of which appear in the breathing record as reported by the conventional rubber tube pneumograph.

Even in the case of the apnoeic pauses observed in a few neurotic animals (see section on "Respiratory manifestations of the experimental neurosis") the mask again acted as a suppressor; for only occasionally are these apnoeic pauses observed in the respiratory tracings when it was used.

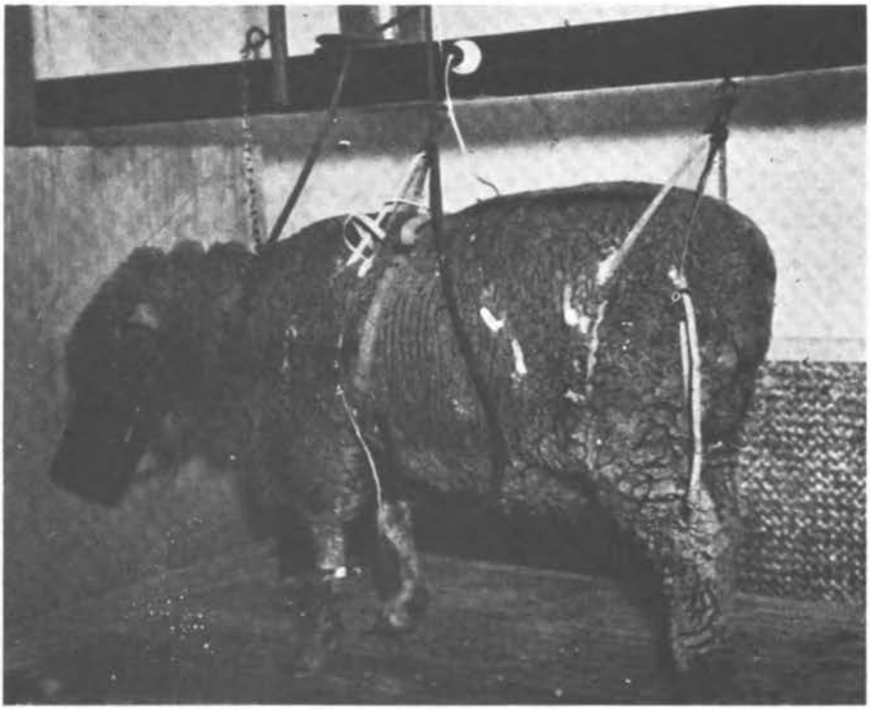


FIG. 15. A photograph showing the breathing mask in place on the sheep's muzzle.

We have found in practice that a loose rubber band placed about the muzzle and used in recording head movement does not evoke the above phenomena. The sheep apparently do not notice this.

Although the dogs were found to be very sensitive to annoying agents applied to the head we did not observe in them any notable inhibition of the conditioned defensive leg movements. It should be pointed out, however, that no bulky objects were attached to the head as was done with the sheep. Only the loose rubber band was placed behind the ears for recording head movement, as in sheep.

The above described transfer of the reaction pattern suggests a common observation of the clinician, namely the unaccountable shifting in neurotic patients of pains and other sensations from one part of the body to another. The experimentally neurotic animal may provide a means of investigating this problem.

7) *Diurnal neuromuscular activity outside of the laboratory.* The question naturally arose as to whether or not symptoms of the experimental neurosis could be detected outside of the laboratory, when the nervous animal was in its usual surroundings, as well as in the laboratory situation. In other words,

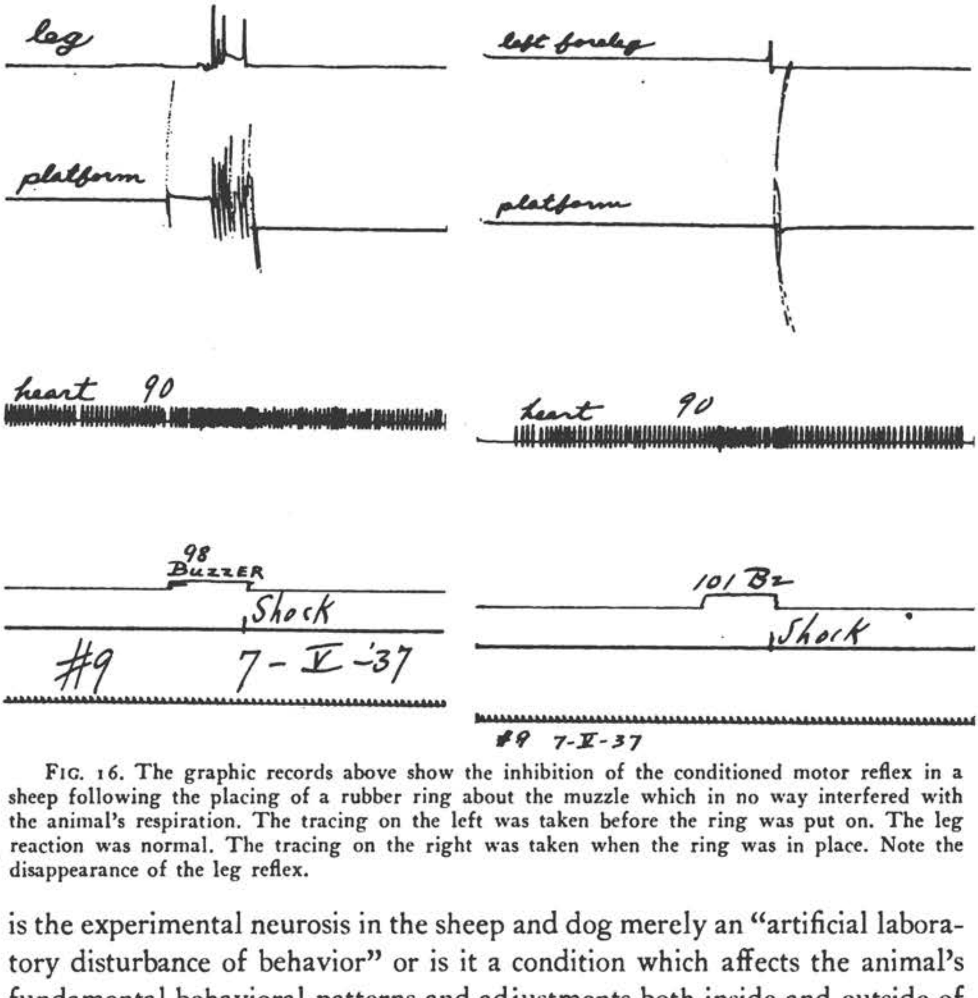


FIG. 16. The graphic records above show the inhibition of the conditioned motor reflex in a sheep following the placing of a rubber ring about the muzzle which in no way interfered with the animal's respiration. The tracing on the left was taken before the ring was put on. The leg reaction was normal. The tracing on the right was taken when the ring was in place. Note the disappearance of the leg reflex.

is the experimental neurosis in the sheep and dog merely an "artificial laboratory disturbance of behavior" or is it a condition which affects the animal's fundamental behavioral patterns and adjustments both inside and outside of the laboratory.

For the past 8 or 10 years observations of the behavior of the disturbed animals when they were with their fellows in the animal quarters (in the sheep barn or pasture and in the dog kennels) have shown conclusively that the signs of the experimental neurosis are by no means confined exclusively to the laboratory chamber. The animals were found "to take their neurosis home with them" just as the functionally hypertensive office clerk who has feelings of hostility toward the boss takes his high blood pressure home with him. The signs of the animal neurosis can as easily be detected outside the laboratory.

These expressions are, as would be expected, many and varied. Some of them have been described under the section on "Hyperirritability" and others will be discussed in later sections on manifestations referable to the autonomic nervous system (respiratory and cardiac) and on social and emotional manifestations. It will suffice here to present an account of the peculiar behavioral reactions, outside of the laboratory, of an experimentally neurotic sheep, #52, whose case is not included among the appended case histories. This case illustrates the ease with which one can "spot" a nervously disturbed sheep among his normal fellows in the barn and surrounding pasture.

The following is taken verbatim from notes on this sheep's behavior made during the observations of a single typical day. The excitatory experimental neurosis was at its peak. "We called the flock in from the pasture. We are standing inside the barn. The flock is grazing. On beating upon the metal oats bin the sheep run toward the barn. Sheep #52 comes warily and hesitantly behind all the rest. All but this animal file through the open door and begin to eat from the food trough. #52, on seeing the experimenter standing just inside the door at once stops, backs out of the door and runs rapidly behind the barn. We then attempt to drive it in individually. It is bleating incessantly. It circles the barn several times and then eludes us by running rapidly back to the pasture. The whole process is repeated and, with the help of the animal attendant, the sheep is eventually driven into the barn. We enter and close the door. This sheep moves restlessly about the barn and does not join the flock quietly eating from the trough. The movements, especially of the head, are quick and jerky. When we approach the sheep it dodges this way and that and dashes past us. Instead of seeking "shelter" in the middle of the flock as is seen in normal sheep under these circumstances, it cannot be driven into the flock and dashes about on the fringes. We go outside the barn to observe its behavior without being seen. The animal's activity is not so intense as before. It approaches the food trough but does not find a vacant place and does not try to force its way among the animals to get to the trough. An animal gives up its place and moves away; #52 now approaches the trough and eats with the rest."

A strikingly similar account can be given in the case of the experimentally neurotic dog. All three cases here reported (#868, #881 and #929) were in general a great deal more difficult to handle in the kennel than were normal quiet, friendly dogs. These dogs were at all times somewhat "suspicious" of the experimenter. In their extreme "fear" they were the ones which we had to watch in order to keep from being bitten. With the exception of dog #929 when in the inhibitive phase described above (section on "Rigidity of the extremities") all the nervous dogs were excessively shy, not only of the experimenter but of their companion dogs as well. Thus, when the experimenter approached them in the kennel room they crouched and ran away. And it was extremely interesting to notice that when a single pan of food was placed between a nervous dog and a normal companion the latter always approached the pan without hesitation and ate all the food while the former watched from a "safe" distance. When the shy animal approached the pan a growl from the companion caused it immediately to retreat. Indeed, as a rule it was necessary to provide individual pans for the nervous animals in order that they might get enough food.

In order to give proper objectivity to such observations outside the laboratory we have registered and recorded in normal and neurotic sheep their spontaneous diurnal neuromuscular activity.

Graphic records were obtained by the use of large, mobile activity platforms upon which the sheep could live comfortably for days at a time.[5] The platforms were situated in the pasture near the barn so that the sheep on them would not be isolated from the flock grazing nearby. Many sheep grazed or walked about within a few feet of the animals on the platforms.

Each platform was 22 feet long by 10 feet wide and was bordered by large-mesh wire fencing. Its movements were recorded by means of a pneumograph rigidly attached above it and connected to a tambour located 100 feet away in the laboratory. Each movement made a vertical mark upon the paper of a slow-moving long paper kymograph. Such records of activity were obtained throughout 24-hour periods. As strain-producing procedures were introduced into the experimental situation sequential records of the activity were obtained, thus enabling us to trace directly any "carry-over" effect from the laboratory.

The records of general activity in the nervously disturbed sheep show certain definite characteristics which mark the animal as different from the normals. The most striking result was a difference in the temporal distribution of spontaneous activity in the 24-hour day. The normal, undisturbed animal, when put upon one of the platforms, showed a great deal of activity during the daylight hours and little or no activity at all during the night hours, and this was the case also with the experimentally neurotic animals before the

[5] These were initially used by one of us (O.D.A.) in earlier activity experiments on the dog (3). The platforms used for the sheep were modified from the earlier ones by G. F. Sutherland, who employed the scale-platform principle in their construction. This was a great improvement.

experimental neurosis had supervened. During the height of the neurosis in the latter, however, the diurnal distribution of the activity underwent a marked alteration. The graphic record showed that about as much activity occurred during the hours of darkness as during the daytime, although there was, in general, no noticeable increase in the *total* amount of activity for the 24-hour period as determined from the records and as shown by simultaneous registration of activity by a pedometer attached to the sheep's foreleg. This alteration in the temporal distribution of activity was an invariable accompaniment of the neurotic manifestations produced in the laboratory. The neurotic animal, like the neurotic human, is apparently a frequent sufferer from "insomnia."

A movie film was taken of the reactions of a normal and an experimentally neurotic sheep on the activity platform. "Stills" of this movie are shown in the photographs of fig. 17. The normal sheep (photograph *A*) walked quietly about on the platform. The neurotic animal (photographs *B* and *C*) often ran wildly about and at times tried to jump the fence surrounding it. The sheep did not appear to be afraid of the observer, for it often ran directly toward him rather than away from him. The slightest unusual sound or other mild disturbance, such as a sudden rapping upon the side of the structure, evoked quick flight and the sheep bleated frequently. The normal remained undisturbed, however, and would continue chewing its cud or feeding, or would simply stand there and stare at the observer, or come quietly to the fence and eat oats from his outstretched hand.

The vigorous neurotic reactions were, however, sporadic and were often followed by periods of complete quiescence, as though the animal were exhausted. These quiescent periods naturally reduced the total amount of activity in 24 hours, so that the level was about the same as in the normals. If the violent reactions had been sustained, the activity of the neurotics would have been three or four times that of the normals. This inability to sustain the vigorous activity may be due to "easy fatiguability" as is probably the case in many human psychoneurotics. Whatever the ultimate explanation for this may be, one inevitably forms the impression that both normal and neurotic sheep have about the same level or amount of energy to expend in a given time; the normal expending it by almost continuous activity during the day, the neurotic expending it by sudden bursts of activity throughout the 24 hours.

When the neurotic sheep was given an extensive period of rest, sometimes a year or more, from the experiment, many of the neurotic symptoms, as observed in the laboratory, disappeared. The animals remained fairly calm when the experiments were resumed but this period of quiescence was gener-

A

B

C

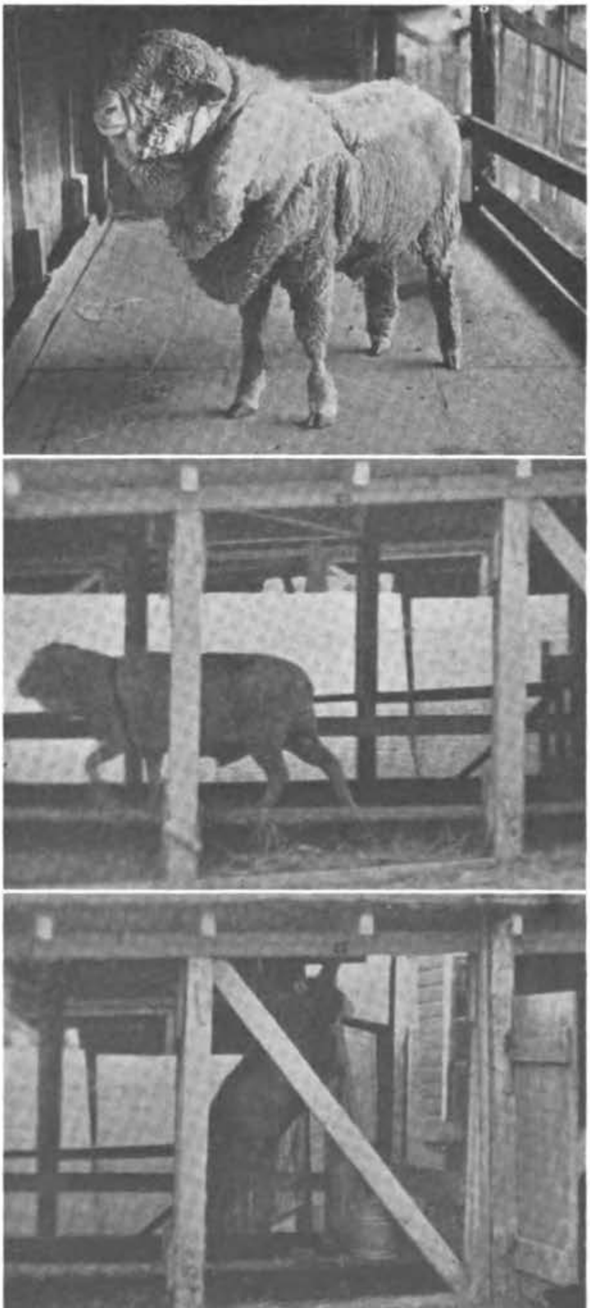


FIG. 17. Photographs showing the activity of normal and experimentally neurotic sheep on a special recording activity platform. The normal animal shown in *A* stands quietly. The neurotic animal shown in *B* and *C* shows signs of extreme agitation.

ally short-lived. The quieting effect of rest observed under laboratory conditions was also very evident in the platform activity. Activity showed a distribution of the same type as that of a typical normal sheep, that is, considerable activity during the daylight hours followed by almost complete rest during the night. However, after the laboratory signs of strain put in an appearance again, on resumption of the laboratory experiments, the distribution of the activity was again that of the neurotic, showing clear evidence of "insomnia."

The facts described above are shown in the graphic records of fig. 18. In this figure *A* represents the activity of the normal, undisturbed sheep, *B* the activity of the experimentally neurotic sheep #8, *C* the activity of this same experimentally neurotic sheep after one year's rest, *D* the activity of the same animal shortly after resumption of the nervous strain producing procedure in the laboratory.

The amount of spontaneous general activity of experimentally neurotic sheep was compared with that of "normals," when the animals were allowed complete freedom in the barn and pasture. In the experiments, two neurotics and two normals were used (sheep #8 and D, neurotic; sheep #4 and #7, normal). Activity was studied by means of pedometers. In each animal the pedometer, encased in a small wooden block, was strapped to one of the forelegs. Each instrument was carefully checked daily as to mechanical operation and as to its calibration in miles and tenths. Activity was determined on 21 consecutive days.

The results did not show any clear-cut difference in the activity of normals and neurotics. The two neurotics were slightly more active than one of the normals, but were considerably less active than the other normal. The average activity in 24 hours for each animal is shown in the table below, together with the activity range.

	Neurotic		*Normal*	
	Sheep #8	Sheep D	Sheep #4	Sheep #7
Average per day	.97 mi.	1.77 mi.	.91 mi.	2.54 mi.
Greatest activity on a single day	1.50 mi.	5.00 mi.	1.75 mi.	6.50 mi.
Least activity on a single day	.25 mi.	.75 mi.	.50 mi.	1.50 mi.

Although the neurotics #8 and D, whose nervous disturbance was at its peak at the time of this experiment (February 1937), were somewhat more active than sheep #4, they were not as active as sheep #7, it should be specifically pointed out that sheep #7 later developed an experimental neurosis of the inhibitory form, although at the time of these observations the animal was considered perfectly normal. We do not know whether or not this fact influenced the result.

Since the sheep employed in this experiment were all of mixed breed, the work is now being repeated with pure bred stock. There is evidence from a study of spontaneous activity of various pure bred strains of dogs (*3*) that a more definitive result may be obtained. Slender, wiry, "nervous" breeds, such as the German shepherd (German police dog) and the saluki were

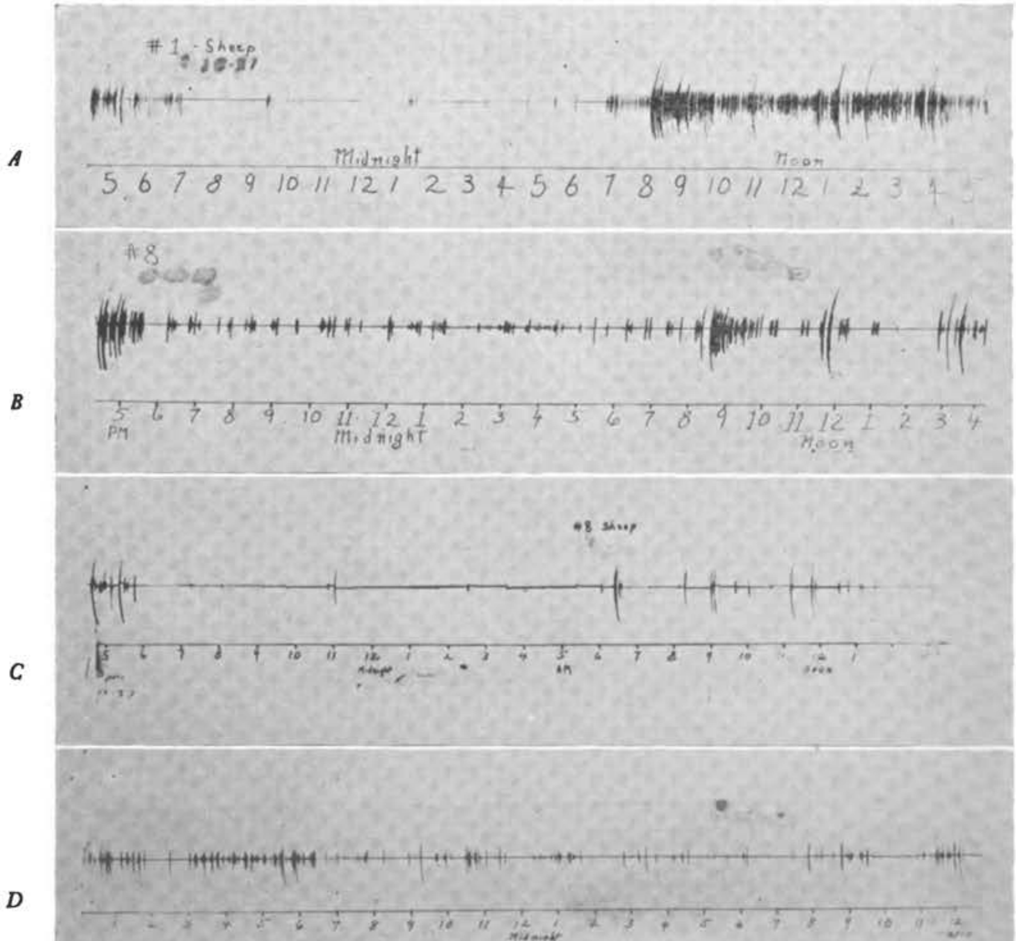


FIG. 18. Graphic records of the diurnal spontaneous activity of normal and experimentally neurotic sheep. *A* shows a record of a normal animal; *B* that of a typical neurotic. During the night hours the normal record shows quiescence, while that of the neurotic shows activity. Record *C* illustrates the effect of a prolonged rest from the experiments upon the diurnal activity. The animal is quiescent at night. Record *D* shows the return of the characteristic neurotic distribution of activity when the experiments were resumed in this animal following a period of rest. The activity of the neurotic during the night hours suggests "insomnia."

found to be far more active than the fat, stocky hound breeds such as the English bassethound, and the activity was fairly uniform within a breed. Similar evidence may be found in sheep. The purebred Cheviot may be more active than the Shropshire. In view of this possibility, it is clear that our mixed breeds of sheep, some exhibiting predominant physical characteristics of one breed, some exhibiting those of another, cannot be used successfully in determining a standard of general spontaneous activity applicable to the "normal" sheep in general. We must immediately ask the question, normal sheep of what breed? When a "standard" has been determined for each of several breeds, the activity of normal and neurotics within a single breed can then be directly compared. Until this is done results of activity studies of this sort will remain inconclusive.

The pedometer study of activity in our mixed stock of sheep was here presented as a case in point, demonstrating the importance of genetic considerations in these experiments and others of a similar type.

We have thus far described the overt, neuromuscular expressions of the experimental neurosis. We shall now present certain of its covert manifestations referable mainly to the autonomic nervous system.

The homeostatic mechanisms of the body require that there be compensatory changes in a number of the physiological functions when an individual is under emotional or mental stress. The action of these mechanisms is often expressed in an acceleration of pulse, a hastening of respiration, a rise in the blood pressure, sweating, and pilometer activities. These changes, no doubt, occur in all higher animals normally. They are, however, in the normal individual, usually of brief duration, appearing when the emotional or other mental state is present and disappearing when that state no longer exists. When the nervous system is under a more or less continuous strain, as in the human psychoneurotics, these physiological changes may persist over long periods of time. Thus it is well known clinically that persons continuously experiencing feelings of hostility may show a fairly constantly heightened pulse and elevated blood pressure. Other psychoneurotic patients may show equally perservering alterations in the rhythm and rate of respiration.

In the experimentally neurotic sheep and dogs we have observed, over a period of years, marked and continuous disturbances of respiration. And since 1934, following the development of a proper technique, we have noted an equally marked and persistent disorder of the heart's action. Disordered action of the sphincters was also noticed (micturition and defecation).

8) *Respiratory manifestations.* From Liddell's earliest conditioned reflex experiments on sheep, respiration has been a matter of study along with the motor reactions. In these experiments it was clear that conditioned stimula-

tion evoked not only movements of the reaction limb but a simultaneous alteration of respiration as well. And such an alteration could be detected even without the aid of recording devices, for breathing during stimulation became audible and forceful, and an increase in the respiratory movements of the abdomen and chest could easily be seen.

For recording respiratory movements in the sheep and dog the pneumograph has been used as the standard device, although other devices have on occasion been tried. In order to circumvent the artifacts incident to pneumographic recording, namely, the recording of the non-respiratory movements of the chest and abdominal musculature, a specially constructed mask was designed to be placed over the muzzle. Good records were obtained from this but unfortunately the animals (sheep on which it was tried) could not become accustomed to wearing it and its use had to be abandoned.

The rate, pattern and rhythm of respiration. In the flock of sheep, including of course both normal and neurotic animals, the rate, pattern and rhythm of breathing, observed in the laboratory or in the barn, showed marked variation from one animal to another and in the same animal from time to time. Naturally, much of this variation was associated with changes in atmospheric temperature, the rate, of course, being far more rapid in the late spring and summer months than in the cooler months of fall and winter.

In order to offset the temperature effect and thus standardize the conditions of the experiments, the studies of respiration were in large part carried out during the cold months of the year. Very few observations of respiration were made unless the temperature in the testing room was lower than 60 degrees F. At this temperature it had been found that panting did not occur.

In the 30 odd sheep whose respiratory rate was determined, the rate was found to range from 24 to 136 per minute. In general, the respiratory rate of the normal animals fell in the lower brackets of this range, their rate being between 24 and 40. The one notable exception to this was the case of sheep #2, with a respiratory rate of 136 who, nevertheless, showed no overt signs of experimental neurosis during the nine years in which he served as a subject of experimentation.

One of the most noticeable changes marking the progress of the experimental neurosis in the sheep as seen in the laboratory is the increase in the average respiratory rate as well as changes of pattern and rhythm which accompany it.

To cite a specific case, sheep #52, before the onset of the neurosis, exhibited in the intervals between stimulations an even, regular rhythm of breathing and a rate which averaged 40 per minute. After the breakdown had occurred both the rhythm and rate showed a great alteration. Breathing became very shallow and rapid averaging 120 per minute. Up to this point regularity of the rhythm remained unchanged. With the deepening of the neurosis, however, a slowing down of the rate took place, but this was not as slow as normal. Simultaneously the rhythm was distorted by frequent sudden gasps and by sighs. These sometimes preceded and sometimes followed each spontaneous tic-like movement of the reaction leg. At the peak of the neurosis apnoeic pauses became strikingly manifest, although no change

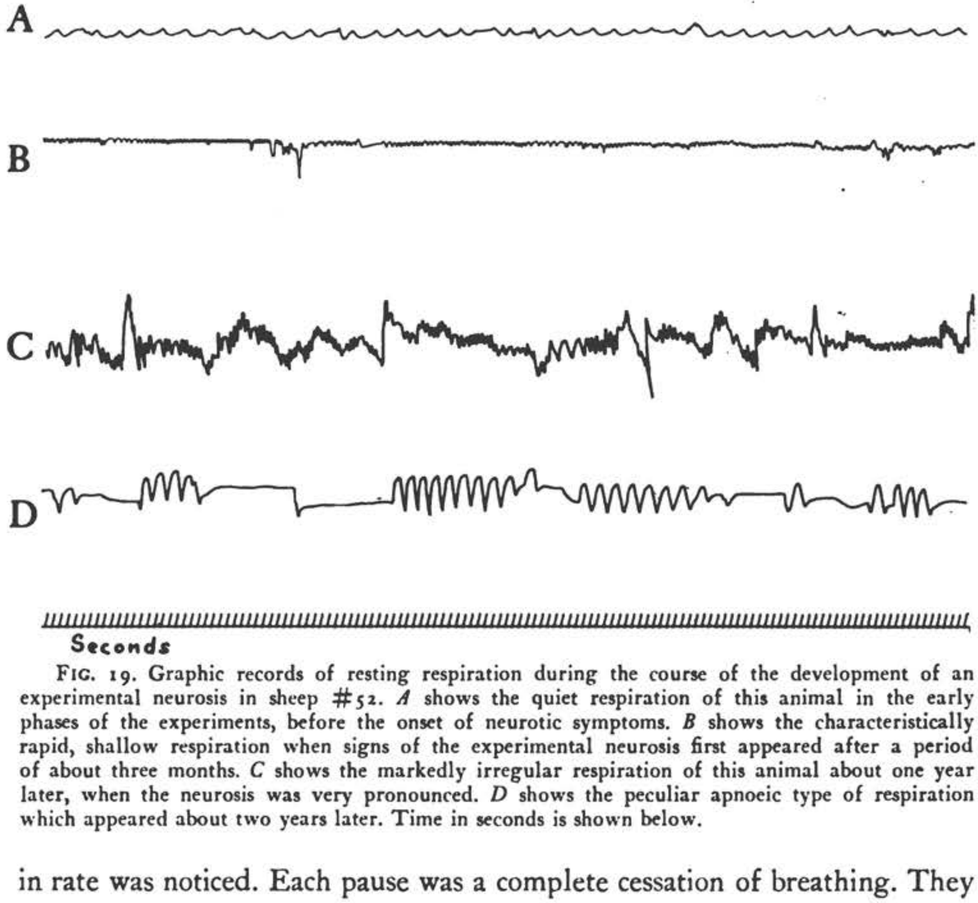


FIG. 19. Graphic records of resting respiration during the course of the development of an experimental neurosis in sheep #52. *A* shows the quiet respiration of this animal in the early phases of the experiments, before the onset of neurotic symptoms. *B* shows the characteristically rapid, shallow respiration when signs of the experimental neurosis first appeared after a period of about three months. *C* shows the markedly irregular respiration of this animal about one year later, when the neurosis was very pronounced. *D* shows the peculiar apnoeic type of respiration which appeared about two years later. Time in seconds is shown below.

in rate was noticed. Each pause was a complete cessation of breathing. They were at times as long as 20 seconds in duration. The resumption of respiration following a pause was characterized by deep inhalations and exhalations which diminished gradually in amplitude until breathing again ceased. Breathing was almost always resumed with a gasp. This type of respiration calls to mind Cheyne-Stokes breathing.

Fig. 19 represents the progressive respiratory changes in animal #52 described above. The changes were observed over a period of three years as the neurosis became more pronounced. Record *A* shows the even, regular breathing of medium depth characteristic of the normal animal before signs of the neurosis had appeared. *B* represents the second stage, namely, the rapid, shallow respiration seen during the early stages of the disorder. *C* shows the pronounced change in both rate and rhythm after the neurosis had advanced for about one year. This "agitated" type of breathing is characteristic of the terminal point of the experimental neurosis in most of the sheep. *D* illustrates the present stage of the condition at the end of three years with the apnoeic pauses clearly evident.

The deepening of the neurosis in many animals is climaxed by a phase distinguished by excessive motor activity. The animal is literally in continuous movement even during the intervals between stimulations. Every part of the body participates in this movement—the head is turned incessantly

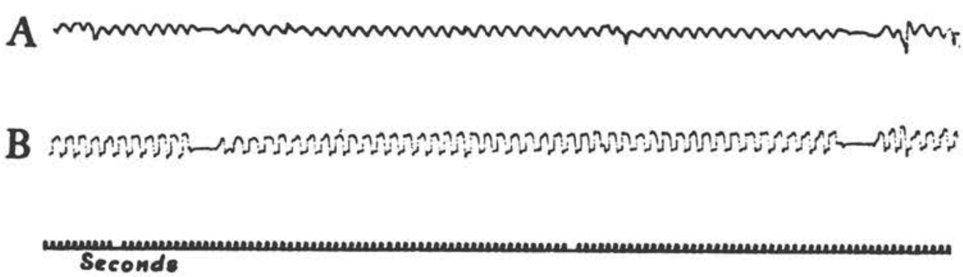


FIG. 20. This figure shows a comparison of respiration tracings taken in sheep #52 with the pneumograph and with the mask. *A* is the respiration as recorded by the pneumograph. *B* is a simultaneous record with the breathing mask. Note that both records show the apnoeic pauses. Time is given below in seconds.

from side to side, raised and lowered; all four legs are in motion; and trembling or shuddering are frequent. In respiration recorded by the conventional pneumograph placed about the abdomen, the tracing is greatly distorted by these movements. That many of these distortions are, nevertheless, truly respiratory in character is clearly shown when a mask is substituted for the pneumograph. They occur both during stimulation and during the intervals between stimulations. A comparison of the pneumographic record with the mask record can be seen in fig. 20.

It is interesting to note that Sutherland, Wolf and Kennedy (*24*), among other psychiatrists, have observed deviations from the normal respiratory pattern among psychoneurotics and psychotics.

Some preliminary studies of respiratory volume were made in 1938. The breathing mask referred to above was used. It permitted the total volume of expired air to be passed through an ordinary gasometer while at the same time a Veeder counter counted the respirations during the same period. The tests were carried out in the experimental room with the Pavlov frame removed and the various leads brought down to the animals from a central point overhead, so that the animal was permitted free locomotion within the confines of the room, a space approximately 10 by 12 feet.

Each member of the flock was tested in turn. The duration of the test was 10 minutes, and since all the tests were conducted during cold weather, when the temperature of the experimental room was below 25 degrees, the artifact of panting does not enter into the rate value.

The values obtained, both as to rate and volume, differed widely from one individual to another, and there was no consistent relationship evident between rate and volume as measured by the gasometer. There were cases in which neurotic animals had both low volume and low respiratory rate, and other cases in which equally neurotic individuals showed high rate and low volume. All the possible combinations of these two factors appeared in the flock and no consistent deviation from the average could be found to be the exclusive characteristic of the neurotic. This is in line with the well-known fact that the basal metabolic rate of psychoneurotic patients (without hyperthyroidism) does not differ in a characteristic way from that of normal individuals.

In view of the close dependence of respiration upon a large variety of factors (exercise, feeding, emotional state, fatigue, etc.) the variations between individuals of our flock do not appear surprising. To these "normal" variations there must also be added, in the present case, a possible artifact arising from the mask itself. Some of our animals were seriously disturbed by this appliance, as mentioned above, and spent the larger part of their 10 minutes in the experimental room running about and striking their noses against the wall and floor in an attempt to dislodge it. The actual oxygen need of the animal was not interfered with by the device. The tubes containing the valves were one inch in diameter and certain members of the flock with rate and volume equal to or in excess of those of wilder ones remained perfectly quiet or walked slowly about during the entire period of the experiment.

Experiments are at present under way to study the general metabolism of normal and neurotic sheep and dogs by means of a calorimeter chamber. The use of this chamber may throw light upon the problem of disordered respiration in the disturbed animals.

In the sheep, respiration was studied in the barn as well as in the laboratory in order to determine, in the neurotics, whether or not the laboratory disturbances were carried over into the "natural" environment. Respiratory tracings were made by means of a "long-distance" pneumograph placed about the sheep's chest and connected, by means of 20 odd feet of rubber tubing suspended overhead, with a recording tambour situated in a small enclosed observation and recording cubicle in the barn. Two such arrangements made it possible to record on the same drum simultaneously the respiration of two animals. The sheep under test could move freely about in the barn among the flock. They seemed, after a brief interval, to be unaware both of the pneumographs and tubes and of the presence of the observer operating the recording kymograph in the adjoining room, so that their behavior was "natural."

A number of such simultaneous respiratory tracings, comparing a normal with a neurotic sheep, were made, and a typical example is shown in fig. 21, in which the breathing pattern of a normal sheep (#4) may be contrasted

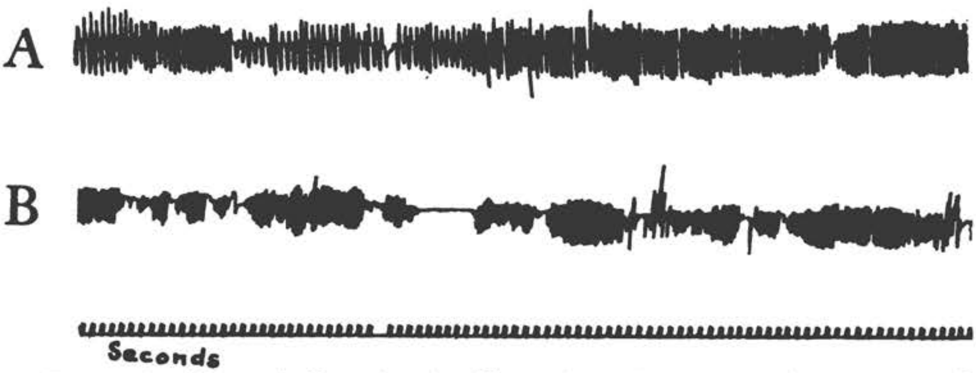


FIG. 21. Graphic records illustrating the difference in respiratory pattern between a normal (*A*) and an experimentally neurotic sheep (*B*) in the barn. The neurotic sheep was #52. Note, as in figs. 19 and 20, the appearance in the neurotic record of the apnoeic pauses. Note also that the breathing rate is far more rapid in the neurotic than in the normal. The records were taken on the two animals simultaneously, under exactly the same conditions. Time is given below in seconds.

with that of a neurotic sheep (#52) under precisely the same conditions. It can be seen at once that the respiration was much faster and more irregular in the neurotic than in the normal. Note particularly the apnoeic pause in the neurotic. The time record below is in seconds.

Similar striking contrasts were noted in other neurotic sheep compared in this way with the normals. The respiratory rate in some cases was about twice as rapid in the neurotic as in the normal and similar distortion of the rhythm was observed. This distortion, however, is at least in part due to non-respiratory movements of the chest and abdominal muscles occasioned by startle responses and other sudden movements.

The importance of this result is that it clearly demonstrates, as does the diurnal activity, that the experimental neurosis expresses itself in manifestations outside as well as inside the laboratory. And further confirmation of this fact was found in a study of the pulse rate and rhythm in the barn, reported in the next section.

Respiratory disturbance in the experimentally neurotic dogs was remarkably similar in general pattern to that in the sheep, although certain differences are noteworthy. The three nervous cases (dogs #868, #881 and #929)showed a characteristic and persistent heightening of respiratory rate together with distortions of rhythm.

Out of the colony of 26 dogs, whose conditioned reflexes (salivary and motor) were studied, a statistical analysis of respiration was made in 12 animals. The analysis was made from respiratory tracings taken during the course of 250 conditioned reflex experiments in the laboratory. Since the conditioned stimuli were presented rhythmically, at exactly 5-minute intervals, the respiration during these non-stimulated intervals was chosen as a standard for the determination of rate and rhythm.

Five of these dogs were trained with the motor (defensive) reflex technique and seven with the salivary. Since the two techniques produced a difference in the respiratory rate we shall consider the two groups separately and comparatively. In the first group, including three normals and two neurotics (#868 and #929) the resting (interval) rate ranged from 8 per minute, the slowest rate seen among all the animals at a given time, to 35 per minute, the highest rate. However, the highest average rate of this group was 19 respirations per minute. The range in the normals was 8 to 20, averaging 14, while that of the neurotics was considerably higher, being 12 to 35, averaging 24. The highest rates appeared in the latter animals when they were in a state of manic excitement. The conditioned stimulus signalling shock evoked an increase of respiration, and this was much greater in the neurotics than in the normals. For the normals this increase averaged 5 respirations per minute, for the neurotics, 9 per minute.

In the second (salivary reflex) group, including six normals and one neurotic (#881), the range and the average of the respiratory rate were notably less than in the first (motor reflex) group. The lowest rate observed was 6 per minute in an animal asleep on the platform; the highest, 28 per minute in the neurotic dog. The average rate of the group as a whole was 15 respirations per minute. The range of the normals was 6 to 21, averaging 15 as compared with 14 in the first group; while that of the neurotic dog was 14 to 28, averaging 20 as compared with 24 in the first group. As in the neurotics of the first group the most rapid respiration in this dog was observed during marked nervous excitement. (See case history of dog #881.) The average increase in the respiration rate induced by conditioned stimulation, signalling food, was no different in the neurotic from that in the normal. On the average the stimulus caused an increase of 1.8 respirations per minute in the normals and 2 in the neurotics. The difference between the normals and neurotics was much greater in this respect in the first group (an increase of 5 in normals and 9 in neurotics).

In each experimentally neurotic case in the dog the respiration rate and rhythm were altered progressively as the neurotic symptoms became increasingly more manifest. This is well illustrated in the case of dog #868. (See case history for the stimulation conditions and procedure.) In the early stage of the experiments, when positive stimulations alone were being given, no attempt being made to establish a differentiation, the dog stood quietly in the 5-minute intervals between stimuli. During one month at this stage the respiration rate in the resting intervals averaged 14 per minute, and little deviation from this average was seen, the range being 12 to 16. A differentiation of conditioned stimuli was now attempted without success. As the attempts were continued the dog became nervous. It could not distinguish between metronome 120 (beats per minute) and metronome 42. Signs of the experimental neurosis were in evidence for some months. During one month of extremely agitated behavior the average respiration rate was 19, the lowest rate being 16 and the highest, during great excitement, being 35. The rhythm was very irregular. During subsequent experiments in which the dog solved an easier problem (metronome 120 *vs.* metronome 36) the signs of nervousness diminished and finally disappeared. The respiration rate during a typical month near the end of work on this dog averaged 16 per minute, the range being from 12 to 20 per minute. The breathing was regular.

A similar relationship between nervousness and respiration was observed in the cases of dogs #881 and #929.

On the whole, when the respiration of the dogs is compared with that of the sheep, it is apparent that the range was considerably less in the former (6 to 35 respirations per minute) than in the latter (24 to 136 respirations per minute). In addition, there were characteristic differences in the respiration of neurotic dogs as compared with neurotic sheep. The breathing records taken in the intervals between stimuli show not only that, during excitement, the dog had a lower maximal rate than the sheep (35 per minute in the dog as compared with 136 per minute in the sheep) but that the dog exhibited a much less evident and marked distortion of respiratory rhythm as well. This latter fact can be seen by comparing the respiratory tracings of the neurotic dogs #929 and #868 in figs. 9*B* and 30*A* respectively with those of a neurotic sheep in fig. 19 (particularly *C*). Sudden gasping, seen frequently in the disturbed sheep, was seldom observed in the dog, although sighing was occasionally seen. The apnoeic pauses shown in the sheep records in fig. 19*D* were never noted in the dog.

The sheep's typical respiratory response to the conditioned stimulation, signalling shock, was a series of sudden, sharp, deep inhalations and exhalations, the breathing rate being increased. The shock itself evoked an exceedingly deep inhalation or gasp. It never evoked vocalization. The dog, on the other hand, exhibited, under the same conditions, a somewhat different respiratory reaction. The conditioned signal evoked only a slightly increased depth of breathing and a moderate increase in rate. The shock often caused a slight gasp accompanied by vocalization (a yelp). Frequently the mild shock (in the case of the dog a single break shock was employed instead of the tetanizing shock used on the sheep) caused little perceptible change in respiration.

9) *Cardiac manifestations.*[6] *Heart rate and rhythm.* The study of the sheep's cardiac reactions, in association with the conditioned motor reflex, was begun in 1935. Initially, a long-distance stethoscope was used. This arrangement consisted of the chest piece of a stethoscope placed over the apical region of the heart and held in position by a belt about the sheep's chest. To this a 14 ft. rubber tube was attached and connected in the adjoining recording room with the ear pieces. The observer listened to the heart beat and recorded it upon the kymograph by operating a telegraph key which actuated a signal marker. Thus a picket fence type of record was obtained. The manual recording was, however, not entirely satisfactory due to subjective errors, *i.e.*, the reaction time of the observer together with his preoccupation with the operation of a number of other devices simultaneously recording. To answer this need one of us (R.P.) designed and constructed a direct recording vacuum tube cardiotachometer. This device has been successfully used in all conditioned reflex experiments at the Cornell Behavior Farm in which continuous pulse records were required. It should be pointed out, however, that, although good records were usually obtained, the recording of the heart beat was sometimes masked when the animal's muscular reactions became extremely violent.

As in the study of respiratory rate, the studies of the pulse rate took place during the cooler months of the year. The heart rate was found to be highly variable, both from individual to individual and in the same animal from time to time. In the flock as a whole we encountered a range of 56 to 180 beats per minute. The higher limits of the range represent pulse rates in the experimental environment.

We have observed that the average rate of pulse in normal sheep in the experimental room is distinctly lower than that of the neurotics. A detailed

[6] The manifestations described in this section refer altogether to the sheep, since no systematic observations of the heart's action were made in the experimental dogs.

study of this phenomenon has appeared elsewhere (2). It is sufficient here to mention that the average resting rate of two normal sheep in the laboratory was 82 beats per minute as contrasted with an average of 107 beats per minute for three neurotic animals in the same room.

Not only was the pulse rate of the neurotics faster than that of the normals, it was also far more irregular. The most obvious form of irregularity observed was a spontaneous and a fairly sudden change of rate. The rate on many occasions changed, for example, from 84 to 100 and back to 84 within five seconds, many such alterations being seen during the course of 5 to 10

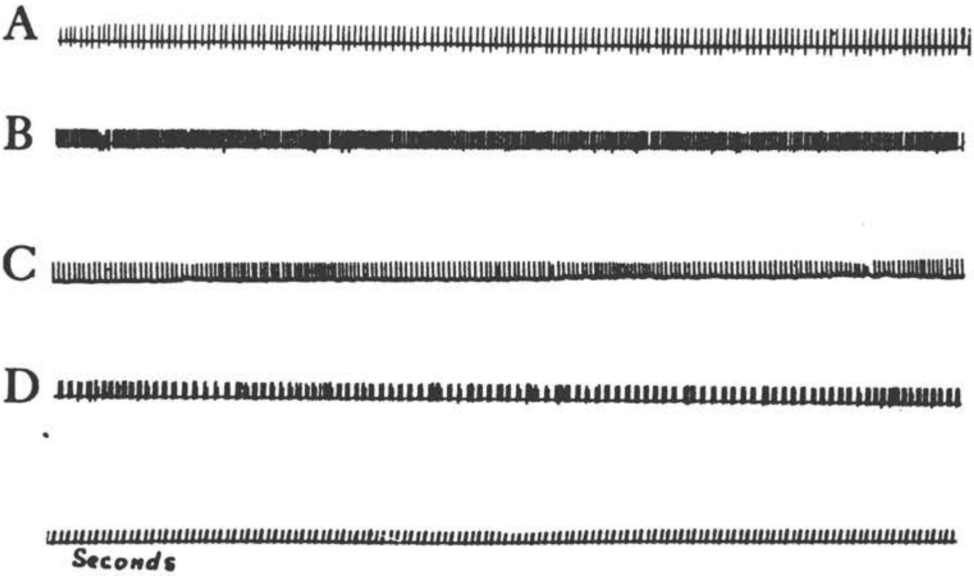


FIG. 22. Records of the heart beat taken with the cardiotachometer in normal and experimentally neurotic sheep. In the latter, several varieties of pulse abnormalities are shown. *A* shows a record of the regular, slow heart beat of a normal animal. *B* shows marked acceleration of the pulse without irregularities of rhythm, seen in the early phases of the experimental neurosis. *C* shows a rapid pulse with sudden changes in rate. This is seen in a number of the older neurotic animals. *D* shows slow pulse rate with marked irregularities, *i.e.*, premature beats and coupled rhythm, seen in our oldest case, sheep D. Time is shown below in seconds.

minutes of continuous observation. However, other types of irregularity were seen, such as premature beats and coupled rhythm.

In fig. 22 cardiotachometer records in normal and neurotic sheep are shown. The above types of disordered heart action in the neurotic animals can be directly compared with the heart action of a typical normal. The records were all made in the laboratory during quiet periods. In *A*, the record of a normal, quiet sheep, the pulse is regular and slow, averaging 64 beats per minute. *B*, which is the record of a highly disturbed animal, shows a pulse which is fairly regular but much more rapid, averaging 112 beats per minute. This is characteristic of the early stage of the neurosis in almost every case. This condition differs from type *C* in which the rhythm is irregular and is marked by spontaneous accelerations of considerable degree. This type of pulse is frequently found in our older neurotic animals as is also type *D*, which is characterized by coupled rhythm and premature beats.

These types of neurotic pulse represent broad categories of classification and show a general trend. They may, however, show variations from day to day and merge with one another. Thus, type *B* may on a certain day show characteristics of either type *C* or type *D*.

In order to find out whether or not such differences between the normals and neurotics could be detected outside the laboratory as well studies were made of the resting heart rate of the animals while they were in the barn. This was done employing the long-distance stethoscope so that the animals were unaware that they were under observation. It was found that even under these "natural" conditions a comparable difference between the pulse rate of normal and neurotic individuals still existed. In the barn the two normal animals cited above had an average pulse of 71 as compared with an average of 83 for the three neurotics.

In the experimentally neurotic sheep the heart was found to be extremely sensitive to conditioned and other stimulation. The signal followed by shock, and indeed any unusual sound or sight, evoked a sudden, marked and prolonged rise in the pulse rate. In the normal, quiet sheep the same stimulation either elicited no cardiac reaction at all or a gradual, slight acceleration in rate which returned to normal within a few seconds after the stimulation had ceased.

Such observations were made, not only in the laboratory, but in the barn as well. Here the usual night sounds such as the barking of a dog, the passing of an automobile, and the like, always caused brief acceleration of the pulse in the neurotic sheep and no pulse change in the normals standing beside them.

In the course of our observations of the heart we encountered a curious and unexpected disparity between the cardiac and neuromuscular response to stimulation in one sheep showing the inhibitory form of the neurosis. This animal (#7) had been trained for many years to a series of 10-second buzzer stimulations habitually reinforced by shock. In 1937 we began work to establish a response to a metronome beating 60 times per minute, reinforced by shock, and the animal's habitual feeble reaction was quickly stabilized. A typical response at this period consisted of an acceleration of the heart at the end of 8 seconds of stimulation, occasionally accompanied by a feeble defensive reaction of the conditioned limb and a general alerting movement upon the platform.

When the duration of stimulation was increased to 20 seconds it became apparent, after a few trials, that the animal's cardiac responses were still taking place in accordance with the long familiar 10-second stimulation, the acceleration occurring only after a latent period of about 10 seconds or at the time when the shock would have been delivered. Fig. 12 shows this response very clearly. There is an acceleration of the pulse beginning at 10 seconds but this is transitory, the heart slowing again within a few seconds. It is not until 18 seconds have passed that the animal gives any evidence of anticipating the shock. This is shown by a slight movement recorded on the platform line.

As pointed out above, in most neurotic sheep the heart was found to be extremely sensitive to the application of the conditioned stimuli. Often the heart rate was accelerated by the very first tick of the metronome and it became more and more rapid up to the moment of the application of the shock. This was the typical pattern. And the case cited above was the only exception observed.

The electrocardiogram. Using the Hindle electrocardiograph we have obtained electrocardiograms in both normal and experimentally neurotic sheep under carefully standardized conditions. The records were all made in the conditioned reflex laboratory, with the sheep standing upon the platform in the animal room as though a conditioned reflex experiment were about to begin. However, no such experiment was carried out. The cardiograph and the operator were in the same room with the animal. The room was necessarily darkened.

Three modified battery-clip electrodes were used. They were attached to freshly shaved spots on the two forelegs and the left hind leg. In each animal the conventional leads I, II and III were taken. The string was standardized in each lead to deflect 1 cm. per millivolt of the standardizing current. The animal's resistance was taken in the case of each lead. In most cases this resistance was well below 3000 ohms and, on the average, about 1500 ohms. The standardized string deflection was registered upon each record.

The electrocardiographic wave forms of the neurotic sheep were not characteristically different from those of normal sheep. When the limb electrodes were used the T-waves were inverted in all three leads in both normal and neurotic animals. For all the sheep the P-R interval was 0.12 seconds, the Q-R-S interval 0.04 seconds, and the S-T interval 0.08 seconds. In the old neurotic sheep D, on which electrocardiograms had been taken regularly for about two years, the R-wave voltages were always larger than in the other sheep, but this fact may not be associated at all with the neurosis. It

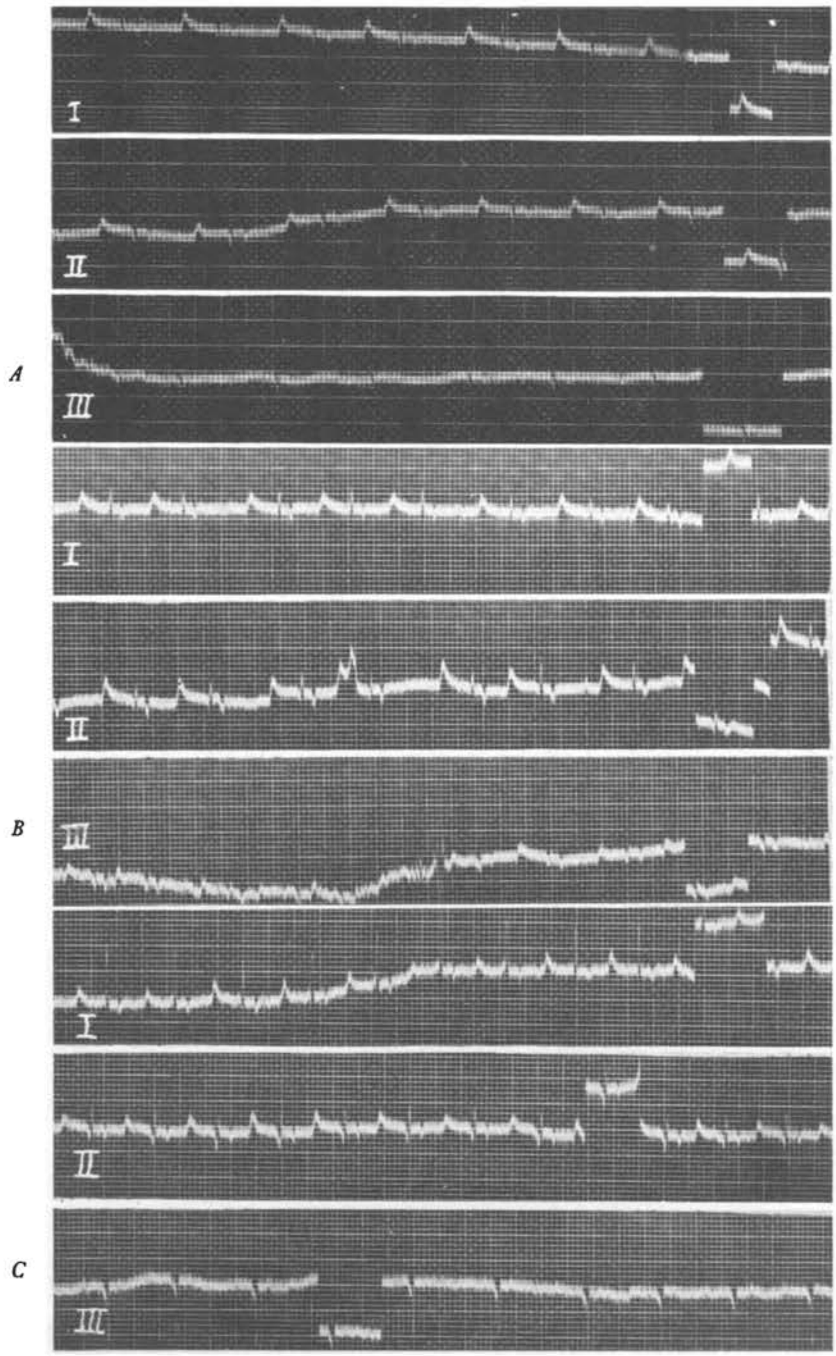


FIG. 23. Typical electrocardiograms of normal and experimentally neurotic sheep. *A* shows records of a normal sheep. *B* shows records of sheep #52, an experimentally neurotic animal. *C* shows those of sheep D, an old neurotic animal. The numerals I, II, and III indicate the three standard electrocardiographic leads. No essential characteristic differences are to be found in the records of the normal and the neurotic animals.

may be due to a large heart[7] or to other factors known to produce an increase in R-wave voltage.

Typical records of leads I, II and III taken in normal and neurotic sheep are shown in fig. 23. *A* is that of a normal animal and *B* and *C* are those of neurotics.

In a few sheep electrocardiograms were taken during the conditioned stimulation. We wished to study the cardiographic wave forms during a condition of excitement.

Successful records of this sort could be taken only on those animals who would stand fairly quietly during the conditioned signal. The inhibited neurotic sheep #7, described above as exhibiting a delayed cardiac acceleration followed by deceleration during the conditioned stimulation, was the best animal for this purpose since it stood without movement during a metronome signal lasting as long as 30 seconds. In this animal and in two others, sheep D, neurotic (in a quiet phase) and sheep #4, normal, an interesting result was found. When the stimulus induced the usual cardiac acceleration, the normal *positive* T-wave of the electrocardiogram disappeared and, as the stimulus continued, the T-wave reappeared, but in *inverted* form. This T-wave inversion continued throughout the rest of the stimulation and in some cases for some minutes after stimulation had ceased, when it gradually assumed the upright position. This result was repeatedly obtained in the three sheep upon which the test could be made. It is shown in the electrocardiogram of sheep #7 in fig. 24.

In these experiments two battery-clip electrodes were used. One was attached over the apex of the heart on the left side of the chest, the other being attached to the right shoulder.

The inversion of the T-wave, we suggest, may be due to a vasomotor reaction of the coronary vessels during the emotional excitement (possibly "fear") incident to the conditioned stimulation signalling the approach of the electric shock. Since T-wave inversion occurred during cardiac acceleration, a diminution of the oxygen supply to the heart muscle due to constriction of the coronary vessels, occurring at such a time, might conceivably produce the inverted wave form. Such an explanation might account for the fairly common observation of farmers that sheep sometimes drop dead when being chased by dogs.

This problem of the T-wave inversion during exciting conditioned stimulation merits further investigation. Anatomical study and dissection of the coronary vessels in the sheep may throw light upon this question.

[7] We intend, of course, upon this animal's death, to make an anatomical study of the heart at autopsy.

10) *Micturition and defecation.* In the majority of the experimentally neurotic sheep the urine and feces were retained throughout an entire experimental period in the laboratory which at times was as long as an hour and a half. And it was very interesting to note that as soon as the experimenter

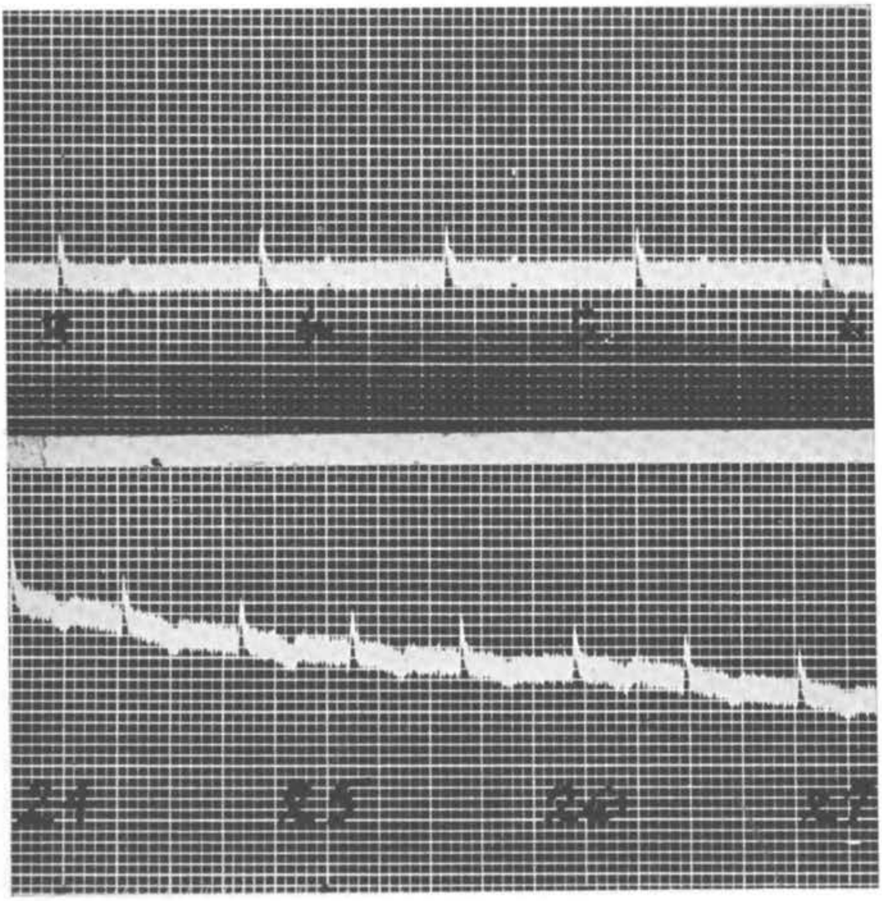


FIG. 24. An electrocardiogram taken during conditioned stimulation in an experimentally neurotic sheep, #7, which showed an inversion of the T-wave. The conditioned stimulus was a metronome sounded for 30 seconds, followed by a shock. The records show the heart action during the first part of this signal (3rd, 4th, 5th and 6th seconds) and during the latter part (24th, 25th, 26th and 27th seconds). At first the heart is not accelerated and the T-wave remains in the upright position. During the latter part of stimulation, as the shock is approaching, the heart rate accelerates and the T-wave becomes inverted. The possible significance of this finding is discussed in the text.

came into the room and *began* to release the animal from the restraining harness, thus indicating that the experiment was over, both the bladder and anal sphincters were relaxed, releasing a copious amount of urine and feces upon the experimental platform. This was almost invariably observed year in and year out in these cases. Sometimes, however, the contraction of the sphincters would be maintained until the animal was outside the building and approaching the animal quarters, when micturition and defecation would take place. In any event, the end of the experiment was always accompanied by an emptying of the bladder and rectum.

In one of the neurotics, sheep D, the violent manic motor reactions evoked by the conditioned stimulation signalling the approach of the shock (see fig. 1, right) were frequently accompanied by both micturition and defecation. During the intervals between stimuli, however, the urine and feces were retained, unless spontaneous manic reactions occurred as occasionally happened.

In another neurotic sheep, #11, as the neurosis deepened an interesting deviation from the above general picture was observed. In each pause between stimuli, of 5 minutes duration, the sheep was quiet during the first minute after stimulation, but evidences of nervous tension became increasingly evident as judged by an increase in the number of spontaneous leg movements as the time for the next stimulus approached. This increase in tenseness was accompanied by a small but almost continuous flow of urine. We have noticed such a flow to continue without interruption for as long as three minutes of the interval and up to the very moment of presentation of the next stimulation, at which time the flow would suddenly cease, the sphincter remaining contracted during the period of stimulation (10 seconds) and for about one minute afterward, when the flow would be resumed. On one occasion this slow dripping (occasionally a continuous stream) was observed to occur with few interruptions for a period of 12 minutes.

In the neurotic dogs a state of violent excitement in the laboratory was very frequently accompanied by micturition. Defecation under such circumstances was never observed.

Micturition accompanying manic reactions was most often noted in the experimentally neurotic female dog (#881). This was seen in the intervals between stimuli during which remarkably intense struggling responses appeared (described in a previous section). In the male dog, #868, trained by the motor reflex technique, micturition occurred at times during the vigorous, struggling type of conditioned motor reaction.

In normal sheep and dogs, in which less intense "emotional" reactions were encountered, micturition and defecation were not seen in the laboratory.

3. Social and Emotional Manifestations

Anti-social behavior. The experimental neurosis manifests itself not only by changes in the reflex actions of the central and autonomic nervous systems but by changes in social behavior as well. And, although these latter alterations are not expressible in quantitative terms as are the reflex changes, they are none the less notable.

Outside of the laboratory one of the most striking symptoms exhibited by certain experimentally neurotic animals was that of shyness. This was especially evident in two of the dogs (#881 and #929), as mentioned in a previous section ("Diurnal neuromuscular activity outside the laboratory") and in one of the sheep (#52), also mentioned in the same section.

These dogs showed every evidence of shyness in their reactions to other dogs and to the experimenter. It will be recalled that they were especially shy of the companion dog in the same kennel run when only a single pan of food was placed in the run. The normal companion got the food always, while the neurotic went hungry. Each of these dogs appeared to be quite content to be left by itself in its kennel pen. (Indeed this had to be done in order that the neurotic animals might get sufficient food.) And the evidence for this solitariness was that the animal paid little attention to the other dogs in the adjoining runs, showing, for example, no sign of joining in their playful running and barking activities as normal neighbor dogs always did. Indeed it is interesting to note that the observer never heard dog #881 bark at all in the kennel.

The anti-social behavior of the neurotic sheep #52 was so pronounced that it merits further description.

Everyone is aware of the immense gregariousness of the domestic sheep and hence changes in this fundamental reaction of the animal are all the more easily observable and the more striking when they appear.

In the case of this sheep a deepening of the neurosis was accompanied by a drawing apart from its mates in the natural environment of the barn and pasture. This animal, when the others pressed toward the food trough to get their daily ration of oats, would run about on the fringes of the flock and would make no effort to thrust aside the animals already feeding. This is shown clearly in fig. 25. If the observer approached the flock this sheep, instead of dashing to cover amidst the others, did just the opposite, *i.e.*, ran wildly out, often toward the source of potential danger. When dogs attacked the flock it was the neurotic sheep #8 that was killed, as mentioned above.

When the flock, feeding in the pasture, ran toward the barn at the call of the attendant, this sheep alone of all the number would refuse to come with the others and could be caught only after the greatest exertion. Further, when feeding in the pasture, this particular animal did not attach itself to the group but remained often as much as 200 yards away from the main body of the flock.

Aggressiveness. During marked agitation both neurotic dogs and sheep became at times somewhat aggressive. And this was but little more marked in the dog than in the sheep, in spite of the fact that the sheep is ordinarily thought of as a most docile animal.

As was pointed out above, the shy, neurotic dog may suddenly, when cornered, attempt to attack and bite the attendant. This type of reaction is in all likelihood engendered by fear and by uncertainty as to what the attendant is about to do. Whatever the cause, the observer finds out from experience that this is the type of dog which is a "biter." Similarly, when

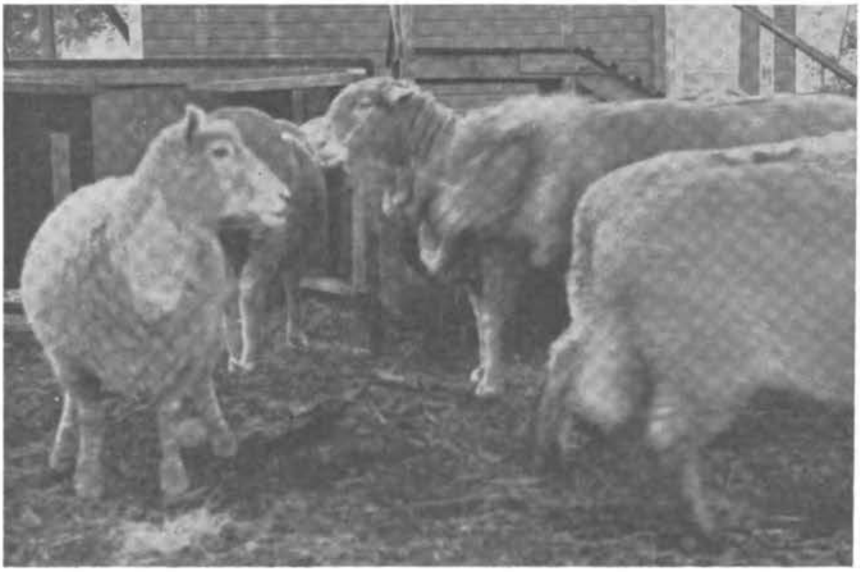


FIG. 25. A photograph showing a neurotic sheep, #52, circling about the fringes of the flock which is feeding at the trough in the barnyard. This animal (at the extreme left) made no attempt to thrust its way toward the trough, but segregated itself from the other sheep.

such an animal is in a state of manic excitement during an experiment it may exhibit aggressive (attacking) behavior. However, apparently it is never aggressive with other dogs.

Among the neurotic sheep, two of the animals, sheep D and #11, developed traits of aggressiveness not seen except in rams heretofore. Animal D is, moreover, a female, which renders this phenomenon all the more astonishing in her case. After being brought to the animal room and put in the Pavlov frame she frequently attempted to butt and bite the experimenter. The castrate male, #11, showed more violently aggressive performances. It was the only sheep observed who attempted, in addition to biting and butting, to kick the experimenter in the face as he bent over to adjust the harness. The sheep had never shown the slightest evidence of such behavior until the experimental neurosis supervened. The kick, delivered with the hind leg, was so often observed that the caution "watch your glasses" was well known in the laboratory.

"Anxiety or apprehension". When the objectively observed behavior of the neurotic sheep and dogs is interpreted in psychological terms, it is undoubted that these animals experience apprehension and terror. Unlike the patient being examined by the psychiatrist, however, the animals cannot tell us that they are "afraid," but this is certainly a reasonable interpretation to put upon the facts. The fact, for example, that the neurotic sheep attempts to run away from the experimenter in the barn, that he runs to a corner, stands trembling, crouches and urinates, coupled with his extreme restlessness and refractoriness in the laboratory situation, all confirms this interpretation. These actions of the sheep "tell" us that he is apprehensive. And the fact that this apprehension is persistent is shown by the spontaneous, tic-like movements of the reaction leg in the laboratory, which may be thought of as a symbolic form of running away, and by violent over-reactions. Regarding these latter the reader has only to view the abnormal posturing of sheep D (fig. 1, right) to confirm this by his own observation. Similarly, the manic reactions of the dog in the laboratory, the trembling, the crouching posture, the micturition, and so on, point to the same conclusion. Such dogs are "afraid."

However, it is not vital to the particular view which we take in this work to labor this point. We are concerned primarily with that part of the total syndrome which can be directly observed and studied by instrumentation, without dependence upon psychological interpretation.

Sexual and reproductive reactions. Sheep habitually go through their rutting period in the late summer and autumn, but no apparent change in the magnitude of the conditioned reflex, in the respiration, or in the pulse, centering around this period, has been noted.

Copulative behavior in the female was normal in all cases. Nor was there any neglect of their lambs on the part of the neurotic ewes.

The only possible sexual deviation observed among the neurotic dogs was in the excessively shy dog, #929. This male dog, on several occasions, paid no attention whatever to a bitch in heat placed in the same pen with him. The female, #881, came in heat regularly and was normally receptive to the male.

4. Variability of the Manifestations

The symptomatology of the experimental neurosis in both sheep and dogs was found to be extremely variable—so variable, in fact, that *variation must* *itself be considered as symptomatic of the disorder*. For indeed the experienced worker in this field has come to know that he cannot expect to find in his cases a standard, uniform, stereotyped set of symptoms. Such uniformity is far from the actual fact. The syndrome in animals as well as in human psychoneurotics exhibits numerous, heterogeneous and somewhat diffuse features.

In the present animal cases the symptom complex varied not only from one individual case to another but also in the same case from one day, week or month to the next. A perusal of the numerous manifestations described in the above section will to a certain extent disclose this fact. However, we shall here cite a few examples from the case histories in order to make this point clear.

Probably the most variable manifestation is that of *hyperexcitability*. When we examine the protocols and graphic records of experiments on the various neurotic animals, extending over a period of years, it is at once evident that this symptom varies not only from animal to animal but also from time to time in the same animal. Its variation between animals is well illustrated by comparing the case of sheep A with that of sheep #8. When the neurosis was at its height the former animal was always extremely quiet when the attendant went to the barn to fetch him, whereas the latter, on almost every occasion, ran immediately into a corner, crouched trembling and urinating and when approached closely collapsed to the ground and had to be carried to the laboratory.

Indeed, in the case of animal #8 it is our belief that its life was lost through the operation of this extremely passive type of defense reaction, for this sheep apparently made no attempt to defend himself when attacked by dogs.

Excitability among the neurotic group varied considerably in the laboratory. In some sheep it took the form of tossing movements of the head, while in others little of this form of activity was seen. Sheep #52 and sheep D exhibited these movements to a marked degree while sheep #7 did not. The type of movement was a quick, jerky alert motion which often had an offensive significance, that is, the sheep often attempted to butt. And we have frequently seen sheep #11 attempt to bite the shock electrodes attached to the reaction limb, a performance which has not been observed in any other animal in the flock.

Spontaneous leg movement is one of the most frequently seen expressions of excitability in the laboratory, but even this manifestation was not found in all animals, and substitutive reactions sometimes took its place. Sheep J, in which "fixation" or immobilization of the reaction limb took place during stimulation, showed practically no spontaneous movements during the succeeding intervals, but remained almost immobile with head lowered until the nose was practically touching the floor. Sheep #8, on the other hand, manifested spontaneous movement of one of the limbs during the entire eight years of its life. Other animals evinced this manifestation in a lesser degree, so that there was a continuum extending from extremely active animals such as #52 and #8, who were in almost continuous motion, to relatively inactive ones such as sheep J, who remained practically immobile even during the actual period of conditioned stimulation.

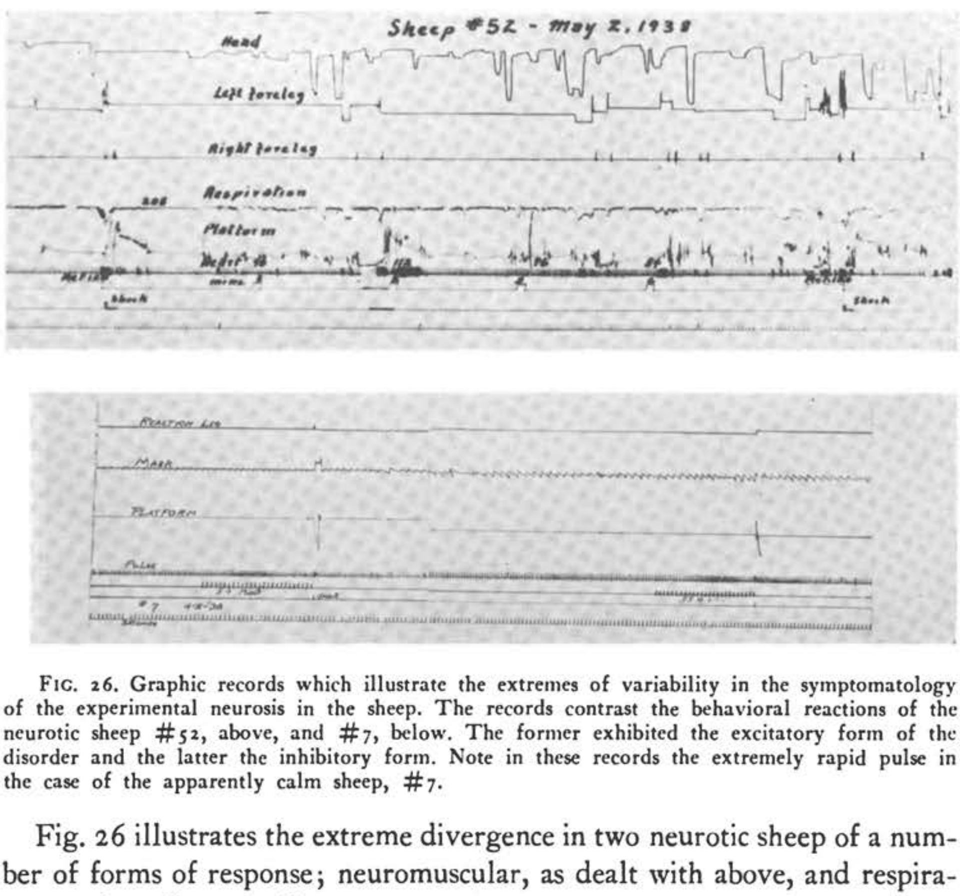
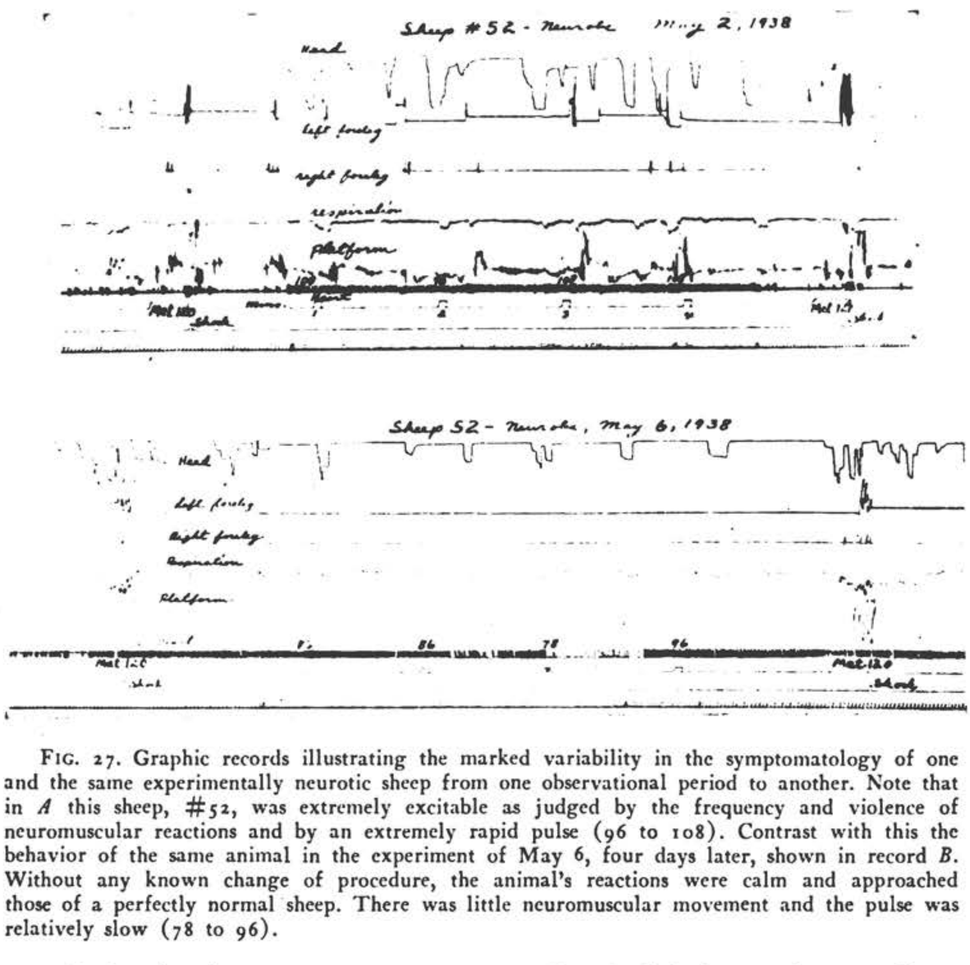


FIG. 26. Graphic records which illustrate the extremes of variability in the symptomatology of the experimental neurosis in the sheep. The records contrast the behavioral reactions of the neurotic sheep #52, above, and #7, below. The former exhibited the excitatory form of the disorder and the latter the inhibitory form. Note in these records the extremely rapid pulse in the case of the apparently calm sheep, #7.

Fig. 26 illustrates the extreme divergence in two neurotic sheep of a number of forms of response; neuromuscular, as dealt with above, and respiratory and cardiac as well.

Phasic variations in excitability occurred in all neurotic animals. We shall cite the cases of Sheep A and D as examples. In the first animal the habitual spontaneous leg movements disappeared completely for a period of about 4 months, during the mid-term of its experimental neurosis. After this brief interlude, the movements reappeared and continued up to the time of death, about 3 years later. In the case of sheep D, two phases of quietude occurred. This animal had been a lifelong neurotic, but under the influence of an experimental procedure consisting of a long series of unreinforced stimulations occurring in its ninth year a very marked diminution of spontaneous activity was observed which endured for the term of this phase of the experiment. As soon as stimulation upon a rigid time schedule was reintroduced the excitable form of the neurosis immediately reappeared. Finally, however, in the animal's twelfth year, despite the continuation of this procedure, there has taken place a general slowing down of the bodily processes, accompanied

A



B

FIG. 27. Graphic records illustrating the marked variability in the symptomatology of one and the same experimentally neurotic sheep from one observational period to another. Note that in *A* this sheep, #52, was extremely excitable as judged by the frequency and violence of neuromuscular reactions and by an extremely rapid pulse (96 to 108). Contrast with this the behavior of the same animal in the experiment of May 6, four days later, shown in record *B*. Without any known change of procedure, the animal's reactions were calm and approached those of a perfectly normal sheep. There was little neuromuscular movement and the pulse was relatively slow (78 to 96).

by a diminution in spontaneous movement, the whole being perhaps attributable to advancing senility. Day to day phasic variations in the manifestations were frequently seen in these and other neurotic sheep. These may be seen in the case of neurotic sheep #52 in fig. 27.

The pattern of respiration also showed individual and phasic variation. Although the hyperexcitable neurotic sheep usually exhibited hastened and distorted breathing not all the neurotics showed this. Slow, regular breathing was frequently seen in sheep D. Sheep J and #7, with the inhibitive form of the neurosis, also had a slow, regular pattern.

An illustration of phasic respiratory variation was seen in the case of sheep #52 (see section on respiratory manifestations and fig. 19). When first experimented upon this animal had exhibited slow regular breathing. As neurosis supervened, the respiration became shallower and more rapid. As the neurosis deepened, this phase was succeeded by one marked by a highly irregular pattern in which deep inhalations were followed by rapid shallow breathing and the trace upon the kymograph was highly irregular in appearance. However, in the animal's sixth year, the respiratory pattern has shown a further change in that periods of apnoea have made their appearance and this type of respiration has been observed for about a year.

The heart rate and rhythm also show marked deviations when one animal is compared with another. And this may also be seen in the same animal from time to time. Although the heart rate in cases of the experimental neurosis is almost always greatly accelerated and has a greater range than the normal, there are still great variations in this range among the neurotic group. In a study reported elsewhere (2) it was found that the heart rate ranged from 68 to 96 in neurotic sheep #7 and from 60 to 100 in neurotic sheep D. Again, from day to day, the rate may range from as low as 60, when the animal is relatively calm, to as much as 100, even within the same experimental period. In the case of sheep D a greatly distorted cardiac rhythm was observed, and this was seen in only one or two other cases among the members of the neurotic group. In this animal D, as detailed elsewhere, extrasystoles, coupled rhythm and other spontaneously appearing rhythmical changes in the pace of the heart were seen.

The manifestations also showed marked individual and phasic variability among the experimentally neurotic dogs, although here we do not have as many cases for comparison as in the sheep.

All three of the dogs with experimental neurosis were, at one time or another, hyperexcitable with respect to the motor reactions. In dog #881, however, the conditioned salivary reflexes were extremely weak and disappeared altogether for long periods of time. And in the case of dog #929 the conditioned motor reflex was dormant during the phase of pseudo-decereberate rigidity. These dogs, during these phases, contrast strikingly with the case of #868 in which the conditioned motor reflex remained exceedingly strong over a period of years. However, general restlessness and vigorous struggling reactions which occurred in the intervals between stimuli were generally more pronounced in dogs #868 and #881 than in dog #929, and this contrast was, of course, all the more marked when the latter was in the inhibited (pseudo-decerebrate) phase.

As pointed out previously the restlessness in the experiment took a different form in the three dogs. In dog #868 the movements were confined chiefly to the reaction leg; the tic-like flexing of the limb caused the foot to be raised slightly from the floor (as seen in most of the nervous sheep). In dog #929, during the hyperexcitable phase, the tic-like movements were also confined principally to the reaction limb, but they were superimposed upon a partial flexion of that limb. In dog #881, in which food instead of the shock was used, the restless movements were diffuse and involved all the bodily extremities as the animal struggled to extricate itself from the restraining straps.

The variation of the whole symptom complex in dog #929, occurring over a period of more than two years, was the most astonishing phasic change noted in any of the neurotic animals. The manifestations varied from those indicative of a state of hyperexcitability to those indicative of a state of deep inhibition. Almost continuous movement was superseded by immobility and rigidity of the body.

The above examples in the sheep and dogs should suffice to indicate the nature and degree of variation in the symptomatology of this disorder. Through the observation of such wide individual differences we have concluded that, in work of this sort, it is a highly inaccurate procedure for an experimenter to attempt to use one animal as a behavioral "control" for another animal. Indeed, since there are also such marked phasic differences in an animal from time to time, it is evident that they must be taken into account even in experiments in which an animal serves as its own "control" as in the comparison of its behavior previous to a change of experimental conditions with that occurring after such a change. The phasic variations also make it extremely difficult in the neurotic animals to judge or predict the course of the disorder, and this certainly cannot be done from a single period of observation of the animal's behavior.

It is very interesting that the variability of the experimental neurosis observed in these animals coincides with that long ago observed in human neurotics. The animal observations at once call to mind the well-known clinical fact that psychoneurotics often present widely differing symptom complexes, although similarities in personality structure and reaction may, in broad outline, be present. And phasic differences are clinically well illustrated in the case of the hypochondriac whose symptoms and complaints may vary considerably from "one office call to the next."

III. PROCEDURES WHICH PRECIPITATE AND MAINTAIN THE EXPERIMENTAL NEUROSIS

THE TASK of the clinical psychiatrist is to assay the causes of neurotic behavior in order to effect a cure. We have similarly attempted to determine the procedures which bring about the nervous disturbance in the sheep and dog. Many of the experiments have been designed to throw light upon this difficult problem of etiology. Following clinical leads we have investigated the part which environmental situations play in the production of the experimental animal neurosis.

In this work we have been impressed by the fact that the experimental neurosis may be produced by relatively simple procedures—that is, simple according to human experience. And these are few in number. Effective procedures which we have employed involve 1) difficult differentiations, 2) experimental extinctions and 3) training according to a rigid time schedule. They have been used singly and in combination. A discussion of these methods together with the results which follow upon their use in typical animal subjects is presented in this section.

DIFFICULT DIFFERENTIATIONS

Among the most potent procedures for producing the experimental neurosis are those situations in which differentiations between closely allied positive and negative conditioned signals occur. When two stimulations, the one habitually reinforced and the other not reinforced, gradually approach each other in intensity, rate, sound, shape, color, etc., there comes a point at which the animal can no longer effect a discrimination. This incapacity has in certain animals a decidedly noxious effect upon behavior, and this was observed whether the reinforcing agent was an electric shock, which is undoubtedly unpleasant, or a dish of food, which is unquestionably pleasant. It was very interesting that in certain other sheep and dogs the inability to solve the problem did not seem to "bother" them, and it was consequently not followed by any observable deleterious effect upon behavior.

In the earlier phases of the work upon the conditioned reflexes of the sheep, the experiments were not at all concerned with the experimental neurosis. The nervous disturbance made its appearance in the course of work to determine the differentiating ability of the experimental sheep under various conditions. Using the conditioned reflex method, we were attempting to force the animals to discriminate, for example, between a rapidly-beating metronome and a slowly-beating one. It was noticed that, when the problem became too difficult for the animal to solve (that is, when the rates of the metronome were close together) the sheep not only was unable to effect a perfect differentiation, but its general behavior underwent a change as well. While continuing to react both to positive (reinforced) and to negative (unreinforced) stimulation, the sheep began to "fidget" during the course of the experiment.

At first we were simply annoyed by the fact that the animal would not stand still, and it is recalled that, on one occasion, the experimenter (O.D.A.) became so discouraged at this continuing manifestation which destroyed the experiment that he went into the animal room to see whether he could not hold the animal's fidgeting limb upon the platform and thus calm the sheep. This proved to be impossible. The opposite effect was produced. The animal showed a manic form of reaction, consisting of violent and forcible attempts to jerk the limb from the experimenter's grasp.

Sheep A was, during a period of two years, gradually brought into the experimentally neurotic condition by means of an experiment involving extremely difficult metronome differentiations. (See case history of sheep A for details of the procedure.) The sheep quickly and easily formed a positive conditioned motor response to the sound of a metronome beating at the rate of 120 per minute, reinforced by a mild electric shock, and was presently able to distinguish successfully between this and the sound of a metronome beating at a rate of 50 per minute and unreinforced by shock. The rate of the negative stimulation was now advanced to 60 per minute, then to 72, then to 84, and at all stages of this procedure a clear-cut differentiation between positive and negative stimuli was successfully maintained. When, however, the negative metronome rate was advanced to 92, and then to 100 per minute, discrimination broke down and the first signs of an experimental neurosis appeared. All conditioned responses disappeared. This phase, lasting for months, was succeeded by a phase of gradually increasing excitability, wherein all stimuli evoked violent reactions, and the animal became extremely restless at all times while in the laboratory.

The case of animal #4, the only uncastrated male member of the flock (autopsy revealed bilateral orchidectomy) is cited here as an exception to the generally noxious effect of experiments involving difficult differentiations. This sheep succeeded in effecting a remarkable series of tactile differentiations to Krasnogorsky skin stimulators attached to the outer surface of the left hind leg. A spot on the ankle of the left hind leg was maintained throughout the experiment as an area of positive stimulation and the test was begun by forming a differentiation between stimulation of this spot, reinforced by shock, and stimulation of a point 6 inches higher on the flank as negative, unreinforced by shock. A new negative was now introduced into the experiment, by stimulating a point only 4 inches above the positive area, and when this discrimination had been successfully made a further differentiation was

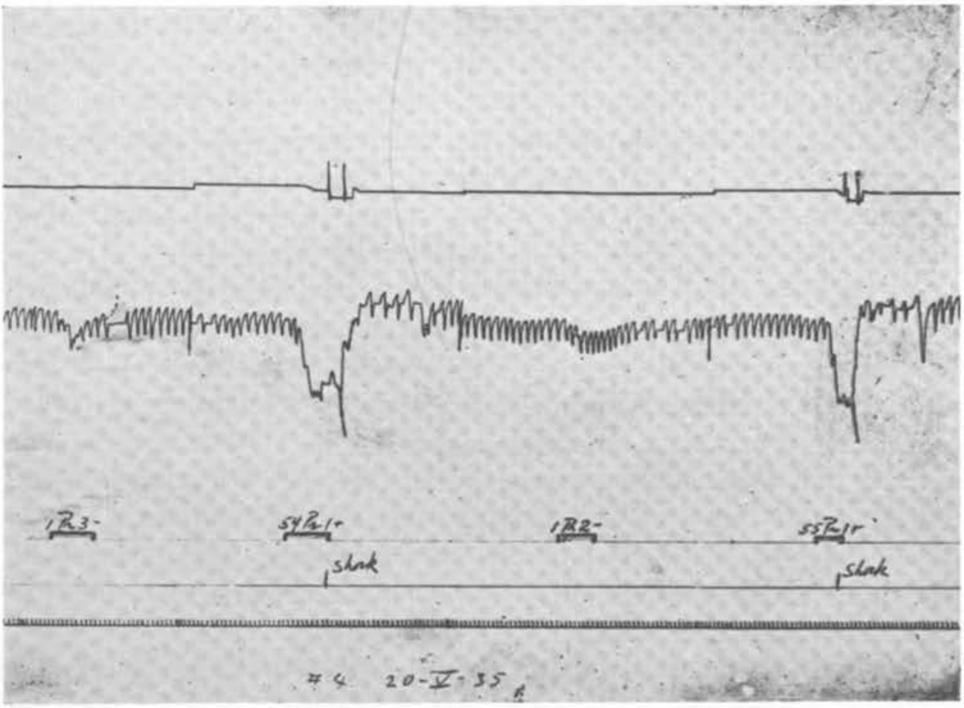


FIG. 28. A graphic record showing the quiet behavior of a normal sheep after a strenuous routine of stimulation. This animal, sheep #4, succeeded in differentiating between stimulation of skin spots located only 2 inches apart. Although this and other difficult experiments were carried out in this animal over many years it never showed any sign of the experimental neurosis.

formed to a spot still closer (2 inches) to the positive area. The animal successfully accomplished these differentiations and, although observed for ten years, it showed no signs whatever of the experimental neurosis. It should be added that the clear-cut solution to this problem was considered an extraordinary feat, and was indeed a far more difficult task to achieve than those which had been set before other sheep and dogs with resulting experimental neurosis.

Fig. 28 is a graphic record of the differentiation formed in sheep #4 between tactile stimulation of regions only 2 inches apart.

Experimental Extinction

In our experience, the extinction of the conditioned reflex may be another potent cause of the experimental neurosis under certain conditions, namely, when the negative differential stimulus is repeated successively in a long series, each stimulus being separated from the next by a very short interval of time.

In the early experiments on differentiation in sheep, we had adopted a procedure used for many years in Pavlov's laboratory, namely, the method of contrasting the negative with the positive stimulus a few times each day (positive stimulus—negative—positive—negative—positive). We had found, however, that the use of this procedure in practice was time-consuming and, since we were interested in assaying discriminative ability, we attempted to hasten the whole process in one animal, sheep D, whose case is cited below. (See case history for detailed protocol.)

Accordingly, instead of using the above method of "contrast" we followed the presentation of a positive metronome stimulation by an exceedingly long series of negative stimuli (as many as 20 separated by one-minute intervals) presented in a single experiment. In the case of the neurotic sheep D the continuation of such an extinction procedure did not succeed in producing a clear-cut differentiation. It produced instead every sign of the experimental neurosis within the short period of 10 days. This neurosis was produced more quickly than in the case of any other sheep upon which we worked. The disturbance was also observed over a longer period of time, about 11 years. This sudden "breakdown" is all the more remarkable in view of the fact that an extremely simple differentiation was attempted, namely, that between metronomes beating at 120 and 50, the latter being the negative stimulus. Many sheep had succeeded in discriminating between these stimuli. So, in this case, the neurosis was, in all probability, not associated directly with discrimination difficulty, but rather was associated with the mode of presenting the problem for solution, that is to say, with the fact that the negative differential stimulus was "forced" too rapidly upon the animal thus making it almost impossible for the sheep to form a basis for the judgment.

It is interesting that 7 years later, when the animal was in the hands of another experimenter (R.P.) a long series (125) of unreinforced stimulations with the doorbell was given with a decidedly calming effect. Apparently the explanation for the divergence of result in these two sets of experiments must be sought in the two principal factors which were altered, namely, the experimenter and the intensity of the schedule. In the first series the duration of the experiment was only three days, 65 negative stimulations, separated by one-minute intervals, having been given in that time. In the second run, stimulation was extended over a period of 4 or 5 months. Also, in the second and longer experiment, the animal was made a pet of and encouraged in various ways.

Rigid Time Schedule

When Dr. P. S. Kupalov visited this laboratory in 1929 he acquainted us with experiments he had been performing in Pavlov's laboratory in Leningrad in which conditioned stimulation was presented to the dog according to a rigid time schedule, that is, stimulation every 4 minutes. The experiment was designed to study interval salivary secretion. He suggested that, in the experiments with the conditioned motor reflex in sheep, we conduct a series in which stimulation was presented in this manner. Previously, in Pavlov's laboratory and at the Cornell Behavior Farm, the intervals between successive stimulations had varied widely in duration, that is, from one minute to six minutes, no set temporal order being used.

In October, 1930, we began a new series, using three sheep in which stimulation was given exactly every 7 minutes. Pure tonal stimuli produced by an audio-oscillator were employed. The experiment had a two-fold object. We wished first, to find out what the animals would do during the long pause between stimulations, and second, whether or not the rigid time schedule would be to our advantage in the establishment of differentiations when the stimuli were contrasted one with another in the same experiment. Formerly our procedure in the formation of differentiation was briefly as follows. The conditioned reflex was first formed and then standardized over a period of months to a stimulation always reinforced by shock, the positive stimulus. We then introduced the negative stimulus, that is, one that was never followed by shock. When these two stimulations were contrasted in the same experiment differential reactions were in time obtained.

In the present experiment with these three sheep we introduced positive and negative stimuli from the very first (before any conditioned reflexes had been formed). In one sheep, #8, a day's stimulation schedule consisted of the following: pure tone of 435 cycles; shock; 7 minutes pause; pure tone of 900 cycles; no shock; 7 minutes pause; pure tone of 435 cycles; shock; 7 minutes pause; pure tone of 900 cycles; no shock; animal released. In the other two animals in this series a similar stimulation schedule was adopted. Each stimulus was always given for 10 seconds. This monotonous routine of stimulation was adhered to without variation throughout the initial phase of the work.

The results of this experiment were definite and quite surprising. Of the three animals studied one developed a typical experimental neurosis within one month. Another showed many of the signs of this disorder for a number of years. The third showed only a few of the manifestations of the disturbance.

Another curious result was found. In order to make this result clear it is necessary to consider certain earlier experiments. In these we had noticed that if the positive conditioned stimulus was always given for the same length of time, let us say 10 seconds, and the intervals between stimulations were *unequal*, and if, furthermore, such a procedure was continued for even a few days, the vigor or magnitude of the conditioned motor reflex gradually became less and less and finally the reaction disappeared altogether. It was always recognized in this work that a delayed conditioned reflex would inevitably be formed unless positive conditioned stimuli of exceedingly brief duration (1-3 seconds) were occasionally interjected into a series of longer ones. This procedure, as it were, buoyed or maintained the reaction to stimuli of longer duration. The short stimuli kept the latent period of the reflex short, and therefore it could be maintained over long months of experimentation.

Consequently, in the rigid time schedule experiments, we were surprised to find that not only did the conditioned reflex *not* diminish in magnitude, rather it *increased in strength* as the experiments progressed. The only new factor in the situation which could account for this unexpected increase was the fact that the *intervals* between stimulations were always exactly equal. The sheep, instead of exhibiting what, in anthropomorphic terms, would be considered "boredom," showed marked alertness and indeed two of the animals became extremely sensitive to all kinds of stimulation.

As months passed, we noticed that the animals were not only responding more vigorously to the conditioned stimulation, both negative and positive, thereby implying no differentiation at all, but that even extremely weak sounds, which accidentally occurred and which were quite unlike the pure tone, would evoke the reaction of defense. For example, an accidental scraping sound made on the wall, as the experimenter adjusted equipment in the adjoining experimental room, often evoked startle reactions. Similarly, the sound of a passing automobile or a barking dog elicited the same reaction, and in later experiments with other sheep, when the conditioned reflex had been formed under a rigid time schedule to the sound of an ordinary door buzzer instead of the tone, the passing of airplanes over the laboratory elicited violent defensive reactions in the interval between stimulations at a time when no reaction was expected. From all these observations it was apparent that the sheep's *level of excitation* was greatly augmented by the simple procedure of rhythmic stimulation at exactly equal intervals of time.

Sheep #8, in which the experimental neurosis made its appearance as a direct result of the attempts to form a very simple discrimination (tone 435 *vs.* tone 900, which had been formed by other sheep quite easily), under this rigid schedule became excitable to the point of "mania." This condition was under continuous observation for eight years. (See appended case history.)

Since we had previously produced experimental neuroses in the sheep by *difficult* differentiations we naturally sought the part which the differential situation played in producing the neurosis in the present experiment. We suspected that possibly another neurosis-precipitating factor had been introduced into this experiment, namely, the monotony or rigidity of the stimulation schedule.

We decided to put this to test. First of all we wished to find out whether or not the excitation level in a normal, calm sheep could be increased by a change from variable to constant intervals between stimulations. In the case of such a sheep we did find that the conditioned motor reflex could be maintained apparently indefinitely at a uniform magnitude when the intervals between stimulations were always the same. But in this particular case the experiment did *not* involve the use of the negative conditioned stimulus.

This method was also found to be effective in maintaining the neurosis once it had been established and where no differential problem was involved. We cite the case of sheep #8. In this animal, in October of 1931, about one year after the neurosis had been produced by the rigid time schedule with differentiation, a new stimulus was employed and tonal stimulations were abandoned. The sound of an ordinary door buzzer was presented, always for 10 seconds, and was reinforced each time by the shock. The rest intervals between stimuli were always exactly 7 minutes. *No negative conditioned stimuli were used at all. Every sign of the neurosis was maintained from the fall of 1931 to the day of the animal's death in December, 1937, a period of six years.*

Recently Goldmann, working with goats, and Jensen, working with sheep,[8] have shown in this laboratory that the typical experimental neurosis can be both produced and maintained by rhythmical stimulation with positive stimuli alone, no differential problem at all being involved in the experiment.

Daniel and Anderson[9] have recently produced the experimental neurosis in a dog by the same means (without differentiation).

Liddell, in 1932-33, and in later experiments with sheep, has amply confirmed the "deadliness" of this temporal routine in experiments contrasting

[8] Unpublished work of Marvin M. Goldmann and of Arthur V. Jensen.

[9] Unpublished experiments of L. B. Daniel and O. D. Anderson.

positive and negative conditioned stimuli (in sheep B and sheep C). In his experiment, intervals between stimulation as short as 3 minutes were employed.

We became aware that, in this technique, we had found what we considered a "standard" procedure for the production of the experimental neurosis. We had long sought for such standardization of the situation for a variety of reasons. One reason was that we wished to have a procedure which would enable us to compare, in one and the same animal, one day's results with the next, in order to observe the progress of the development of the symptomatology without change of the experimental conditions. Thus, the fact that every stimulation was always of equal duration would enable us to compare the value of the magnitude of the conditioned reflex elicited by one stimulation at one time with that elicited by the same stimulation at a future date. Again, the fact that the intervals between stimulations were always equal would enable us to compare and study the amount of restlessness in one interval with that in another at another time in the animal's life span. A study of this restlessness has enabled us to assay the depth or intensity of the neurosis at a given time. This could be done quite objectively by simply counting the number of leg movements occurring in the interval, for it was obvious that the greater the number of leg movements, the more nervous was the animal, and *vice versa.* Indeed, the totality of reaction during the *waiting* period between stimulations (movements of the extremities, pulse, respiration, etc.) is, in our experience, of equal importance with the reactions directly associated with the conditioned stimulation. It is true that as the neurosis develops, the accompanying rise in the level of general excitability induces a change in the general character of the conditioned motor reflex, and this event is important. But it is none the less evident that the most valuable single criterion of the presence of nervousness is to be found in the amount of interval activity.

Given the undeniable fact that adherence to a testing schedule comprising equal intervals between stimulations has a disastrous effect upon the nervous system of the experimental animal and is capable, not only of maintaining a neurosis, but of producing it as well, we have naturally sought for an explanation of the phenomenon. A logical explanation arises from the fact, demonstrated time and again, that these animals are able, with fair accuracy, to time an interval to which they have become accustomed through training in the experiments. Once this timing is established, the animal is "aware" during the interval of the inevitable imminence of the next stimulation. His nervousness is the result of the certainty of being confronted with the necessity for making an adequate psychobiological adjustment, an adjustment which is impossible since he cannot escape from the experimental environment. It does not matter whether the stimulations which he is accurately anticipating are of an unpleasant or pleasant nature—shock or food. The important thing is that he is impelled to make this psychobiological adjustment and that he is certain of the necessity for it over the entire interval between stimuli. In other words, in animals trained to rhythmic stimulation, *the waiting time interval itself becomes a conditioned stimulus efficient enough to evoke, throughout its duration, frequent conditioned defensive movements of the reaction limb and head, distorted and hastened respiration and rapid pulse—the chief signs of the experimental neurosis in the laboratory.*

IV. SOME THERAPEUTIC PROCEDURES

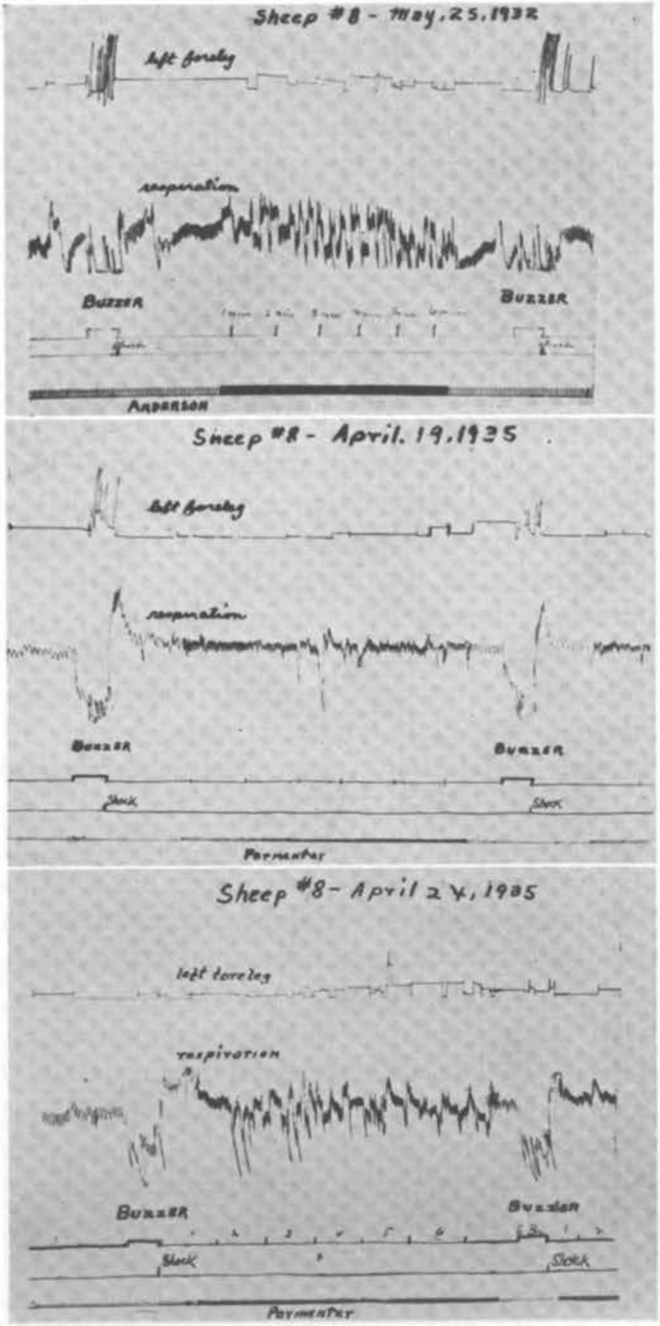
1. The Influence of Rest from the Experiments

Following the lead of Pavlov and of clinical psychiatrists, one of the first therapeutic procedures employed was to give the nervous animal a complete rest from all experimentation, allowing it to remain in the animal quarters among its fellows. It was thought that our neurotic sheep might be suffering from over-testing or overwork and, as in many a case of the human psychoneurosis, the most obvious suggestion in such circumstances would be to "go away and have a good long rest."

We did not know whether the neurotic symptoms were caused by fear of the experiment or whether the symptoms were directly due to the complexity of the problem that was presented. We had observed, however, in a relatively large number of cases of the disorder in the sheep and dog, that when the neurotic symptoms had once made their appearance they could be exacerbated by an increase in the number of daily stimulations and a corresponding increase in the length of time during which the animal remained in the experimental chamber.

In general, if any animal was given only a few stimulations per day and tested only once or twice a week it did not become neurotic even after years of testing; but if an animal had been given a greater number of stimulations per day, kept in the room for long periods of time and tested 5 or 6 times per week, signs of neurotic behavior often appeared within a short time (within 10 days in sheep D). We were therefore convinced that the animal was "overworked" and hence the prescription of rest seemed obvious.

The periods of rest which we have given our animals have ranged from one month to as long as three years. The result was somewhat beneficial. However, the improvement was of short duration once testing of the animal was resumed. The degree of improvement did not seem to be a function of the duration of the period of rest. It was surprising that the beneficial effect was little, if any, more pronounced following a rest of three years than following a rest of three months. In almost every case the neurotic symptoms reappeared within a few days after the testing was taken up again. The case of sheep #8 is a noteworthy example and is illustrated in fig. 29. A period of nearly three years elapsed between record *A* and record *B*, and the number of spontaneous interval movements was noticeably reduced with a corre-



A

B

C

FIG. 29. Graphic records showing the transitory calming effect of a period of rest and of a change of experimenter upon the manifestations of the experimental neurosis in the sheep. *A* shows the neurosis at its height in this animal on May 25, 1932, with experimenter O.D.A. *B* shows records of this animal taken on April 19, 1935, three years later. The experimenter was R.P. Note that the reactions were calmed to some extent following the prolonged rest. *C* shows the extremely transitory nature of this improvement. Five days later, on April 24, 1935, the neurosis was as pronounced as ever.

sponding decrease in respiratory disturbance. Nevertheless, after 5 days of experimentation, signs of the neurosis returned in full force.

The fact that this condition returns so quickly is conclusive evidence that the pathological condition "carries over" in latent form during the rest period and is lost sight of only because the animal is not subjected to the close observation and measurement attendant upon work in the experimental situation. We are convinced that, had we made samplings of physiological functions during the rest period, differences between these animals and their normal fellows of the flock would have been found.

2. The Influence of Making the Experimental "Problem" Easier

In view of the clinical management of certain cases of psychoneurosis in which the patient's problems are made capable of solution through the medium of psychotherapy we decided to investigate the effect of a similar reduction in the complexity of the animal's problem. One such case is reported in detail in the appendix, the case of dog #868. It will suffice here to give an outline of this experiment. The conditioned motor (defensive) reflex was formed in this animal to the metronome beating at the rate of 120 per minute, always followed by a shock to the right forelimb. We then attempted to form a differential reaction to the rate of 60 per minute, not reinforced by shock. We were entirely unsuccessful. The animal reacted equally to both rates.

At this stage the experiment had not advanced sufficiently, in spite of an inability to differentiate, to produce any sign of nervous disturbance. The dog simply could not distinguish between the two rates of the metronome.

We then made the problem easier, reducing the negative metronome rate from 60 to 42, and still no sign of differentiation appeared. As we persisted in attempts to develop this differentiation, signs of nervousness made their appearance. We reduced the negative rate still further—from 42 to 36 beats per minute. Still the animal did not distinguish between the rates and became more and more nervous.

The neurosis at this phase was at its height and presented the classic symptoms of spontaneous restless movements of the reaction leg, quick, jerky head movements, whining, barking, attempts to attack the observer, disturbed breathing, and tachycardia.[10] At this point the problem was made even simpler by giving the animal a cue as to when the negative signal was being sounded. The sound of an ordinary door buzzer was combined with

[10] The heart action was observed now and then during the experiment by means of a stethoscope.

the negative metronome rate of 36. The positive rate of 120, reinforced by the shock, was not combined with the buzzer.

This radically altered procedure brought about a profound change in the neurotic picture. After as few as three applications of this "cued" negative signal, signs of differentiation appeared for the first time. At the end of four days the differentiation was perfect in that the metronome 120 always evoked a vigorous reaction while the metronome 36, combined with the buzzer but unreinforced by shock, did not evoke any response at all.

At this stage the buzzer cue was withdrawn; the differentiation persisted. During the ensuing 6 months perfect differentiations were obtained in nearly every case between metronome 120 and metronome 36. With the perfection of the differentiation, what in terms of human experience may be thought of as a "solution" to the problem was obtained. The animal's general behavior became far calmer, and on almost all occasions a perfectly normal, calm type of behavior was observed. Neurotic symptoms were not again noted in this dog during the remaining year of the experiment.

The graphic records in fig. 30 show the marked change in this animal's behavior associated with the above changes in the experimental procedure.

This experiment shows clearly the influence of the differential problem itself on the establishment and maintenance of the experimental neurosis. Indeed, it is ample confirmation of the perfectly well-known clinical fact that when the neurotic patient obtains a solution to his "difficulties" the organic and other expressions of the neurotic condition often disappear altogether.

3. The Influence of the Experimenter upon the Neurotic Animal

It has occurred to us from time to time to test the effect of changing from one experimenter to another in the course of an experiment on the production and maintenance of the neurosis. There is unquestionably, in experiments of this sort, a social relationship between the experimenter himself and the animal. This is clearly seen when, in an experiment, the animal constantly looks in the direction of the experimental room, watches the experimenter's movements, shows some evidence of what can be taken to signify "affectionate regard" in some cases and in all probability "hatred" and "fear" in others. Each experimenter at the Behavior Farm seems to evoke in a given animal a somewhat characteristic type of social reaction. Thus, in the case of sheep D, the animal was unquestionably friendly in its attitude toward R.P. and entirely unfriendly toward O.D.A. In the case of the former experimenter she frequently nuzzled his hand and pushed against his body, even though the experiments involved the delivery of an electric shock. When in

A

B

C

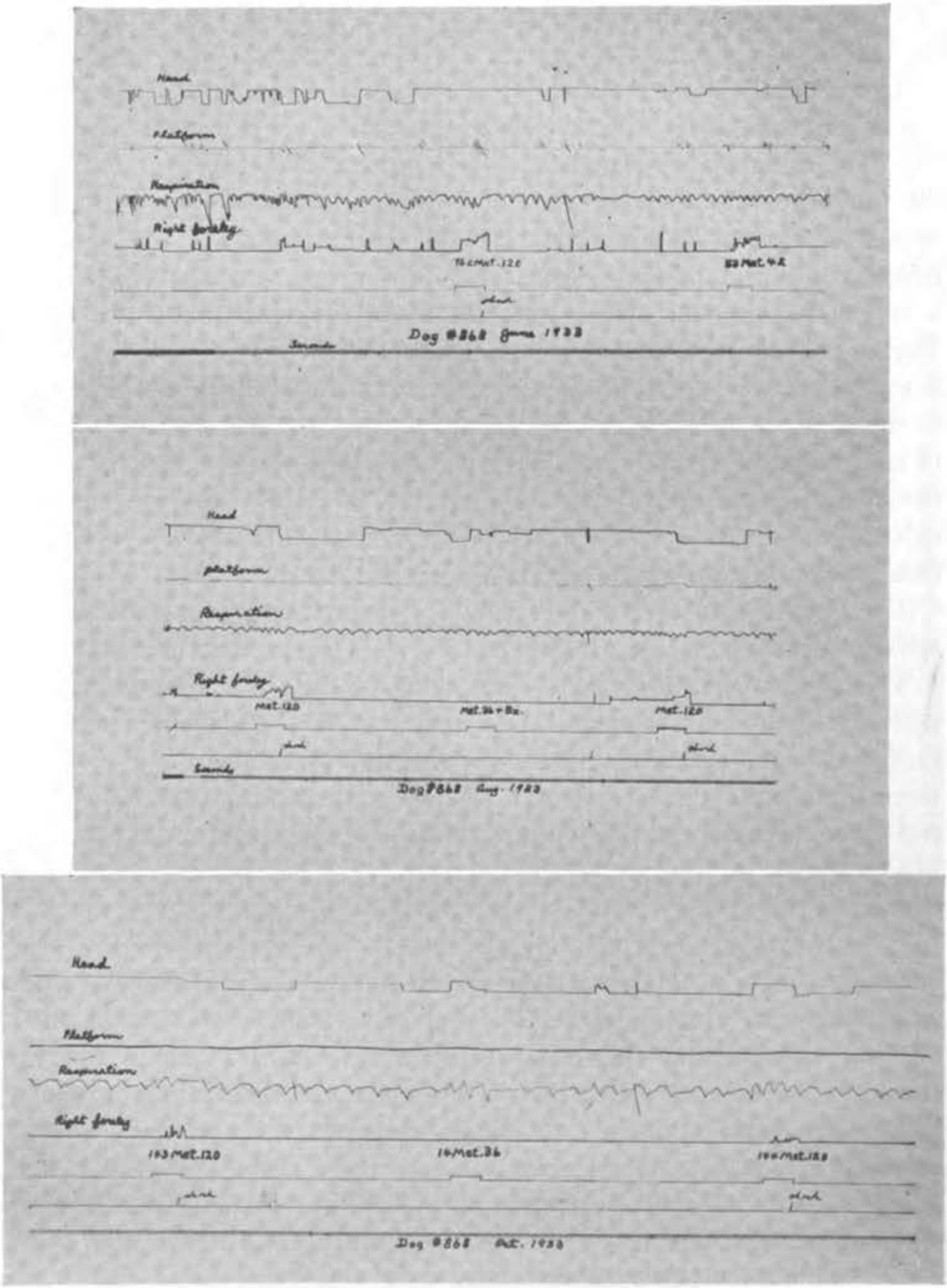


FIG. 30. Graphic records showing the effect in an experimentally neurotic dog of making the problem easier of solution. *A* shows a record of the disturbed behavioral reactions of dog #868. *B* is a record of the restoration of calm behavioral reactions in this dog when it "solved" the dierential problem by means of a "cue." *C* shows a later record in this animal. Note that the calm behavior persists. No further signs of the experimental neurosis were observed in this dog. (See text for experiment.)

the hands of O.D.A., however, her reactions under the same circumstances consisted of resistive and offensive reactions, including attempts to butt him.

This phenomenon of alteration of behavior with change of experimenter was so often observed that an attempt was made to fix the precise rôle of the experimenter in the manifestations of the experimental neurosis by making this shift while all other conditions in the experiment remained the same. Thus, for example, the testing was continued in the same experimental room under the new experimenter.

This procedure was tried out in the case of sheep D, #8, and others when their neurosis was at the high point. O.D.A. had first formed the neurosis in these animals and had studied them for a number of years when R.P. then took them over.

In general, it can be stated that, as the result of this testing, with no change in the experimental situation other than the experimenter himself, the neurotic signs persisted with little or no change. In spite of the fact that animal D, for example, was more friendly with R.P., this seemed to make no difference at all when the animal was subjected to the experiment. The diffuse conditioned motor reactions and the marked restlessness in the experiment continued unchanged. Of course, it must be realized that the experimenter is not in the same room with the animal during the experiment. Indeed, he does not enter the room at all unless to adjust or to make repairs upon the recording apparatus. When O.D.A. resumed the testing he could perceive no change in the animal's neurotic behavior.

In regard to the question of the social relationship of the experimenter to the animal it is certainly noteworthy that the neurotic sheep never showed the restless interval activity characteristic of the disturbance at any time when the experimenter stood nearby in the same room. We have for many years noted this fact and it has been emphasized by the further observation that such restless movements were resumed immediately following the experimenter's leaving the animal and returning to the instrument room. It is true, however, that the sensitivity of the animal's nervous reactions persisted, even though the experimenter stood nearby. For example, vigorous, defensive movement of the reaction leg, and occasionally of other limbs as well, could easily be evoked by the slightest touch upon the reaction limb.

4. The Influence of Making the "Problem" Easier, Plus a Change from One Experimenter to Another

The therapeutic value of easing the testing schedule, plus a change in the person conducting the experiments, is illustrated in detail in the appended case history of sheep D. When this double change in this animal's experimental surroundings was made the sheep was already thoroughly neurotic as a result of attempting to differentiate between contrasting metronome rates. Work was begun on the animal in 1928 by O.D.A. at which time a neurosis developed following attempts to establish a metronome differentiation (metronome 120, positive and metronome 50, negative). This neurosis remained acute during the three and a half years of experimentation by O.D.A. The animal then had a rest of over two years during which no work whatever was done on it.

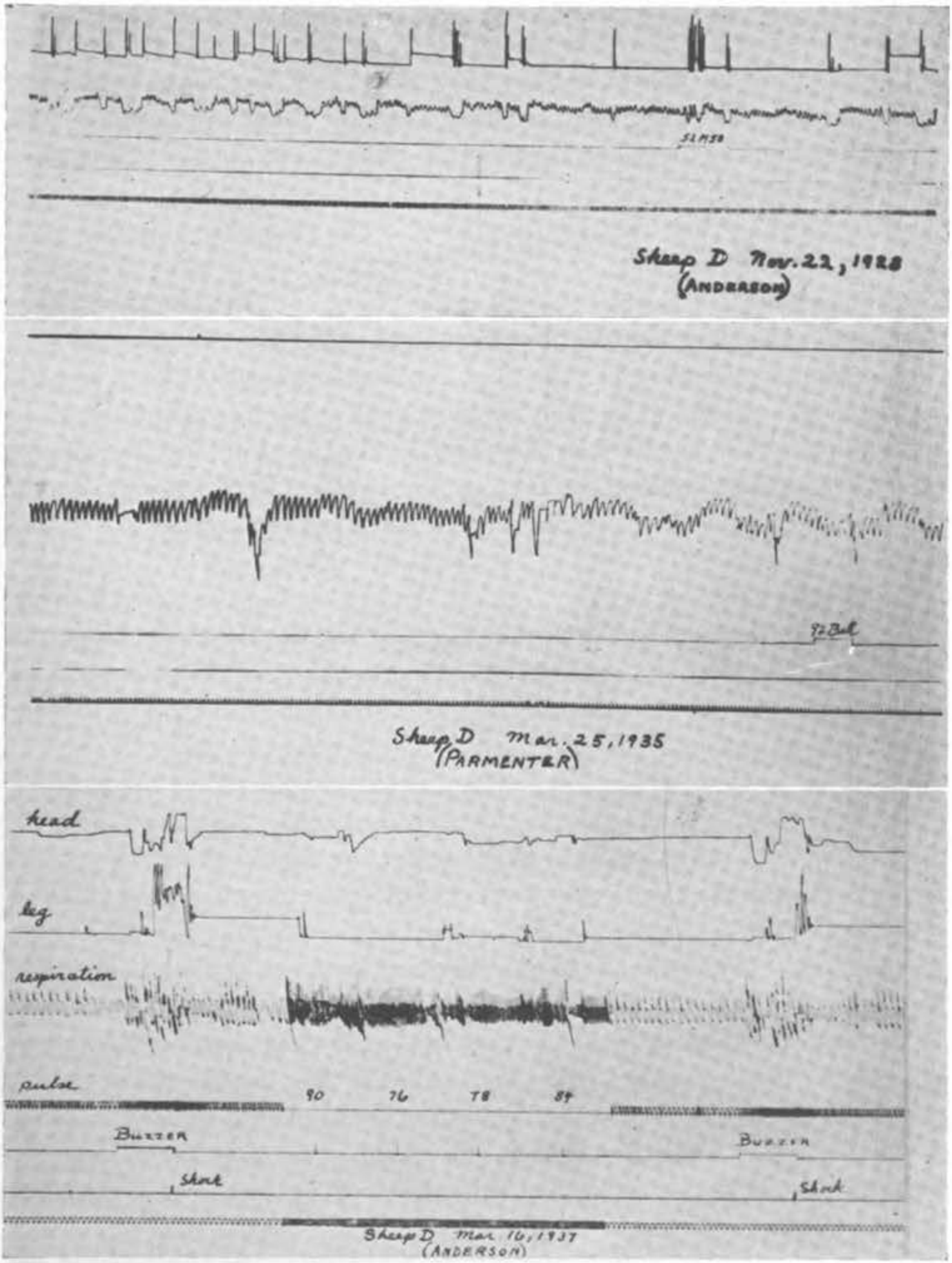
It then came into the hands of R.P. and was put upon a regime in which all conditioned stimuli were negative, *i.e., unreinforced by shock.*

The start of this series was made in December, 1934 after the complete rest, and 99 consecutive negative stimulations with a common door bell as the conditioned stimulus were given during 25 test periods ending in April, 1935. During the first 24 negative stimulations, which occupied two test periods, almost no change in the animal's wild and generalized responses could be noted. She had to be dragged to the laboratory and onto the experimental platform and would hang swinging in the straps, bleating and struggling wildly at each presentation of the signal. At the 35th presentation of the bell the conditioned response suddenly disappeared, and although it had returned 6 days later when three more negative stimulations were given and again on the following day, it was not very considerably decreased in magnitude and, beginning with the 42nd bell, responses from the conditioned limb abruptly disappeared and did not return except at very considerable intervals and in very small magnitude.

On the 7th day of January 1935 three new unreinforced stimuli were briefly introduced into the experiment. On this day, following three presentations (70, 71, 72) of the unreinforced bell, each of 10 seconds' duration, a tone of 2100 cycles, unreinforced by shock, a metronome beating at 120 per minute, a steady white light, and a tone of 250 cycles were successively presented to the animal for durations of 10 seconds. There were massive generalized responses to each of these stimuli except the light.

How much of the calming effect of the long series of negative bell signals was due to the fact of their unreinforcement by shock and of the removal from the experiment of the necessity for discrimination, and how much was due to the change in experimenters, can only be estimated by consideration of the previous section in which the therapeutic value of a change of experimenter alone is set forth.

Representative graphic records of the behavior of this sheep under these variations of the conditions are shown in fig. 31. From these records the pronounced degree of calmness produced by the long series of negative



A

B

C

FIG. 31. Graphic records showing the calming effect on the experimental neurosis in sheep D when only negative, unreinforced, stimuli were presented and when a new experimenter made a pet of the animal. *A* shows a record of behavior when the experimental neurosis was at its height. The experimenter was O.D.A. *B* shows a record of the completely calm behavior of this animal following negative stimulation and "coddling." The experimenter was R.P. *C* shows a record in which behavior again became disturbed following a resumption of the original procedure. The experimenter here was O.D.A.

conditioned stimuli given by the new experimenter is clearly apparent in a comparison of record *A* with record *B*. In the latter the sheep stood quietly in the experimental chamber. However, when O.D.A. again resumed the experiment employing positive conditioned stimuli (buzzer followed by the shock) presented at the 5-minute intervals, the neurosis quickly reappeared. This fact is shown in record C.

5. The Influence of Drugs and Hormones

On various occasions since 1931 we have "tried out" the effect of certain drugs and hormones upon the experimental neurosis in the sheep.

The earliest experiments (1931) followed the lead of Pavlov and his associates. We wished to see whether or not the sedatives, sodium bromide and sodium amytal, would have a beneficial effect upon the sheep's neurotic symptoms since Pavlov had observed an improvement in the dogs following such treatment. In these experiments the effect of ethyl alcohol was also observed.

In later experiments (1932) Liddell, Anderson, Kotyuka and Hartman (*17*) studied, in this laboratory, the effects of extract of the adrenal cortex (cortin) and of adrenalin upon the sheep's neurotic manifestations. And we have made as yet unreported observations on the administration of thyroid extract and thyroxin.

In recent work (1938-40) we have carried out numerous experiments upon the effect of phenobarbital in the nervous sheep.

The effect of hormones. We shall present first a brief summary account of the endocrine work, for most of these results have been reported in detail elsewhere (*17*).

Continuous administration of the substance cortin to the experimentally neurotic sheep resulted in a profound increase in the vigor or magnitude of the conditioned motor reaction of the limb and at the same time a marked decrease in the frequency of the spontaneous, tic-like movements in the intervals between stimuli, that is, a quieting effect. Improvement in other symptoms of the disorder was seen, the animals becoming generally more cooperative and manageable. The calming effect persisted for almost one month after therapy ceased.

When adrenalin in a concentration of 1:200,000 was administered repeatedly to these animals a result exactly the opposite to that of cortin was observed. Adrenalin decreased the vigor of the conditioned reflex and simultaneously aggravated the general symptoms of nervousness as evidenced by an increase in the amount of restlessness in the intervals between stimuli, an increase in sensitivity to tactile stimulation (touch upon the reaction limb) and an augmented degree of uncooperativeness.

In several of these neurotic sheep, exhibiting the typical manifestations of the *excitatory* form of the disorder, thyroid extract and thyroxin were administered. We naturally expected to find an exacerbation of the symptoms. But such was not the case. The substance produced no observable effect at all upon behavior. A typical case may be cited, namely, that of sheep A. This animal was given orally 1 gm. of thyroid extract per day for three weeks when the neurosis was at its height. Although the standard conditioned reflex tests were carried out before, during and for one month after the treatment, no change was observed in the magnitude of the reflex or in the frequency of the spontaneous interval limb movements. Outside of the laboratory the sheep behaved as usual.

The same result (or lack of result) was obtained in two other neurotic sheep. We cannot account for this lack of effect. And it is all the more puzzling in view of the fact that, in later work along this line in dogs (*4*), normal animals (that is non-nervous ones) became exceedingly nervous in the same laboratory tests following the continuous administration of the same daily amount (1 gm.) of thyroid extract. The observation is further confirmed by the fact that the behavior (the conditioned reflex) of the dog is more profoundly affected by thyroidectomy than appeared to be the case in sheep in the early experiments of Liddell (*18*). One of us (O.D.A.) observed Liddell's thyroidectomized sheep in the conditioned reflex laboratory. The defensive reaction was about as vigorous as in the normal controls. In dogs, on the other hand, ablation of the thyroid was followed by a profound weakening of the conditioned motor and salivary reflexes and, in most cases, these reactions disappeared altogether.

There appears to be a species difference in this respect which merits further investigation.

The effect of sedative drugs. In the work upon the effect of sedative drugs on sheep with experimental neurosis, only those animals which exhibited the *excitatory* form of the disorder were used.

After selecting the animal, behavior was studied prior to the administration of the substance, during the administration, and, in some cases, for some time afterward. The general reactions of the animal to the observer, the magnitude or vigor of the conditioned motor reflex, and the frequency of restless, spontaneous movements of the reaction leg were the behavioral items which were particularly studied.

The effect of a single, massive dose of sodium bromide, of sodium amytal, and of ethyl alcohol was observed in neurotic sheep #8 and we cite this case as exhibiting the typical effects observed. About one month elapsed between the administration of each of the three substances.

Conditioned stimulation was presented according to the following schedule: buzzer 10 seconds; shock; 7 minutes pause; buzzer 10 seconds; shock; 7 minutes pause; buzzer 10 seconds; shock; administration of drug; then resumption of stimulation.

Sodium Bromide. After the "control" tests had been executed, the sheep, while remaining on the platform in the straps, was given 2.5 gm. of sodium bromide by rectum. About 10 minutes later the tests were resumed.

TABLE 1

THE EFFECT OF A SINGLE DOSE OF SODIUM BROMIDE ON THE BEHAVIOR OF A NEUROTIC SHEEP

Sheep #8. Experiment of April 14, 1932				
Time (P.M.)	Conditioned stimulus	Duration of conditioned stimulus	Magnitude of conditioned reflex in mm.	Number of spontaneous leg movements in the 7 minute intervals between stimuli
2:00	buzzer	10 sec.	72	
2:07	buzzer	10 sec.	45	18
2:14	buzzer	10 sec.	128	22
2:18—sodium bromide, 2.5 gm., by rectum:				
2:28	buzzer	10 sec.	45	4
2:35	buzzer	10 sec.	180	0
2:42	buzzer	10 sec.	90	16

The results are shown in Table 1 and in fig. 37 (*A* and *B*). Table 1 shows that the conditioned reflex was unaffected. The number of spontaneous interval leg movements were, however, reduced in the interval immediately following administration of the dose and leg movement disappeared entirely in the second interval, that is, between 17 and 24 minutes after the dose. By the third interval (24 to 31 minutes after the dose) the usual number of restless movements was again observed. Fig. 32 (*A* and *B*) shows graphic records of behavior, *A* before and *B* about 20 minutes after the dose. The quieting effect is shown not only in the recording of leg action, but in the respiration as well.

When the sheep was released, about 40 minutes after the administration of the bromide, no effect of the substance could be detected in its behavior as it returned to the barn and rejoined the flock.

Sodium Amytal. After three preliminary control tests with the buzzer followed by shock the sheep was given 5 gr. of sodium amytal intraperitoneally. After a pause of 8 minutes buzzer stimulation was again taken up.

The vigorous conditioned reflex was reduced to zero and the restless leg

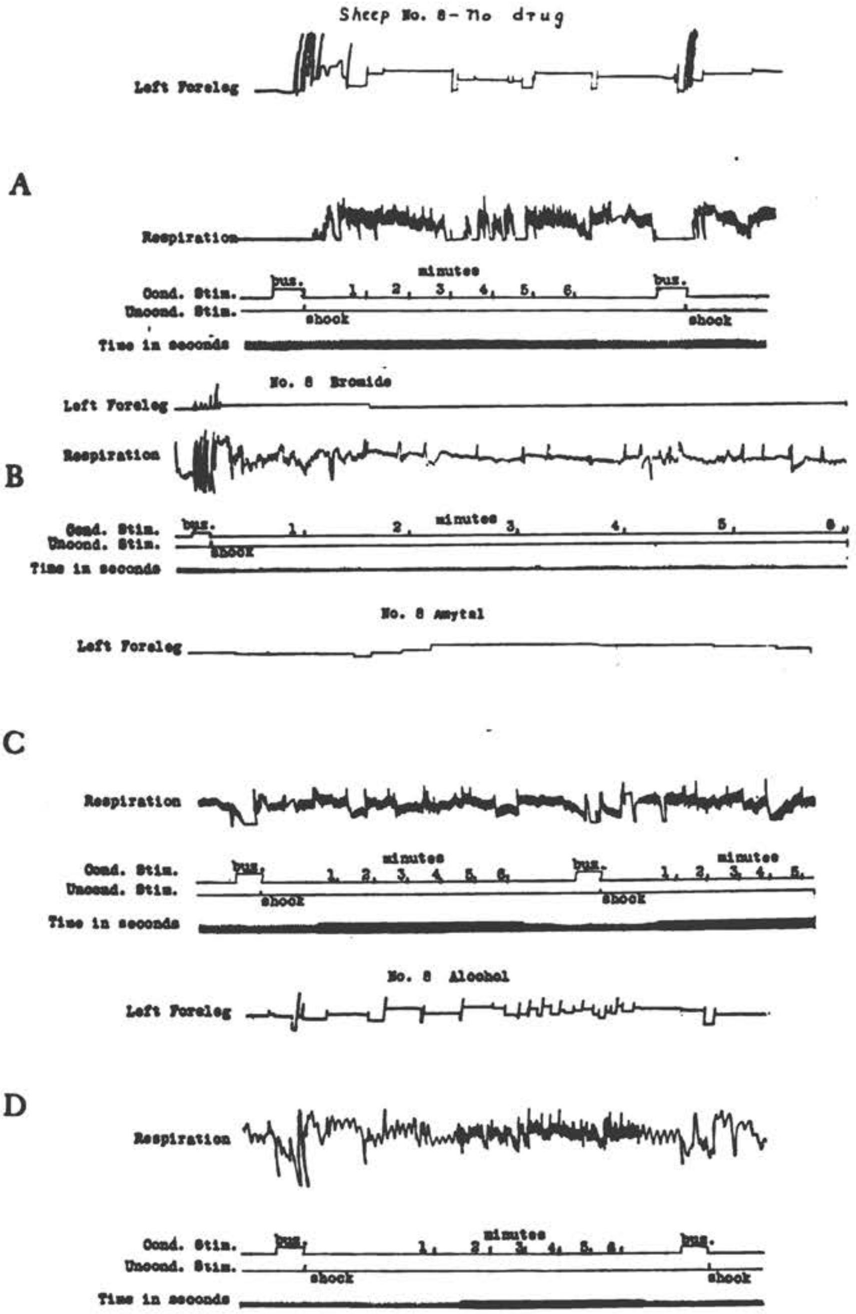


Fig. 32

FIG. 32. Graphic records showing the effect of sodium bromide, sodium amytal and ethyl alcohol upon the experimental neurosis in a sheep. *A* shows a typical record of neurotic behavior in sheep #8 before medication. *B* shows a record of the effect of sodium bromide. Note the diminution of the number of spontaneous interval leg movements and the calmer response. *C* shows a record of the effect of sodium amytal. Note that the well-established conditioned motor reflexes to the buzzer disappeared entirely and that the interval leg movements were few in number. *D* shows the effect of ethyl alcohol. Note that the number and frequency of the spontaneous interval leg movements is greatly increased over that shown in record *A*.

movements disappeared almost entirely. In Table 2 this two-fold effect is shown. The magnitude of the first conditioned reflex, elicited 8 minutes after the dose, was unaffected; 15 minutes later, however, it was reduced to zero. A marked reduction was evident up to 43 minutes afterward when the conditioned reflex reappeared suddenly with great vigor; and vigorous reflexes were noted throughout the remainder of the tests, 71 minutes after the dose. Restless interval movements were diminished in number during the first interval following the dose, between 8 and 15 minutes afterward; further decreased 7 minutes later; and the maximal effect was seen 14 min-

TABLE 2

THE EFFECT OF A SINGLE DOSE OF SODIUM AMYTAL ON THE BEHAVIOR OF A NEUROTIC SHEEP

Sheep #8. Experiment of June 27, 1932

Time (P.M.)	Conditioned stimulus	Duration of conditioned stimulus	Magnitude of conditioned reflex in mm.	Number of spontaneous leg movements in the 7 minute intervals between stimuli
3:31	buzzer	10 sec.	360	
3:38	buzzer	10 sec.	400	28
3:45	buzzer	10 sec.	130	11
3:48—amytal, 5 gr. intraperitoneally:				
3:58	buzzer	10 sec.	258	
4:03	buzzer	10 sec.	0	7
4:10	buzzer	10 sec.	0	3
4:17	buzzer	10 sec.	6	1
4:24	buzzer	10 sec.	0	2
4:31	buzzer	10 sec.	411	1
4:38	buzzer	10 sec.	450	4
4:45	buzzer	10 sec.	180	2
4:52	buzzer	10 sec.	220	3
4:59	buzzer	10 sec.	195	17

utes later, when only one interval movement appeared, *i.e.*, between 22 and 29 minutes after the amytal had been administered. The decrement was apparent for 64 minutes, after which the usual number of movements was observed.

A graphic record of the effect of the amytal is shown in fig. 32 *C*. In the barn, two hours after the dose, no effects were noticed.

Ethyl Alcohol. As usual, three control tests preceded the critical period. The sheep was then given by mouth approximately 160 cc. of 40 per cent ethyl alcohol, and the testing was resumed a short time later.

The conditioned reflex gradually diminished and finally disappeared almost entirely. The restless interval leg movements, on the other hand, were tremendously increased in number.

The results are shown in Table 3. The conditioned reflex began to show a decrease in magnitude 26 minutes after the dose, and the maximum decrement was seen 7 minutes later. 47 minutes after the alcohol the reflex began to show recovery, and at 60 minutes the reflex was again normal in magnitude. The interval leg movements showed an initial decrease in number between 5 and 12 minutes after the dose; and this was evident for 28 minutes. A rise above the control values then occurred in the interval between 26 and 33 minutes after the alcohol. From this point on the values were about normal.

Note in this experiment that the leg movements had reached a *maximum* value at the same time at which the conditioned reflex showed its *lowest*

TABLE 3

THE EFFECT OF A SINGLE DOSE OF ETHYL ALCOHOL ON THE BEHAVIOR OF A NEUROTIC SHEEP

Sheep #8. Experiment of May 13, 1932

Time (P.M.)	Conditioned stimulus	Duration of conditioned stimulus	Magnitude of conditioned reflex in mm.	Number of spontaneous leg movements in the 7 minute intervals between stimuli
2:32	buzzer	10 sec.	132	
2:39	buzzer	10 sec.	280	19
2:46	buzzer	10 sec.	125	21
2:55—ethyl alcohol, 160 cc. 40 per cent by mouth:				
3:00	buzzer	10 sec.	360	11
3:07	buzzer	10 sec.	133	11
3:14	buzzer	10 sec.	205	4
3:21	buzzer	10 sec.	35	12
3:28	buzzer	10 sec.	3	26
3:35	buzzer	10 sec.	3	13
3:42	buzzer	10 sec.	11	11
3:49	buzzer	10 sec.	82	20
3:56	buzzer	10 sec.	115	19
4:03	buzzer	10 sec.	122	25
4:10	buzzer	10 sec.	220	20

value. It is noteworthy that this inverse relation between these two values was observed later in the same animal following the administration of adrenal cortex extract and of adrenalin (*17*). The cortex extract (cortin) caused an increase in the conditioned reflex magnitude and a simultaneous decrease in the number of restless interval leg movements; adrenalin brought about the opposite picture in which the two factors were still inversely related. The effect of alcohol on these aspects of behavior thus appears to be similar to that of adrenalin.

When released one hour and 20 minutes after dosage with alcohol the sheep seemed slightly lethargic and was noticed to stagger as it walked back to the barn. No effects were observed two and a half hours after the dose.

A graphic record of the effect of alcohol on the behavior of this sheep is shown in fig. 32 *D*.

The effects of the doses of bromide, amytal, and alcohol were unexpectedly short-lived. No effects of bromide were observed after 40 minutes, amytal after 2 hours, and alcohol after 2½ hours. We have adequately confirmed these facts on numerous occasions in sheep when we have attempted to use drugs for surgical anesthesia. The effects of chloroform, of ether, of nembutal and of chloral hydrate are of extremely short duration in sheep. We have no adequate explanation for this except to suggest that the sheep may possess some special physiological process by which such drugs are rapidly eliminated.

The effects of phenobarbital in small, continuous doses was studied in an excitable, experimentally neurotic sheep, #52. The experiment, which extended from May to August of 1939, was carried out with the invaluable assistance of Mr. Archer Speers who, indeed, did the greater part of the actual work. The authors herewith extend their thanks to this worker who permits us to give a brief outline of his results which were obtained with care and diligence.

The sheep's neurotic behavior, which was manic at times, was studied for three months (May, June and July) prior to the beginning of the critical tests involving the administration of the phenobarbital. This was done in order carefully to establish a norm or standard for the animal.

Daily experiments were executed according to the following standard procedure: metronome 120, 10 seconds; shock; 5 minutes pause; metronome 72, 10 seconds; no shock; 5 minutes pause; metronome 120, 10 seconds; shock; 5 minutes pause; metronome 72, 10 seconds; no shock; 5 minutes pause; metronome 120, 10 seconds; shock; sheep released.

After the standardization period a daily dose of 6 gr. of phenobarbital was given orally for 6 days, beginning August 15 and extending through August 20. The dosage was then increased to 12 gr. per day (in a single dose) and this was administered for three days, beginning on August 20 and extending through 23. The therapy was then stopped. Each day during the critical period the behavior tests were carried out about two hours after the substance had been administered.

Behavior was studied throughout the critical period and observations were continued for four days after the substance had been withdrawn.

As in previous experiments, we were concerned primarily with the effect of the drug upon the magnitude of the conditioned reflex, upon the number of spontaneous movements of the reaction leg, and upon behavior in general as observed in the barn or pasture. Only the responses to the *positive* conditioned stimulus were counted.

The results were definite. Phenobarbital *increased* the magnitude of the conditioned reflex and simultaneously *diminished* the number of restless interval leg movements.

The results are summarized below:

Conditioned reflex magnitude	Number of restless leg movements in 5 minute intervals
3 months prior to phenobarbital	
av. 126 mm.	av. 5
phenobarbital 6 gr. per day for 6 days	
av. 152 mm.	av. 2
phenobarbital 12 gr. per day for 3 days	
av. 174 mm.	av. 1
after withdrawal of phenobarbital (4 days observations)	
av. 98 mm.	av. 1

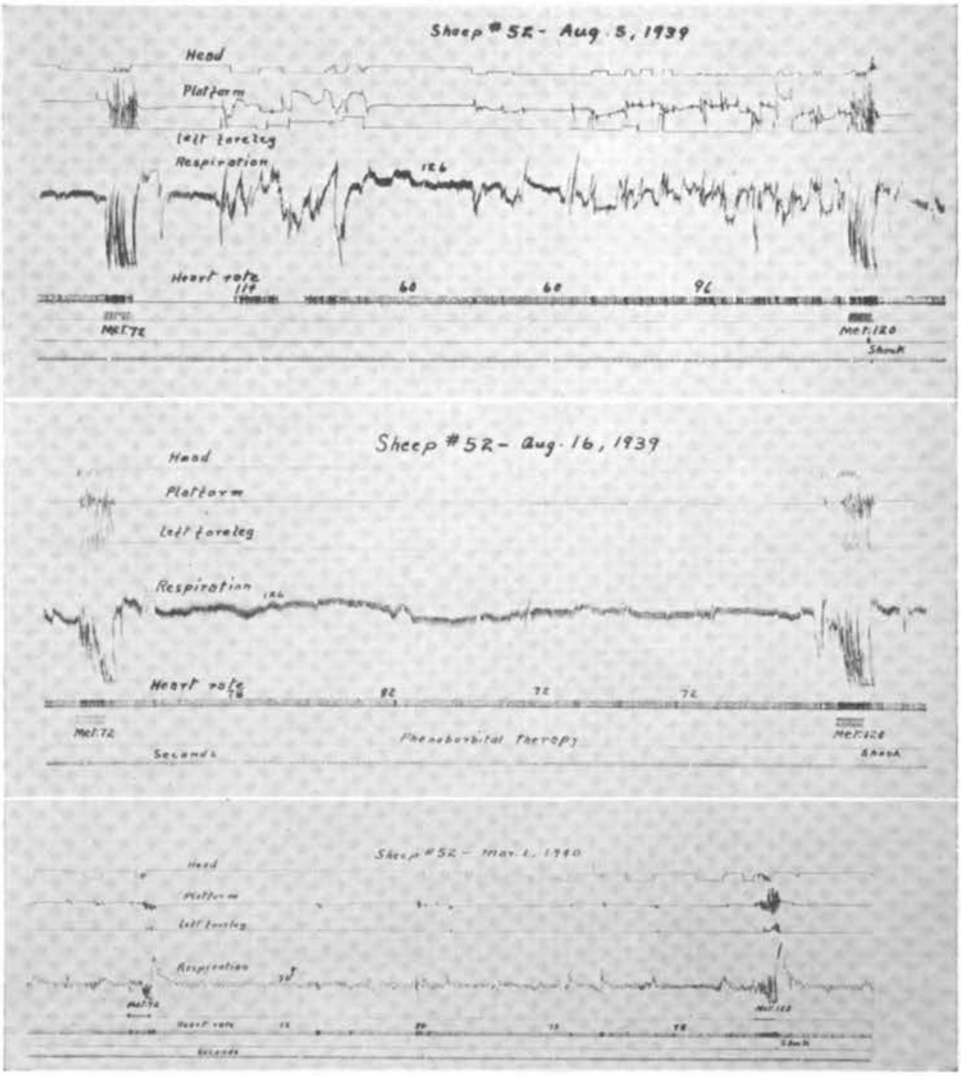
As the magnitude of the reflex increased from 126, to 152, and to 174, the number of restless movements decreased from 5, to 2, and finally to 1 per interval (average figures).

On many days no sign of restlessness at all was seen, the animal standing without movement upon the platform.

During the four days following withdrawal of the drug the average magnitude of the conditioned reflex showed, curiously enough, a considerable decrement. Its value (98) had dropped below that of the standardization period (126). The sheep still remained quiet in the intervals between stimuli (average 1).

Graphic records of the animal's behavior during this experiment are shown in fig. 33. *A* shows the manic reactions before phenobarbital was administered, and *B* the calming effect of the sedative. Note the absence of the restless interval leg movements and the slower and more regular respiration and heart rate.

During the period of administration of the drug the same phenomenon which had been observed in the earlier experiments with adrenal cortex extract (*17*) was here apparent, namely, the inverse relation between the magnitude of the conditioned reflex and the number of restless interval move-



A

B

C

FIG. 33. Graphic records showing the effect of continuous small doses of phenobarbital upon the experimental neurosis in sheep #52. *A* shows a record of the disturbed behavior immediately prior to the administration of the drug. *B* shows a record taken after phenobarbital therapy was begun. Note the remarkable quieting effect of this drug on the neuromuscular responses, respiration and heart rate. *C* shows a record taken 6 months after the therapy was withdrawn. The sheep remained quiet.

ments. Both phenobarbital and cortin increased the conditioned reflex magnitude and simultaneously decreased "nervousness."

This phenomenon was considered in this earlier paper (*17*) to indicate that the more vigorous reactions to conditioned stimulation provide for the animal a sort of "escape valve" mechanism through which pent-up nervous energy might flow. The strong conditioned reactions afford a "relief" from strain and this "relief" carries over into the ensuing period of waiting or pause between stimuli, so that no spontaneous leg movements appear in such an interval. Just how these substances produce such an effect is not, of course, understood. However, the above view will serve, for the present, as a tentative hypothesis upon which to initiate further experiments along this line.

It was interesting in the present experiment to note that the sheep was very calm in the barn or pasture during the phenobarbital therapy. Previously it had been very uncooperative when being led to the laboratory for an experiment. It would dash madly about and do everything possible to evade capture. We had also experienced difficulty, in other experiments involving the use of a stomach tube, in getting the animal to swallow the tube. In this it had required the assistance of two men to hold the struggling sheep. The following notes taken on August 23, 1939, when the phenobarbital effect was pronounced, will serve as a contrast to the above described behavior.

"The sheep stood quietly as I approached with the chain and no movement was seen as the leash was placed about its neck. The animal followed quite quietly and was placed in the straps. No excited defensive movements were seen during administration of the drug by the stomach tube. The tube was readily swallowed without gagging. The animal was given its freedom and it walked calmly out of the room and stood quietly looking about in the corral. It did not join the flock nearby. It showed no evidence of stupor or dopiness."

At the present writing (September 1940), about one year after the experiment, this sheep appears in general to be somewhat calmer and is definitely easier to handle in preparation for the experiments. Interval restlessness is not as apparent as during earlier phases of its neurosis. This, however, may be quite unrelated to the phenobarbital effects and may be an entirely spontaneous, phasic affair. A typical graphic record of this sheep's behavior at the present writing is shown in *C* of fig. 33.

6. Spontaneous Remission of the Experimental Neurosis

We have observed but one case of spontaneous remission of this disorder in sheep and dogs. This occurred in sheep D near the end of its life span. The neurosis had been observed almost continuously for about 9 years. During that period various therapeutic procedures were employed, including long periods of rest from the experiment, and a long series of negative conditioned stimuli. None of these procedures had resulted in any permanent "cure."

During the past two years (1938-40) of work upon this senile animal the motor reactions have gradually diminished in vigor, the usual restlessness

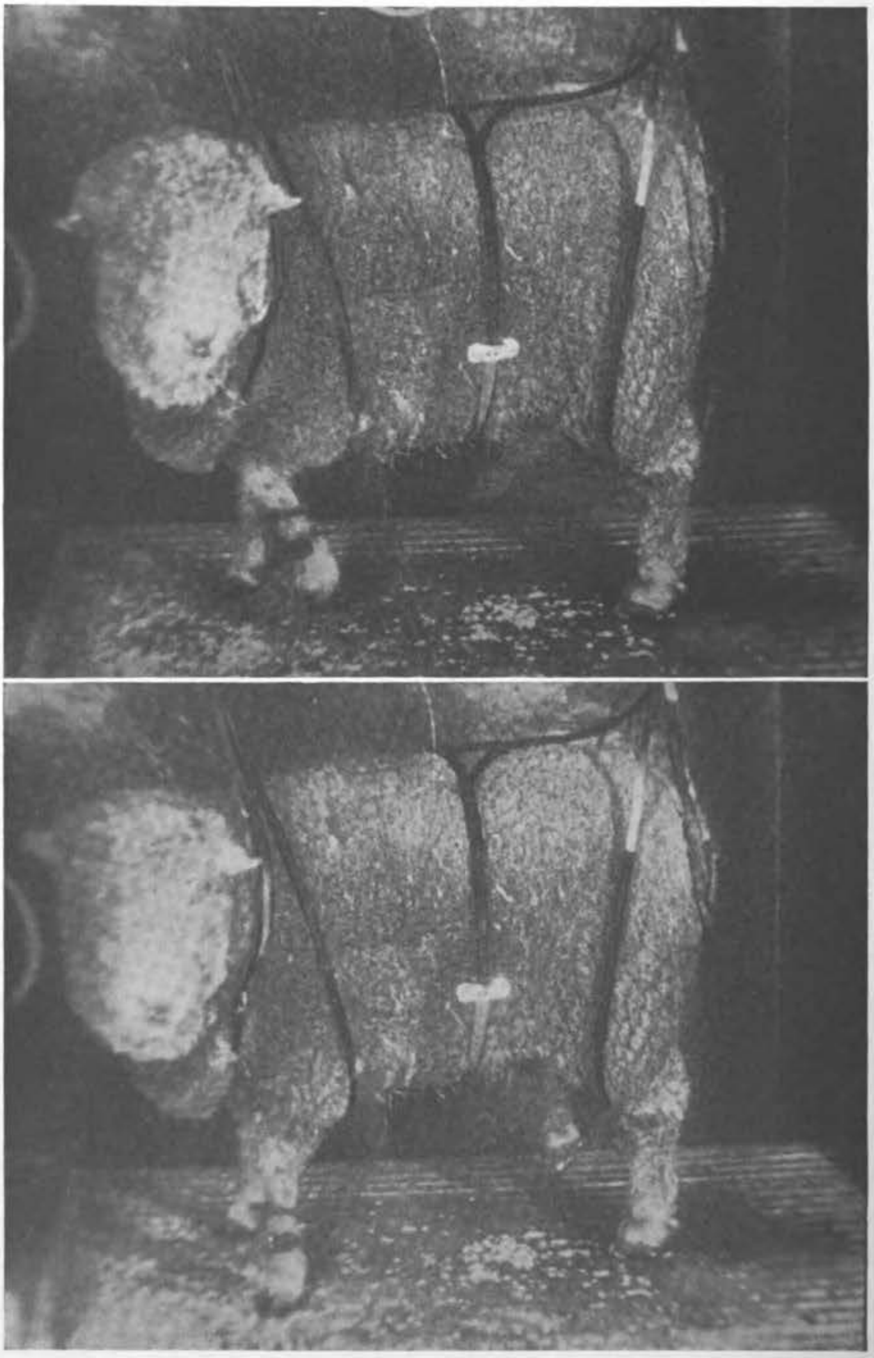


FIG. 34. Photographs illustrating the spontaneous remission of the experimental neurosis in an old animal, sheep D. This animal had shown the typical signs of the experimental neurosis for over 9 years. The upper photograph shows the calm, precise, conditioned motor reflex elicited by the metronome and the lower photograph shows the calm, alert posture of the sheep in the 5 minute intervals between stimuli. Contrast these reactions with those shown in fig. 1 (right) when the neurosis was at its height in this sheep.

in the experiment has disappeared, and the heart rate and respiration have now become normal. The sheep stands quietly upon the stand for more than an hour. When muscular movements are executed they are slow and weak.

It is obvious that the factor of senility complicates the entire picture in this case. For this sheep is now 13 years old (the equivalent of 80 to 90 years in the human life span) and is extremely feeble in all its reactions.

The photographs in fig. 34 should be compared with those in fig. 1. In fig. 1 (right) the animal is shown at the height of its neurosis. At this time it was about 6 years old. Compare the violence of the reaction portrayed here with the quietness shown in fig. 33, taken four years later, near the end of its life, under identical circumstances.

Fig. 35 shows a graphic record of the quiet behavior of her later years

FIG. 35. A graphic record showing the complete remission of the neurotic symptoms in the case of sheep D. Contrast this record with a previous record of this animal shown in fig. 31, *A* and *C*.

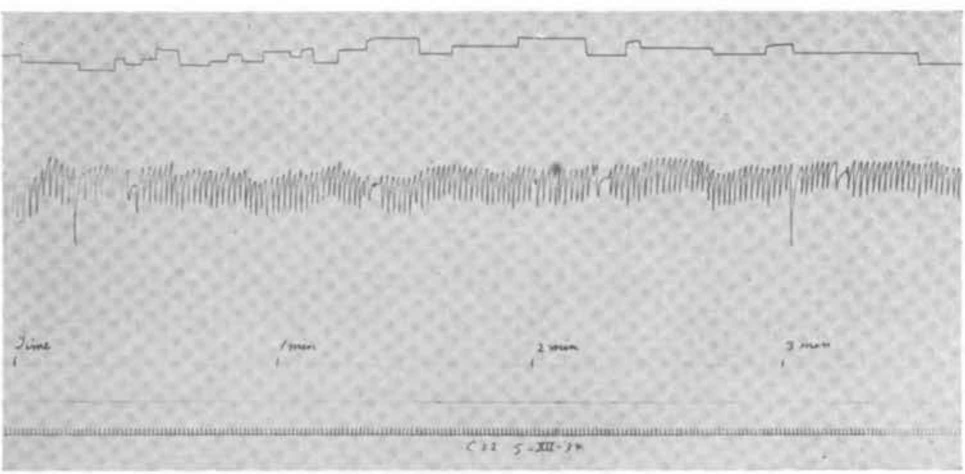


FIG. 36. A graphic record of the disturbed behavior in an old neurotic sheep (sheep C), a case studied by H. S. Liddell. Contrast the behavior of this animal with that of sheep D in fig. 35. The neurosis in sheep C persisted to the day of its death and was seen over a period of about 13 years.

and this should be compared with the animal's previously violent reactions recorded graphically in fig. 31, *A* and *C*.

Fig. 36 is the record of another senile neurotic animal, sheep C, standing unstimulated on the experimental platform. This is H. S. Liddell's case, observed for more than 12 years. In this animal signs of the neurosis persisted to the time of its death in spite of senility.

V. DISCUSSION

During the course of this long-term investigation many questions concerning its general implications and methodology have naturally been asked. Questions have been put to us not only by our undergraduate students, some of whom have observed the experiments at first hand, but by physiologists, psychologists and psychiatrists as well. Because of the scope and pertinence of these questions we have decided to turn the discussion of the animal neurosis upon an attempt to answer certain of them. In order that this might be done systematically they have been grouped under topical headings. These headings are: 1) A proposed hypothesis to account for the onset and maintenance of the experimental neurosis, 2) The experimental neurosis and its relation to the human psychoneurosis, 3) The production of the experimental neurosis, 4) Therapeutic measures, and 5) Certain general implications of the experiments.

1. A Proposed Hypothesis Concerning the Experimental Neurosis

Many a visitor to this laboratory, who has been shown the phenomena of the animal neurosis has asked the inevitable question: What really is the matter with a sheep or dog exhibiting these manifestations? What are the pathological processes which underlie the overt phenomena? The answer is, of course, that we do not know—any more than does the internist know the basic pathological causes of many a disorder or disease of the human patient. And the task of the psychiatrist, in internal medicine, is tremendously difficult in essaying to find out what are the fundamental causes of those often vague and always heterogeneous and variable mental and nervous symptoms conveniently grouped under the broad term "neurosis."

The answer of the psychiatrist to this problem is not always (perhaps not often) comprehended by the physiologist; and the answer of the physiologist is not always (perhaps not often) comprehended by the psychiatrist. Perhaps what is needed in the ultimate solution of this perplexing question of the pathology of the neuroses is a greater number of well-trained psychophysiologists and physiological psychiatrists who are interested in the problem's solution. For, indeed, the problem itself is inherently two-fold in that it involves the necessity for the consideration of an animal—whether human or infra-human—*simultaneously* from two points of view—from the point of view concerned with the individual's mental processes and from that concerned with his somatic processes. For it is plain that the individual who constitutes the subject of psychiatric investigation is above all a psychosomatic individual.

In attempting to answer the question, What really is the matter with a sheep, or dog, showing the typical manifestations of experimental neurosis, we could, of course, fall back upon a sort of re-description of the detailed, objective symptomatology. We could say that, for example, this animal, which is docile, cooperative, quiet in the experiment, is a "normal," while that animal, which is vicious, uncooperative, restless in the experiment, is a "neurotic." But this is no answer to the question. For a pathological state of the organism underlies these outward expressions and we have to inquire what this state may be.

At this stage of our knowledge we are fully aware that a statement of a theory of the animal neurosis in anything even approaching formal terms would be both premature and presumptuous and, therefore, scientifically valueless. Rather, we shall put down at this point a few more or less random ideas and "hunches" on the subject which have grown out of the work during the past ten years or so. And we wish to state explicitly that the only possible justification for doing this is the hope that the ideas and "hunches" may be of some service in the formulation of plans for future experiments along this line. The notion which we propose is, therefore, to be considered only as a working hypothesis.

The symptom-complex of the experimental neurosis may be due to a chronic imbalance in the internal chemical (nutritive) environment of the body cells, particularly the nerve cells, arising through an imbalance in the activity of the glands of internal secretion, the glandular imbalance being constantly induced by repeated and prolonged emotional states incident to the experiments. Such a long-enduring disturbance of the chemical equilibrium of the nerve cells may involve, among other substances, the ions of sodium, potassium, calcium and magnesium. Thus, for example, a prolonged, even slight, excess or diminution in the concentration of the ions of sodium in the environmental medium of these cells, and brought to bear upon their life processes, may produce prolonged changes in their fundamental functional activity, an increase or a decrease of their irritable properties, so that a general state of hyperirritability or hypoirritability of the nervous system may result.

The notion of the relation between internal body chemistry and behavior is not, of course, new. C. R. Stockard (*23*) years ago initiated work upon this relationship. And C. McFee Campbell (*6*) has long advanced this concept. However, undoubtedly the initial evidence for the view of the intimate association between physiological states and behavioral states was produced by H. S. Jennings (14) in his classic study on the behavior of the lower organisms.

Evidence for the dependence of nerve cell function upon the immediate chemical environment is rapidly increasing. And the recent work of Bronk and his associates along this line is important and highly significant. It was found by these workers (5) that oxygen lack due to perfusion of the stellate ganglion with de-oxygenated Ringer's fluid or arrested circulation causes the progressive and reversible failure of ganglionic pathways as judged by lack of discharge of impulses into the postganglionic nerve. Acetylcholine or potassium chloride injected into the perfusion fluid stimulates ganglion cells directly. An increase of calcium blocks transmission and if the calcium be reduced by perfusion with sodium citrate the cells discharge spontaneously at a time when synaptic transmission is blocked. Larrabee, Brink and Bronk (15) in a further report of this work make the following observation. "Excepting the block produced by low calcium, we have thus found that changes in certain ionic concentrations produce effects on ganglionic transmission which can be explained by assuming that they are due to changes in the irritability of the ganglion cells. The changes are analogous to the alterations of electrical excitability known to be produced by these ions." This work contributes not only to neurophysiology but should form the basis for a truly physiological approach to the study of the fundamental problems of psychiatry, particularly those problems dealing with medication in mental and nervous cases.

In the animal neurosis, under the conditions of our experiments, the imbalance in the concentration of the ionic or other substances may be induced by a chronic disturbance of the endocrines which arises from the repeated arousal over long periods of time of the emotional states of fear and anxiety. These emotional states may be induced by a feeling of uncertainty incident to the experimental procedure—a procedure involving a psychosomatic adjustment which the animal is forced to face and from which it cannot escape, for it is confined to the room and to the experimental platform by restraining straps. The confinement itself may indeed not only modify the overt responses of the animal (we showed evidence above, in the case of dog #881, that when the straps were removed the animal, although being fed, not shocked, at once escaped from the room) but also may increase the intensity of the fear.

In these experiments uncertainty may well be induced by the differentiation procedure, in which the animal receives the shock or the food following one stimulus, and receives no reinforcement following another. With close differentiations the decision is difficult and the animal cannot be certain which stimulus is reinforced and which is not. Uncertainty may also be produced by the rhythmical stimulation procedure, in which positive conditioned stimuli alone (reinforced by shock or by food) are presented at exact intervals of time. In this procedure the sheep or dog cannot be certain, in a given interval between stimuli, *exactly* when the next reinforced stimulus is due, and as a consequence it reveals signs of nervousness, often throughout the course of the waiting interval, in anticipation of the stimulus "which may come at any moment." This lack of certainty may be analogous to the worries and uncertainties of the neurotic patient who is apprehensive about his heart, who thinks "at the *next* step up these stairs my heart may stop."

Repeated and constant fear probably produces a chronic disturbance of the suprarenals and the thyroid through the integrative action of the cerebral cortex, the thalamus, the hypothalamus and the peripheral sympathetics. We do not imply that no other glands are involved in the imbalance of the internal secretions. In all likelihood all are disturbed. But we believe that the preponderant evidence points to the suprarenals and the thyroid as the principal offenders. Some of this evidence is direct and some indirect.

The disturbance of the suprarenals may involve either an excess of adrenalin or a diminution in cortin or both together. There is considerable evidence that the suprarenals may be involved. The work in this laboratory of Liddell, Anderson, Kotyuka and Hartman (*17*), discussed previously in this paper, showed that the essential symptoms of the experimental neurosis in sheep were markedly improved following the administration of cortin and were tremendously exacerbated by injections of adrenalin. Hartman and his associates (*10*) showed that extract of the adrenal cortex had a pronounced beneficial effect upon the nervous and muscular systems generally. He found that in cases of Addison's disease (*11*) cortin relieved the symptoms of extreme muscular weakness and marked nervousness, in addition to affording relief from the other signs of the disorder. And effects of the substance could be detected in normal human subjects as well (*12*). Mental fatigue was frequently diminished; sleep was improved, and a sense of well-being was experienced, which developed in some cases even to the point of euphoria. Hartman, Beck and Thorn (*13*) have demonstrated that the extract (cortin) even has a beneficial effect on the nervous and mental symptoms of disorders unrelated to Addison's disease (functional and organic diseases of the nervous system). Marked improvement was noticed, not only in the motor functions of the patients (diminution in fatigability and increase in strength) but in their mental outlook. States of profound depression and general irritability were replaced in varying degree by cheerfulness and calmness.

The reaction of the human subject to the administration of adrenalin, on the other hand, is the opposite, as is well-known. The normal individual often exhibits and experiences a certain degree of nervousness accompanied by cardiovascular reactions (tachycardia, palpitations, etc.) followed by feelings of exhaustion if the dosage has been excessive.

The evidence for a possible thyroid involvement (mild hyperthyroidism) is equally extensive. Every clinician is aware of the difficulty in making a clear-cut differential diagnosis between slight hyperthyroidism (without exophthalmia) and anxiety neurosis. Both patients are nervous, irritable and exhibit tachycardia and palpitation. And we are informed that the B.M.R. is not always reliable as a criterion since the basal rate may also be higher than normal in the neurotic patient due to his inability to relax completely during the test.

It is equally well-known that, as is the case with adrenalin injections, the normal human subject frequently shows marked signs of nervousness and irritability following the administration of thyroid substance. And these symptoms may appear in hypothyroid patients under thyroid therapy when the dosage is in excess of physiological requirements.

Further, and more direct, evidence for possible thyroid involvement comes from a special study by one of us (O.D.A.) on the influence of the endocrines upon the conditioned reflex actions and behavior of the dog (*4*). In this work every essential sign of the typical excitatory experimental neurosis was produced in normal, quiet dogs by the continuous administration of thyroid extract. In one dog, during the training period, when the conditioned motor reflex was being standardized, and before the substance was administered, the animal showed no signs of nervousness and would stand with no trace of restlessness in all the intervals between stimuli (which were always exactly 5 minutes in duration). After about ten days of the thyroid treatment the quiet behavior changed to excessive restlessness, and a general increase in the level of excitability to all stimulation resulted. These symptoms persisted for some time after the substance had been withdrawn but finally normal quiescence supervened.[11]

We observed these phenomena in several other dogs, but, as previously stated, we did not notice any such effects of thyroid substance in the sheep. The negative result on the sheep, however, does not diminish the value of the above observations. Further work may throw light upon this interesting species difference.

[11] This experiment was also tried in dog #868, whose case is recorded in the present report. The thyroid substance was given several months after all signs of the neurosis had disappeared and the animal was considered a typical normal. The same transient nervousness resulted as in the case above cited.

The disturbance of internal chemistry suggested in the foregoing discussion might readily account for the symptomatology of the *excitatory* form of the experimental neurosis. How can this notion explain the manifestations of the *inhibitory* form? This is more difficult. However, the inhibitory symptoms may be due to analogous changes in the chemistry of the environment of the nerve cells, changes which are in the direction opposite to those associated with hyperirritability. This is not inconsistent with the above presented evidence regarding the dependence of the function of the nerve cells upon the concentration of ions of various substances (work of Bronk and his associates, *5*).

In summary, the working hypothesis here advanced is concerned with a circle of connected events. Repeated and prolonged emotions, incident to the experimental procedure, produce a chronic imbalance of the internal secretions which induce a constant state of imbalance of the chemistry of the nerve cells. A change in the irritability of the nervous system results. The nervous system may become hyperirritable. Further and prolonged stimulation of the emotions reinforces and perpetuates the changes in internal chemistry and the vicious circle of events is complete.

A fundamental therapeutic problem of the investigation is to find a means of blocking this circle of events at one or more points in the path—either through therapeutic alteration of the internal chemistry or through interruption (surgical) of the peripheral autonomic nerve pathways which stimulate the endocrines or through therapy directed toward a reduction of the intensity of the emotional processes. Thus the hypothesis leads to further work.

In connection with this general view I. P. Pavlov's view of the pathology of the experimental neurosis is interesting. It is summarized in the following quotation (*21*): "What are the general characteristics of all the pathological instances? Upon what depends the persistent and marked deviation from the normal brought about by our procedures? We have the right to answer, I believe, that it is *a difficult collision, an unusual confronting of the two opposing processes of excitation and inhibition (be it in time or intensity relations or even in both together*[12]*)* which leads to a more or less permanent destruction of the normal balance existing between these two processes." This is probably true. But that such an explanation was not wholly satisfactory in the ultimate physiological sense to Pavlov himself is seen in the following quotation from the same source. "One can hardly deny that only a study of the physico-chemical processes taking place in nerve tissue will give us a real theory of all nervous phenomena, and that the phases of this process will provide us with a full explanation of all the external manifestations of

[12] Italics by Pavlov.

nervous activity, their consecutiveness and their interrelations." This seems to us adequately to state the case. And the suggestions which we have made in the foregoing discussion we hope will provide at least one direction from which one may approach the study of these "physico-chemical processes" of the nerve cells.

2. The Experimental Neurosis and Its Relation to the Human Psychoneurosis

We have frequently been asked the question whether we identify the experimental neurosis in our sheep with the human psychoneuroses. We feel that, at the present state of our investigation, it is not helpful to the solution of the problem in general for us to identify the disturbance in animals with that in the human subject.

Before a meeting of a group of clinical psychiatrists with the group of investigators at the Cornell Behavior Farm in the spring of 1939 Liddell has stated clearly and briefly the position which we adopt, and we shall quote directly from this statement.

"If we begin matching animal and human situations we involve ourselves in insoluble problems. We therefore choose to attempt to standardize a neurosis-producing situation, and then to explore in detail the psychosomatic consequences of the condition. We have no desire to identify the experimental neurosis in sheep with any form of human mental disorder. However, its origin suggests similarity to the human situation, where difficulties arise under social pressure."

It has been of interest to us to have observed that many of the objective manifestations referable to the neuromuscular system and to the autonomic nervous system, which are characteristic of the experimental neurosis, are suggestive of similar symptoms seen in certain types of human psychoneurosis. For example, the markedly unstable cardiovascular reactions of the sheep with experimental neurosis naturally call to mind the human syndrome known clinically as neuro-circulatory asthenia or cardiovascular neurosis.

We are fully aware that our thinking in these problems is colored by the possible ultimate implications of this animal work in the study of the human psychoneuroses. That is inevitable. For indeed, in the ultimate sense, it would be a foolish and naive pretense for us to state that our interest is concerned wholly with the study of neurotic behavior in the sheep and dog.

3. The Production of the Experimental Neurosis

The question of how long it takes for the experimental neurosis to develop can be answered as follows. The rapidity of progress in the development of the neurosis is a function of the genetic susceptibility of the animal; the intensity of the testing schedule; the strength and probably the unpleasantness of the unconditioned stimulus, be it the intensity of the shock or of the hunger urge. Intensity of training schedule embraces both the method of testing (that is, whether with regular or irregular intervals between stimulations) as well as the number of such stimulations per unit of time and whether the experiment involves discrimination or not. In the case of an animal with extreme constitutional susceptibility, sheep D, a Merino, the condition was observed to develop in as short a time as ten days from the beginning of an attempted differentiation. On the other hand, another Merino, #11, not only made differentiations, but was tested on a rigid time schedule as well, and no neurosis supervened in the course of seven years. It was finally brought about only after an experiment involving a long series of insulin shocks.

The experimental neurosis has, in the majority of our cases, required for its development periods of time somewhere between the two extremes.

In our opinion, the mild electric shock as a reinforcing agent is of less importance in the production of a neurosis than are the factors of difficulty of discrimination, frequency of testing, and character of the time schedule. The electric shock has served as a reinforcing agent in tests on all of the sheep and in a large number of dogs, covering thousands of experiments over a period of 10 years and more, and over this period the greater number showed no sign of the disorder during their life span. (See case of sheep #4.) We would also point out in this connection that neuroses are often developed in other test situations in which the electric shock played no part as a reinforcing agent; for example, the salivary reflex experiments upon dogs. (See case of dog #881.)

The restriction of the animal's activity in the experiment probably contributes to the experimental neurosis. This restriction apparently molds the way the neurosis will express itself. A certain degree of freedom from the limitations of the Pavlov frame has been shown by one of us (R.P.), in another paper, to make predictability of response impossible, and to eliminate stereotypy. We have not, up to the present time, attempted the production of an experimental neurosis when the animal was able to maintain the considerable freedom of locomotion possible in the outdoor testing pen. Stereotyped reactions sometimes reappeared when the animals were again tested in the Pavlov frame, after a series of tests conducted while they were free in the experimental room or in the outside paddock; but in one notable case (sheep #7) all reflex response disappeared upon his return to an experimental environment to which he had been accustomed for more than 11 years after only 4 or 5 test periods where freedom of locomotion was possible.

We are unable to answer the question, whether or not castration is a predisposing factor in the development of the experimental neurosis. In the case of one uncastrated animal no neurosis was developed during an entire life of testing, in which extremely difficult tactile differentiations were successfully accomplished (case of sheep #4). Among the rest of the male members of the flock, numbering 18 in all, 11 castrates did not develop neurosis and 6 did. Among the females of the flock, 10 in number, only 2 developed neurosis.

We have been asked whether every animal is equally predisposed to the formation of the experimental neurosis. This is not the case by any means, and we have found a wide variation in predisposition, ranging from animals who never become neurotic even after years of testing to others of whom it might be said that we suspect them to be neurotic from birth. As we have indicated earlier, the sheep of the Merino and Cheviot breeds (and perhaps such excitable dogs as the Saluki and German shepherd breeds) more easily show the neurotic symptoms than do more stolid, less excitable animals such as the Shropshire sheep (and certain of the hound breeds of dog, *e.g.*, the bassethound). When we produce a neurosis in the former type we have doubtless aggravated a predisposition toward this condition, since our experimental technique effects a piling up of more and more tension upon an already tense mode of behavior.

Many of the manifestations which we later study in the laboratory may be observed in certain sheep even before testing begins, a fact which has aided us in selecting from a flock the animal which, when put under strain, would the more readily arrive at the condition which we wish to study. For example, the typical "natural" mode of behavior of a Cheviot or Merino, in a large mixed flock, readily marks it as a possible candidate. It is shy, suspicious and an "individualist," as far as the large mass movements so characteristic of the domestic sheep are concerned; and these qualities render him more than ordinarily sensitive to the strain of the experimental environment.

One of the stages in the formation of the conditioned reflex is the training of the animal to stand quietly upon the experimental platform. It is interesting that this period lasts longer in the case of animals genetically predisposed to neurosis. Two outstanding neurotic examples from our flock, sheep D and #52, during the preliminary stages of training, would often struggle violently in the restraining straps and sometimes they crouched to the floor and refused to rise. A considerable time is therefore required before such animals can learn to remain quietly under a self-imposed restraint, the condition prerequisite to the formation of the precise conditioned motor reflex.

There is also a difference in the unconditioned response of the naturally nervous animal as compared with the more stolid "normal" sheep or dog.

The nervous animal's response to the electric shock consists not of one, but of a series of violent flexions of the reaction limb, continuing for a minute or more after the precipitating cause has been withdrawn. Since the shock itself lasts for but ⅕ *of a second* these after-discharges are very conspicuous and are usually wholly absent in the case of a normal, more stolid animal, who usually responds to such stimulation by a single flexion of the reaction limb.

4. Therapeutic Measures

The principal therapeutic measure which we have attempted on our neurotic animals has been the "rest cure." This, as in the case of human individuals, has always had a salutary effect, but, as a permanent reliever of the condition, it has never been successful. Furthermore, after a rest of as much as three years from the testing schedule, the neurosis has always returned more quickly upon the resumption of testing than it did upon the occasion of its initial appearance.

Other therapeutic measures have been attempted, and a description of the effect of drugs and hormones has been reported in the section devoted to this subject in the main body of the report. It suffices to say here that the therapeutic action upon the animals parallels that of the effect upon nervous human subjects.

In two animals, sheep D and dog #868, we have cases of an alleviation of the disorder by methods which are suggestive of the psychotherapeutic measures employed by the physician. In sheep D the improvement resulted from deliberate coddling, plus a long series of unreinforced stimulations. In dog #868 it resulted from the introduction of a "cued signal" which made the solution of the problem easier for the animal.

5. General Implications of the Experiments

Biologists and others have asked whether the neurotic sheep or dog shows any profound changes in its life habits, particularly regarding care of the young and sexual activity. We have observed few biological changes of this sort. All neurotic female sheep who were exposed to the ram and who have borne young have cared for them in a perfectly normal manner. Similarly, the neurotic dog #881 was receptive to the males, but the experimenter did not permit insemination. One neurotic male dog, #929, never showed interest in a female in heat.

We have not observed alterations in the behavior of the sheep in association with the period of estrus. In the dog, however, this period, which often lasts 15 or 20 days, produces profound changes in neuromuscular activity and in the conditioned reflexes. However, our observations on this point in both sheep and dog have thus far been cursory and experiments are now under way at the Cornell Behavior Farm by M. Altmann on the exact and detailed study of this question.

Numerous psychologists and clinical psychiatrists have asked a very pointed question: "Where is the psychology in your work?"

It has been implied especially frequently during the last 4 or 5 years that our investigations have missed the point entirely in that they do not concern themselves with the psychology of the animal. We are charged with not having studied the effect of conflict, frustration, motivations of various sorts, and so forth, and hence of rendering our results inapplicable to the practical problems of the clinical psychiatrist.

In answer to this we simply say that our technique is not designed to show the effects of such possible causes of the experimental neurosis and we consider it unwise, at the present stage of our investigations, to attempt any study of the fundamental nature of the psychological disorder which does unquestionably exist in our experimentally neurotic sheep and dogs. It seems to us that much more is to be gained for the present in laying a groundwork of physiological findings upon which we may later base more extensive psychological investigations of this disorder. As regards the practical problems of the clinical psychiatrist, our physiological approach to the problem is designed to shed light eventually upon such matters as organ predilection, the origins of the organic symptomatology, and other organic manifestations of the psychoneuroses. Further, it is of advantage that we have at hand a standard laboratory animal, showing a definite organic syndrome, upon which we may test the adequacy of clinical therapeutics and formulate new curative procedures.

We are by no means ignoring the importance of psychological problems and have initiated experiments which we hope will lead toward the clarification of some of them. Investigations are now under way to evaluate the rôle of the situation itself in the production of the state of nervous disorder. For example, we are working upon what may be termed the traumatic causes of neurosis, and are further planning extensive investigation of the problems of social and biological maladjustment insofar as they can be studied in animals who cannot convey to us by language the nature of their distress.

People have wondered why we have used the sheep and dog instead of a higher order of animal such as the infra-human primate. Apart from the purely economic advantages of convenient size, hardiness, long life and relative cheapness in original cost and maintenance, there are certain advantages inherent in the fact that these animals are no higher in the mammalian scale than they are. They represent one of the simplest animals in which not only can a neurosis be produced, but in which individual reactions, such as respiration, specific motor reflexes, cardiac performance, etc., can be observed and measured with the instruments at our disposal. Below them in the scale the rat is, we feel, too simply organized to permit a study of individual responses, and limitation of size beyond a certain point makes a study of specific physiological function in the intact animal extremely difficult. The obstacles to experimentation upon a higher animal such as the ape are, firstly, the great difficulty of maintaining adequate instrumentation attached to the animal, secondly, the complexity of the response system itself, and thirdly, the coloring of the response by the animal's obvious desire to play up to the experimenter. The domestic sheep and the dog have seemed to us admirable animals for our purpose and have been used as standard laboratory subjects for the study of the disorder.

We feel that our investigations make a definite contribution to psychiatry if only in the fact that they lay bare the fundamental symptomatology of neurotic behavior in relatively simple animals who cannot *obscure* their true condition by verbalization.

APPENDIX—CASE HISTORIES

SHEEP D. AN EXCITATORY CASE OF EXPERIMENTAL NEUROSIS, DEVELOPED AT THE FIRST ATTEMPT TO FORM THE SIMPLEST DIFFERENTATION. CASE UNDER OBSERVATION FOR TWELVE YEARS.

Sheep D, a normal female, was born in the spring of 1928. The animal was genetically a hybrid of the Merino and Shropshire breeds, with the physical appearance of the Merino dominant. Indeed, the appearance of the animal was such that it would have been difficult for an expert to tell that she was not a purebred Merino. She had fine wool, wrinkled skin, white nose, long legs and body.

In September of 1928 conditioned reflex experiments were begun. Conditioned defensive reactions of the left forelimb were established to the metronome beating at a rate of 120 per minute, reinforced by a shock to the reaction limb. From the very first the animal's reactions to the metronome and shock, as well as reactions to the caretaker and others outside of the laboratory, were extremely nervous.. The sheep was skittish, very difficult to catch and, when cornered in the barn, would often suddenly lie down on the floor, breathing stertorously. As the animal became accustomed to being handled, and accustomed to the experimental situation, the violence of the reactions diminished somewhat. Within the usual number of applications of conditioned stimulus and shock (6th trial) the conditioned reflex was established and was easily maintained, that is, very rarely did it fail to appear when the stimulus was given. In the quieter animals such was not the case.

During early training tests the animal constantly attempted to watch the experimenter through the glass observation window. Often she refused to eat from the bucket of oats before her. It was usually observed that the animal, when put in the loose restraining straps in the experimental room, would hang on them and refuse to stand on the ground in an erect posture. She also showed marked body tremors and many startle-reactions, some elicited by known stimulations others by no stimulation of which the observer was aware. The head was always held in a drooping position. It was also often observed that as soon as a stimulus and its shock had been presented she would immediately put her head into the feed bucket and eat almost continuously for a minute or so. Occasionally she would raise her head and look about her in what appeared to be a wild manner. When allowed to stand for some time, as when waiting for the experiment to begin, she often alternated between eating ravenously and hanging trembling in the straps.

The duration of the conditioned stimulus varied from 1 second to 7 seconds. The intervals between one stimulus and another also varied from 1 minute to 4 minutes during the early phases of the experiment. Four positive metronome 120 signals were presented each day, the experimental sessions taking place about four times a week. Conditioned responses were very vigorous at all times. This generally excitable type of behavior was observed throughout the initial two months of the work, during which period 120 applications of metronome 120 and shock were given.

On November 6, 1928, differentiation tests were begun. The easiest, that between metronome 120 (positive) and metronome 50 (negative) was attempted, as this was the usual starting point for differentiation experiments in the animals. At this time we wished to find a procedure for developing the metronome differentiation more rapidly than was the case in the other animals. We had made it a practice to contrast in each day's experiment, giving 3 or 4 stimulations, the positive with the negative rates. This had proved to a very time-consuming procedure. We now decided to form a rapid extinction of the generalized response to metronome 50 by giving, in one and the same experiment, a long series of negative stimulations separated by pauses of only 1 minute. The idea was simply to continue presenting the negative stimuli until the response disappeared entirely. Since this period in the animal's history was apparently a critical one, we shall recount it in some detail.

The introduction of the negative stimulus produced a profound change in the animal's reactions.

The first day's extinction experiment consisted of the initial metronome 120 plus shock and this was followed by the negative metronome 50 at 1-minute intervals, 3 negatives being given in this day's test. No sign of extinction of the response appeared. On the next day the experiment began as usual with the positive fast metronome rate and then proceeded, after a pause of 1 minute, to the negative rate. In this day's experiment a total of 26 negative stimulations was given in succession. At the 26th application of the negative there was still only slight evidence of extinction, that is, the response still persisted in spite of complete lack of reinforcement.

On the next test day a total of 15 negative stimuli were given, following the positive. On this day we noticed that the animal objected strenuously to entering the experimental room, showing great hesitancy in going up the ramp to the table and having to be lifted onto the table. When the straps were placed about the limbs the animal collapsed and hung in them. Instead of the differential reaction becoming weaker, as was usually the case, the responses became stronger. Just before the experiment began the animal finally stood up and moved about in an extremely jerky fashion, looking from side to side in a wild manner. Respiration was extremely disturbed, being quite audible and somewhat labored.

The next day's extinction experiment, which consisted of 11 successive negatives, further exaggerated the already apparent signs of general nervousness.

At this point we cut down on the number of negatives used and employed only 4 in each experiment. This routine continued for about a week. We did this in order to prevent, if possible, the formation of a complete experimental neurosis, since we were not at that time interested in the neurosis itself. This change of procedure, however, had no effect upon the neurotic symptoms. The animal became more and more nervous throughout that week. During this time no sign of clear-cut differentiation between the fast and slow rates of the metronome appeared.

By November 23 the animal's behavior clearly showed every sign of the experimental neurosis although differentiation experiments had been under way for only about two weeks. It must be emphasized, however, that the animal had already been exhibiting highly nervous behavior even before the differentiation experiments were begun. These latter seemed rather to be an immediate or precipitating cause of a complete nervous breakdown.

During the next two months, that is, to January 18, 1929, we adopted the more usual method of contrasting the negative metronome with the positive in each experiment, giving the animal only 3 to 4 stimuli altogether. Apparently the damage had already been done. There was no improvement in the nervous reactions. A typical day's observations may well be quoted here:

"Animal very nervous while being put in harness. Much struggling and attempts to lie down on the table. Loud labored breathing. Animal finally induced to stand after about 15 minutes working with her. Reaction leg in almost constant motion; shifting about from one place to another. Slightest touch on leg evoked violent startle reaction. Eats voraciously from oats bucket in front of her and at frequent intervals raises her head from the bucket to look about her in an apparently wild fashion. After the application of each stimulus a brief period of quiet was noted. This, however, did not endure longer than about 30 seconds."

Experimentation on this animal was abandoned at this point and was not resumed until November 6, 1930.

After the animal had had this rest we decided to try an entirely new type of stimulation. Accordingly, a defensive condition reflex was formed to a pure tone of a frequency of 435 cycles per second, reinforced by shock.

Immediately upon hearing this tone for the first time, and even before the shock was given, the animal gave a vigorous conditioned response. She was considerably less nervous in the animal room during the first few periods of testing and the following observations were noted down while she was standing waiting for the tests to begin: "Animal quite calm, breathing fairly regular. No spontaneous nervous movements of the reaction leg."

Each application of the tone evoked the same vigorous conditioned reflex and at the 16th tone (435 cycles) we decided to introduce a negative, unreinforced tone of 900 cycles per second.

We now began long extinction experiments, exactly similar to those tried with the negative metronome 50. In this first differential experiment, 10 unreinforced signals, tone 900, were given. No extinction appeared. This type of experiments continued to December 5. The animal remained fairly quiet, being far calmer than was apparent during the similar metronome extinction experiments. After this date, however, signs of nervousness again appeared. No differentiation was formed to the two tonal frequencies. The experiment was then abandoned.

The next series, in which a differentiation between a loud buzzing sound, plus shock, and a weak one, without shock, was attempted, was begun on March 26, 1931. These experiments proceeded through May 4, 1932. A variety of techniques was used in order to try to build up a differentiation between these two widely different signals. The attempts were quite unsuccessful. Throughout this period the general excitement of the animal mounted continuously and finally attained a truly maniacal form of reaction. She responded so quickly and violently to the buzzer stimulus, both loud and weak, that we thought to test or assay the level of the animal's excitability by the introduction of stimuli which were "neutral" in order to see whether or not a "generalized" reaction would appear. Accordingly, on several occasions in the series of buzzers, stimuli such as bubbling water, flashing light, moving disk, were used. The animal reacted in every case violently, even to stimuli varying so widely in nature from the original metronome, tone and buzzer stimuli. Near the end of this period of the work typical notes such as the following were jotted down at the time: "The reaction to conditioned and other stimulations are so violent that the recording mechanisms are frequently damaged, occasioning much delay in their repair. The reaction limb itself is in almost continuous motion throughout the period of testing."

In the reaction itself to controlled stimuli the entire body, including all four legs are, involved. The measurement of the degree or magnitude of the conditioned reflex was attempted during this period (by means of the modified Fick work adder) but the reactions were too violent for accurate determinations.

After a lay-off of two years and six months, due to the absence of the first experimenter (O.D.A.), work on this animal was resumed late in November of 1934 (by R.P.).

Four periods of 5 minutes duration, without stimulus, were given on 4 successive days, and a record was kept of the spontaneous activity during that time. The animal proved extremely refractory in the testing environment, it being not only extremely difficult to catch her in the barn, but requiring two men to drag her up the inclined ramp, while urination and defecation occurred each time she was brought to the experimental room. When the supporting straps were placed under her legs she was apt to struggle in them, sometimes not putting all four feet to the table during the entire 5 minute period.

On December 1, 1934, a long series of negative, that is, unreinforced, stimulations was begun, a doorbell being used as the conditioned stimulus. This stimulus was new in the animal's experience, but responses to it were massive, with no appreciable latency, the animal going instantly into action upon the sounding of the signal. 14 presentations of the bell at one minute intervals brought about a slight calming of the conditioned response on the first day, but this calming effect had completely disappeared when she was tested two days later with the same stimulus, and responses were again massive and generalized. She was brought to the laboratory every few days and a series of a dozen or more negative stimuli were given.

It was not until after 35 presentations of the unreinforced stimulus that overt muscular response ceased. At this time the orienting response to the signal was still extreme and the reaction of hanging in the straps was common. Negative stimulation was continued throughout the winter of 1934-35 and gradually the animal became calmer, the orienting reactions still remaining, but growing less violent, and there was less and less difficulty in getting the animal to the laboratory.

As the apparent nervousness in the experimental situation diminished, a certain playfulness manifested itself in the animal's behavior. She became no longer difficult to catch in the barn, trotted willingly beside the experimenter to the laboratory, and would even start part of the way up the ramp. At this point she would pause, rub the experimenter's shoulder or arm with her nose, and refuse to budge further until he had moved a forefoot for her. She would then bring up the other foot and wait for the process to be repeated. During these tests she would occasionally dash up the incline, but would drop to her foreknees upon reaching the platform and it was with difficulty that she was persuaded to assume an erect posture in the supporting straps.

The tests which began on the first of March, 1935 (77th bell) consisted of four negative stimulations per day, usually separated by three-minute intervals, and varying in duration from 5 to 20 seconds. It was seldom during this time that conditioned reflexes any longer occurred, and when work was discontinued on the 12th of April, after 99 consecutive presentations of the unreinforced stimulus, the animal had very markedly calmed down since the start of this series on the previous November.

Work was discontinued at this point of the experiment for 6 months, and the animal was turned loose to graze in the pasture with the other sheep. During this time she was never forcibly brought to the laboratory but had developed such an "affection" for the experimenter that she would follow him out of the barn when he had gone there to get other sheep, and was occasionally found away from the rest of the flock, hanging around the laboratory door. On one occasion she even left the flock to follow him and attempted to enter his automobile.

Testing was resumed in the early winter of 1935-36, the 100th bell in a series of unreinforced bells being given on the 4th of November. The animal at that time had apparently not relapsed into her former neurotic state and testing at intervals during the winter brought no conditioned response to the negative signal other than a rather exaggerated startle response at the onset. 22 presentations of the unreinforced bell were given between the 4th of November and the 24th of February, on which date it was decided to test the effect of a long-continued negative stimulus.

Consequently, the 124th bell was given for 2½ minutes and, after a latency of 20 seconds, a very small foreleg response was observed. Only two other conditioned responses to the bell had appeared during this period, although each of these was of great violence. On March 4th the animal was again brought to the experimental room and on this occasion a bell was ringing before its entrance and remained on throughout the 5 minutes that she stood in harness. She was no more difficult than usual about mounting the stand. The experimenter, as always, was obliged to "humor" her by placing her feet in going up the ramp, but once on the table she stood perfectly quiet through the test.

The series of bells was now brought up to 129 on March 10, 1936, at which time it was decided to give a positive stimulation for the first time in over 4 years. The 129th bell was accordingly followed 2 minutes later by a 10 second stimulation by a common door buzzer, reinforced by shock. A vigorous conditioned response was immediately elicited. Another positive stimulation followed with another positive response and this was in turn followed by the 130th presentation of the unreinforced bell. No conditioned response was given, showing that a perfect differentiation had been effected and that the positive conditioning had endured in full vigor during all the intervening years. Four more tests of alternate positive and negative stimuli were made, each time with perfect differentiation by the animal.

At this stage the conspicuous signs of the neurosis had completely disappeared. The animal was tractable, both in the barn and in the laboratory, discrimination was perfect, and behavior on the platform entirely normal.

She now formed part of a larger experiment in which the effect of spatial restrictions on the experimental neurosis were being investigated. A pen about 5 feet square having been constructed in the same room with the platform, the animals under test were now placed in this pen, unrestrained by straps, and their reactions to positive and negative stimuli noted. Sheep D was placed in the pen for the first time on March 16, 1936, and received 2 negative, 3 positive, 1 negative and 1 positive stimulation, using bell and buzzer as the negative and positive stimuli respectively, in the order given. All signs of massive or even vigorous response to positive stimulation disappeared in this new environment. She remained in a state of alert quiet throughout the experiment, moving very slightly from time to time, but giving no apparent conditioned motor response to either stimulus. On March 25 testing in the Pavlov frame was resumed with a series of bell and buzzer differentiations which she effected well.

At this point work was stopped on this animal until the following November, when she was tested in a new laboratory in which the platform was now placed only 3 or 4 inches above the ground instead of 4 feet as had been the previous case. Her discrimination in this new environment was again good.

On the last of December she formed the subject of some determinations of respiratory pattern and volume, being allowed to run free for 10 minutes in the experimental room, wearing a breathing mask which connected with a gasometer in the instrument room. Three such tests were conducted during the next 10 days. She at first resisted the mask, attempting to knock it off by rubbing her head against the floor and wall, gradually quieting down each time toward the end of the 10 minute period. During these three periods her respiratory rate remained remarkably constant, averaging 47.6 per minute, 42.6 per minute and 47.9 per minute. The volume of expired air, as measured during the last 10 minute test, equalled 28.32 liters. It should be noted that the experiments conducted outside the standard Pavlov frame did, however, contain one common element, namely, the presence of the "social" animal, and D's peregrinations about the room usually ended with her in close proximity to this animal.

No further testing was done on this animal for a year and she was not used except as a passive subject for experiments with the cardiotachometer which was in course of construction at this time.

On January 8, 1937, work was briefly resumed with a metronome beating at a rate of 60 per minute and reinforced by shock as the conditioned stimulus. A total of only 16 presentations of the metronome had been given on three test periods before this work was stopped to be continued as described below.

During the period dealt with, namely, from November, 1934, to January, 1937, this animal passed from a condition of full-blown neurosis to one of comparative normalcy. Two factors appear to have brought this change about. First, the calming effect of the long series of unreinforced stimulations (129 without a break), and secondly, a change from one experimenter to another. Just how important was the role of this latter is, of course, impossible to say. Due, however, to the certainly unusual behavior of this animal, both in the experimental situation and even in the barn and field during this time, it is undoubtedly a factor which cannot be left out of account in any estimation of the apparent change in her nervous condition.

Experiments were resumed by O.D.A. on February 18, 1937. By this time we were attempting to develop new standardized procedures for the development of the experimental neurosis. We now adopted the method described elsewhere of presenting stimulations in the tests after exactly equal intervals of time. We wished to maintain and study the neurotic manifestations in this animal when the conditions of stimulation remained reasonably constant. We accordingly used only positive stimulations, the loud buzzing sound followed by the shock, given at intervals of 5 minutes, each stimulation lasting for exactly 10 seconds. The equal intervals of time could thus give us the opportunity of comparing, from one time to another, the number or frequency of the spontaneous nervous movements of the reaction limb.

The buzzer was given without negative stimulations at all 4 times at each experimental sitting, and the experiments continued to March 25, 1938. During this period it became apparent that the neurotic manifestations were not so much in evidence as they had been previously. The reactions themselves were not as vigorous as formerly. The animal on occasion would stand for quite a while in the experimental room showing little or no movement. *The development of this quiescent type of behavior was gradual*, that is, as time went on the periods of quiet were more frequently observed than were the periods of violent activity. The sheep was given a rest from March 25, 1938, to November 1, 1939, when the early metronome experiments were resumed.

The constant time interval between stimuli was maintained, the standard day's testing consisting of the following stimuli: metronome 120; shock; 5 minutes pause; metronome 72; no shock; 5 minutes pause; metronome 120; shock; 5 minutes pause; metronome 72; no shock; 5 minutes pause; metronome 120; shock; animal released. This standard procedure was used from day to day throughout the following year up until the present writing.

We were very much interested to note that on quite a number of occasions differential responses were evident to the metronome rate of 72, a rate which some years before would have evoked in every instance the most violent form of reaction. For the most part, however, clear-cut differentiation was not evident. Even though the differentiation was not present, the animal remained remarkably quiet and calm throughout the whole experiment from the time of bringing it to the experimental room on leash to its return to the barn. It has been noted in recent months (the date of this writing is April 3, 1940) to show the mildest type of reaction to conditioned stimuli, a reaction far less vigorous than before and she is noted to stand quite quietly on the platform in the animal chamber.

SHEEP A. AN EXCITATORY CASE OF EXPERIMENTAL NEUROSIS, DEVELOPED BY ATTEMPTS TO ESTABLISH AN EXTREMELY DIFFICULT DIFFERENTIATION. CASE UNDER OBSERVATION FOR FIVE YEARS.

Sheep A was a castrated male, predominantly Merino, born in the spring of 1928. Experiments were begun on September 14 of that year. The animal was, as a lamb, quite docile and easy to handle and was brought into the laboratory without trouble day in and day out during the early phases of the experiment, an account of which is to follow.

A conditioned motor defensive reaction of the left foreleg was first formed to the metronome beating at a rate of 120 per minute. The reaction was formed within 10 trials. The duration of the conditioned stimulus was variable (from 2 seconds to 10 seconds). The animal was tested about 4 times a week.

Following an initial stage of restlessness before the animal became accustomed to the experimental room and the experimenter, a period of quiet supervened in which the sheep would stand without movement for long periods of time while under observation.

On November 6th, after the reaction to this metronome rate followed by shock had been standardized, a negative metronome rate (50 per minute) with no shock was introduced. In the succeeding two weeks of testing the response to the positive conditioned stimulus was weakened by the introduction of the negative. After 15 applications of the negative metronome the animal differentiated clearly between the two rates, that is, reacted by defensive movements to the faster rate and did not react to the slower rate.

At this point a new experiment was started on February 21, 1929. A conditioned reaction was formed to a blinking light (rate of 160 per minute). The reaction was easily and quickly formed within 12 trials. The light experiment was continued until April 14, 1929, when the metronome differentiation experiments were resumed. The former differentiation held and the slower negative rate was advanced from 50 to 60 beats per minute.

During a period of approximately two years we advanced the negative rate by successive stages from 60, to 70, to 84, to 92, and finally to 100. The technique used in attempting to form this differential reaction was one which we had not used previously. Heretofore, in other animals, we had contrasted from one day's experiment to the next the fast, *i.e.*, the positive rate, with the slow, negative rate, using only *one* slow, unreinforced stimulus. In this experiment, however, we gave a whole series of negative stimulations within one experimental sitting, proceeding from the already established negative stimulus of metronome 50 to successively faster negative stimulations. Thus, we would start out a day's work with the usual positive metronome 120 and shock, then follow that a few minutes later with the negative metronome 50. If the reaction to the latter was a negative one we then proceeded to advance the negative rate to metronome 60. If that evoked a negative response we then advanced the rate to 72, to 84, to 92, and, in a few instances, to 100. By this method the animal would show negative reaction even to the rate of 100.

When, however, at the next day's experiment we proceeded in the opposite direction, that is, after the presentation of the initial positive metronome 120 and shock we went next to the metronome 100, negative, we could not obtain the differential reaction. Under these circumstances the animal reacted to this rate. We then proceeded to the slower metronome rates, to 92, to 84, to 72, to 60, and at about this point we would obtain the negative response to the negative stimulus, that is, no reaction. Of course, the rate of 50 also evoked no reaction. This technique of what we may call an ascending and a descending negative stimulus series we used throughout this two-year period, trying now an ascending series, now a descending series.

During the second year of the experiments the animal began to show some signs of agitation. However, before the appearance of the signs of nervousness, there was a period during which the sheep was excessively quiet, a phase in which the conditioned response was extremely weak and sometimes could not be elicited at all by even the positive stimulus. This negative or inhibitive phase lasted for about 6 weeks and was gradually superseded by a state of great agitation marked by restlessness and by violent reactions to all conditioned stimuli.

We noticed first that the animal was difficult to catch and bring on leash from the barn to the laboratory. When put on the stand where the conditioned reflex experiments were conducted it began to show signs of restlessness if allowed to stand in the room alone for a period of time before the experiments were begun. This restlessness seemed to center about the reaction leg, that is, the limb showed jerky, swift flexion movements even when no stimulus was being applied. At the same time the reaction to the positive metronome 120 evoked a vigorous form of reaction which approached violence at times.

Despite these signs of nervous strain the animal performed with machine-like precision in the difficult differentiation experiments.

On April 16, 1931, we began experiments to form a differential reaction to a new set of stimuli, to the sound of an ordinary door buzzer, reinforced by shock, as the positive stimulus, and to the sound of a weak buzzer stimulus, unreinforced, as the negative. The latter sound was produced by an induction coil and loud speaker so that the intensity or loudness of the buzzer could be easily controlled. Differentiations of the loudness or intensity of these stimuli were formed with comparative ease. In this series of experiments we again used the procedure of the ascending and descending series, passing on some days from the greatest difference in sound (positive, loud; negative, weak) by successive stages to closer differences. On other days the opposite progression was used.

During the early phases of the buzzer experiments the animal seemed to show relatively few signs of nervousness in the experiment and when observed in the barn. However, as the buzzer experiments advanced, just as in the case of the metronome tests, the nervous symptoms appeared. Again the attempts to form close auditory differentiations by the technique of ascending and descending negative series produced signs of nervous strain and throughout the summer months of 1931 this sheep showed all of the signs of what we have termed experimental neurosis. This condition was characterized by intractability in the barn and in the laboratory, restlessness when in the laboratory, and violent conditioned motor reflexes. Since we were at that time not interested in the phenomenon of the experimental neurosis itself and since these manifestations interfered with the conduct of experiments on differentiation, we accordingly halted experimentation on this animal and it was given a complete rest from December, 1931, to April, 1932.

At this time an investigation of the neurotic manifestations themselves was begun on this sheep. The first experiment carried through was a study of the effect of sedative drugs and of alcohol on his condition. For the purpose of this new series of experiments we resumed both metronome and buzzer stimulations. The first tests of the positive metronome 120 and the negative metronome 50 showed at once that the animal did not make even this easiest of his former differentiations, and in this series of experiments the only negative stimulus used was the metronome 50. The interval between stimulations varied between 1 and 7 minutes. The animal, in almost every experiment, was kept in the room for about one hour.

The effect of the sedative was, as would have been expected, to reduce the nervousness considerably and the number of twitching leg movements in the intervals between stimulations was decreased. The animal still showed no sign of the former easily accomplished differentiation between metronome 120 and metronome 50. These experiments were brought to a close on June 11, 1932, and when the sedatives were withdrawn the symptoms of the disorder returned to their fullest extent.

On June 18 experiments on the influence of extracts of the adrenal cortex were undertaken. The administration of cortin over a considerable period of time produced a calming effect upon the animal.

Administration of adrenalin produced an exacerbation of the neurotic symptoms.

Experimentation on this animal was abandoned at this point. He was given a rest, and before further experiments could be carried out he died during the ensuing winter of 1933. At autopsy kidney stones was the only abnormal finding.

SHEEP #8. AN EXCITATORY CASE OF EXPERIMENTAL NEUROSIS DEVELOPED BY RHYTHMICAL STIMULATION WITH POSITIVE AND NEGATIVE CONDITIONED STIMULI. CASE UNDER OBSERVATION FOR EIGHT YEARS.

This sheep was born in the spring of 1930. It was a castrate male, hybrid of the cross between the Shropshire and Merino breeds. As a young lamb the animal was quiet and well-behaved and could be easily handled in the experimental situation as well as in the barn.

On October 13th of that year conditioned reflex experiments were begun. From the beginning the animal was trained according to a rhythmical mode of presentation of stimuli. The stimuli used were presented according to the following schedule: pure tone of 435 cycles; shock; 7 minutes pause; pure tone of 900 cycles; no shock; 7 minutes pause; pure tone of 435 cycles; shock; 7 minutes pause; pure tone of 900 cycles; no shock; animal released. Each stimulation lasted for 10 seconds. This routine of stimulation was adhered to without variation throughout the winter of that year until March 20, 1931.

From October 13 to November 8, 1930 (26 days), during which time there were 7 observational periods, signs of the experimental neurosis made their appearance. On the latter date the following notes were made at the time of the experiment: "Animal brought to the laboratory with some difficulty. Objected to being led on the leash. When led to the door of the experimental chamber he stood stock still and would not enter. When lifted into the room and onto the experimental table many signs of extreme agitation manifested themselves. In the waiting interval on that day, before the experiment was begun, the sheep constantly moved its position on the experimental table, spontaneously flexing the left foreleg (the reaction limb) in small, jerky movements that were suggestive of a tic. When the conditioned stimulus was presented (tone of 435 cycles or tone of 900 cycles) it evoked violent defensive movements of the reaction leg. But the movement was not confined to that limb alone. It involved all four legs, the head, and the trunk, in a vigorous struggling type of reaction which suggested running. These strong motor reactions were always accompanied by stertorous respiration. In the 7-minute intervals between one stimulation and another the tic-like, spontaneous movements of the reaction leg were very much in evidence. As soon as the restraining straps were removed at the end of the experiment the sheep dashed down the ramp leading from the table and out the door."

The above described responses were considered to be typical manifestations of the excitatory form of the experimental neurosis. This state of affairs was observed continuously throughout the animal's entire life, with the exception of certain critical experimental periods during which the effect of sedative drugs and of extracts of the adrenal cortex on the manifestations of the experimental neurosis was being studied.

On October 19, 1931, a new stimulation was employed. The sound of an ordinary door buzzer served to evoke the conditioned defensive reaction. This stimulation was also given in a rhythmical fashion, that is, after rest intervals of exactly 7 minutes between stimuli. No negative conditioned stimuli were used at all. These standardized tests enabled us to assay the degree of nervousness of the animal in two ways, namely, to measure the amount of the reaction to the conditioned stimulus and also to determine the number of spontaneous tic-like movements of the reaction leg in the intervals.

During the months of April and May, 1932, with this standard neurotic animal and standard procedure, the influence of sedative drugs on the condition was studied. Sodium bromide was found to diminish the number of spontaneous interval movements to zero. Sodium amytal had a similar sedative effect. When the effect of the sedation disappeared, the evidences of the neurotic behavior continued to be manifest.

Testing was resumed on this animal by R.P. after a lay-off of two years. In the month of November, 1934, it was brought to the experimental room on two occasions and allowed to stand on the table for a short period of time without stimulation. The number of spontaneous movements of the reaction limb was counted and found to be about as large as when the previous tests had been stopped. In April, 1935, this neurotic animal was placed on the rigid time schedule previously employed. This consisted of four positive stimulations of 10 seconds duration with a common door buzzer, with a 7-minute interval after each stimulation. Immediately before or after each testing a similar series was run on sheep #11 as a normal control.

The series extended to the 28th of May, at which time shearing occurred and work was stopped for the summer. Reactions during this period were characterized by violent conditioned motor reflexes and frequent spontaneous movements during the interval periods, not only of the reaction limb but of other extremities. The schedule was resumed on the 9th of December, 1935, and carried through the winter. No change in the animal's condition was noted. All response remained massive and more or less generalized and frequent interval movements were observed.

These interval movements were made the subject of a statistical study and yielded some interesting results. (See text, section on "Restlessness during the experiment.")

On the 22nd of February, 1936, a critical experiment was performed on this animal. We wished to see whether or not the experimental neurosis would be expressed in the same way if the animal were given relative freedom during the experiment. Accordingly, a pen, roughly 5 ft. square, was set in the same room and the necessary instrumental leads brought down from a central point overhead. The stimulating signals; bell, buzzer, etc., were left in their usual places, but the animal, instead of being rather rigidly confined by straps on the table and "face to face" with the stimulating agent, was now allowed complete freedom of locomotion within the confines of the pen. On this date, February 22, the usual four stimulations with buzzer and shock, separated by 7-minute intervals, were given. At the onset of the first buzzer (number 68 of the series) the animal walked slowly around the pen, moving its reaction limb slightly at the shock, but remaining relatively quiet during the succeeding 7-minute interval. There were occasional startle reactions as though the sheep were startled by a loud noise. At the 69th buzzer the sheep stirred uneasily during the 10 seconds of stimulation and again lifted the reaction leg at the shock. During the succeeding (second) 7-minute interval the animal changed position at the end of the first minute and there were some head movements at 5 minutes. At the start of the 70th buzzer he was quiet, stirring after 8 seconds, lifting the reaction leg to the shock, and then remaining immobile except for one forward movement during the entire succeeding 7 minutes. At the 71st buzzer he stirred, moved the reaction limb several times in a mincing fashion quite unlike the reaction exhibited previously on the platform, and no changes in respiration appeared during the stimulation.

The experiment was repeated on the 11th of March in the presence of another observer (H. S. Liddell) with similar results. In this animal a comparatively small degree of freedom in the experimental situation was such as to alter completely the pattern of the behavior observed without deviation in the Pavlov frame since the onset of the neurosis.

For control purposes work in the Pavlov frame was now resumed and on the 2nd of March this animal and its control, sheep #11, served as subjects of an experiment to test the efficacy of extract of the adrenal cortex orally administered. Between this date and the 21st of May, a period of 80 days, the animal received in all 333 cc. of cortin in glycerin. Cortin was given in five doses of 3 cc., thirteen doses of 6 cc., eight doses of 12 cc., and six doses of 24 cc., beginning with the smaller doses. These were administered at about noon on Monday, Wednesday and Friday of each week. Testing took place in the morning of the succeeding Tuesday, Thursday and Saturday.

Cortin subcutaneously administered had produced a calming effect upon this sheep. The effect of the orally administered extract in glycerin (glycortal) was nil.

In December of 1936 the animal was twice brought to the new laboratory and fitted with a breathing mask. Here he was allowed complete freedom of movement during two periods of 10 minutes each and observations were made on respiratory volume and rate. Respiration averaged 30 per minute with a total consumption for 10 minutes of 39.17 liters of air. No stimulation was given during these 10 minute periods. The animal appeared unexcited, walking only occasionally and sometimes jerking its head in an effort to throw off the mask.

On March 4, 1937, the experiments on this animal were resumed by O.D.A. At this time observations of the action of the animal's heart were begun and continued until the sheep's death in December of that year.

On March 11 the experiments employing the buzzer as the stimulus reinforced by shock were resumed, with the following change in the stimulus regimen. The interval of time between one stimulation and another was reduced from 7 minutes to 5 minutes, and, in addition, the stimuli employed in each day's experiment never exceeded 4 in number. As in previous experiments each stimulation lasted for 10 seconds and was reinforced by shock. It is of considerable interest that this procedure, in which no negative stimulation at all was employed, served to maintain the symptoms of the neurotic condition over a long period.

A description of the animal's behavior noted during the last experiment performed, on November 15, 1937, is of interest by way of showing the persistence of the characteristic symptoms of this disorder. "The animal, during the experiment, shows a complete inability to restrain action. The head and the reaction leg are in almost constant motion. Each movement is of a quick, jerky sort. It watches the experimenter in the control room and his every move while in the animal room. The respiration is audible and extremely irregular in rhythm. The average heart rate is 108 per minute. The heart accelerates on the average 20 beats a minute when the buzzer to be followed by the shock is sounded. The animal attempted to run away when we began to release it from the platform. Startle reactions were very frequent to even the slightest noise from without the building. Each startle reaction was accompanied by a very widespread skin reflex. Its major feature, however, was sudden flexion of the reaction limb. The animal's reactions were so hypersensitive that violent defensive response was noted even when a light touch was applied to the ends of the hairs on that limb."

Unfortunately, this animal was killed by dogs on December 25, 1937. No other sheep was harmed in this raid. This happening in itself is probably of significance, for it was noted that the males of our flock of 30 odd sheep generally defended the flock adequately from the attacks of dogs, and consequently none had been hurt. This animal, however, judging from the position of its body when found, had apparently been "paralysed with fright" (a phenomenon observed in this and in some other neurotic sheep) so that it did not use the defensive butting and rearing commonly shown by vigorous male sheep. This reveals the biological inadequacy of what Pavlov has termed the "passive defense reflex" in situations of extreme urgency.

SHEEP #11. AN EXCITATORY CASE OF EXPERIMENTAL NEUROSIS WHICH FOLLOWED UPON A SERIES OF SEVERE INSULIN SHOCKS. CASE UNDER OBSERVATION FOR TEN YEARS.

This animal, a castrated male, was born in the spring of 1930. The animal was a cross between the Shropshire and Merino breeds. In physical appearance he was very similar to the purebred Merino, having the long legs and body, wrinkled skin, fine wool and white nose of that breed.

Conditioned reflex experiments were begun in October of that year. The sheep was quite calm and quiet in the barn and in the laboratory, showing little or no fear of the animal attendant and of the observer. The reactions in general were rather stolid and complacent. At times they were almost phlegmatic.

For 7 years this animal was considered the most typically normal sheep that we had under observation and his reactions were often demonstrated with that point in mind.

The early tests in this sheep consisted of a standard routine of stimulation in which the positive stimulus was a pure tone of 435 cycles, reinforced by shock, and the negative stimulus was a tone of 900 cycles, unreinforced by shock. The typical day's experiment consisted of the following: tone 435 for 10 seconds; shock; 7 minutes pause; tone 435 for 10 seconds; shock; 7 minutes pause; tone 900 for 10 seconds; no shock; animal released. This exact stimulation schedule was used from the very first day's test and was continued from October 13, 1930, to June 20, 1931. No completely reliable differential reaction was obtained from this method of stimulation during this nine month period. The animal's behavior remained quite calm, no evidence of nervousness appearing.

The sheep was not used in any experiments from June 20, 1931, to March 15, 1932, a nine month period. On this latter date the conditioned reflex was developed to the sound of the buzzer. Again a rigid time schedule was employed, the buzzer being sounded each time for 10 seconds, followed by the shock, but in this experiment the interval of time separating the stimuli was exactly 3 minutes. A very stable conditioned reflex was formed and maintained to April 11, 1932, when the experiments on this animal were abandoned by O.D.A.

Work on this sheep was resumed by R.P. in November, 1934: A procedure similar to the above was carried out. Four buzzer stimuli, each of 10 seconds duration, were separated by intervals of 7 instead of 3 minutes. The sheep remained calm throughout all experiments with the new experimenter.

On the 22nd of February, 1936, it was included in the "pen" experiment with a rather curious result. Whereas animal #8 had apparently carried back no after-effects from this brief excursion into freedom, animal #11 became extremely alarmed at the sight of the pen itself and during a subsequent testing on the platform, while the pen remained in the room, the pattern of behavior was radically altered. A fixation of the reaction limb occurred during two of the positive stimulations. On the second occasion of testing with this disturbing element in the room the animal had to be dragged to the table and hoisted onto the platform where it hung in the straps and showed some evidence of agitation. As soon, however, as the pen was removed from the room the sheep became quiet.

Work on this animal was stopped on the 21st of May 1936, and a test was made in the following December with a breathing mask, the animal being free in the room. Respiration averaged 30.8 a minute as against 30.5 for neurotic sheep #8, an insignificant difference. Exhaled air was 34.36 liters. The animal remained almost immobile during the entire 10 minutes, with head lowered almost to the ground.

Work on this animal was resumed by O.D.A. on February 9, 1937. The buzzer was used as the conditioned stimulus, and was again sounded for exactly 10 seconds each time, but in this series the interval of time between stimulations was always 5 minutes. There was, at this period, no symptom of nervousness. The animal would stand in the experimental room for a half hour to an hour, remaining perfectly calm, and usually eating almost continuously from the bucket of oats.

At about this time we began the study of the heart rate of the sheep in the barn and in the experimental situation and this animal's heart rate was well within the range of the normal (around 78 when in the experimental environment, and considerably slower when in the barn with the other animals). The heart rate increased by about 5 to 10 beats per minute when the conditioned stimulus was given.

The conditioned reflex itself was elicited by the buzzer with machine-like regularity and precision. No nervous spontaneous leg movements were seen.

Experiments were begun on December 6, 1937, on the influence of insulin shock on the conditioned reflexes of a well-trained sheep. These experiments have been reported upon elsewhere (*22*). Suffice it to say here that the insulin shock experiments altered the course of the animal's behavior in a definite manner. Immediately following the series of insulin shocks the vigor or magnitude of the conditioned reflex increased immensely, and this was accompanied by restless movements of the reaction leg in the intervals between stimulations. The conditioned reflex, however, diminished in magnitude during the six months following the insulin tests. At the same time as the conditioned reflex diminished, the frequency of the interval leg movements increased.

This animal gave a more or less typical picture of the manifestations of the experimental neurosis even six months after the insulin experiment. Evidences of the disturbance in behavior were seen at the close of the experiments on this animal on August 24, 1939.

SHEEP J. AN INHIBITORY CASE OF EXPERIMENTAL NEUROSIS, DEVELOPED BY ATTEMPTS TO ESTABLISH A SIMPLE DIFFERENTIATION. CASE UNDER INTERMITTENT OBSERVATION FOR FIVE YEARS.

This sheep, a castrated male, was of the Shropshire-Merino strain. In 1932, when the animal was 3 months old, the conditioned motor reflex was established to a buzzer. It was tested during December of 1934 after a lay-off of two years, and an unsuccessful attempt was made to build up a buzzer-bell differentiation. The animal at this time appeared to be highly neurotic with almost complete leg "fixation" to both stimuli, that is, the reaction (left) foreleg was held rigidly immobile. (See text, section on "Immobilization of the reaction limb" for a detailed description of this peculiar reaction.)

The animal served briefly in April, 1934, as a subject in other conditioned reflex experiments. At this time the reaction leg immobility had disappeared, although a daily schedule of three stimulations, two positive and one negative, yielded, a year later, complete "fixation" of the reaction limb and no differentiation between the stimuli. This rigid immobility was still in evidence a year later when the animal was tested in a new laboratory completely free in the room. On a second test in this room in November 1936, a positive signal caused him to run or walk and there seemed to be little discrimination between buzzer and bell at this time.

The animal was tested again on three occasions in February, 1937, with a brief series of positive stimuli and the leg fixation at this time had almost completely disappeared by the end of the series.

The experiment on this animal was abandoned at this point.

Sheep #7. An Inhibitory Case of Experimental Neurosis, Developed by a Strenuous and Varied Schedule of Experiments, Including Delayed Reactions. Case under Observation for Ten Years.

This sheep, a castrated male, was born in the spring of 1930. It was a hybrid, a cross between the Shropshire and Merino breeds. In physical appearance the animal resembled more closely the Merino than the Shropshire, although it represented a fairly good blending of the characteristics of both breeds. The animal has always been the largest in the flock, the most robust and vigorous of the castrated males. As a lamb, when the experiments were first begun, this sheep was easily handled and was quite friendly with all those about the farm.

Conditioned reflex experiments were begun on November 7, 1930. The animal room in the laboratory was darkened and the defensive reaction of the left foreleg was established to a blinking light which was reinforced by a mild shock to the reaction leg. The light blinked at a rate of 120 times per minute. The conditioned reflex was formed after 10 applications of the signal and shock and was thereafter quite constantly elicited by this mode of stimulation.

After 68 applications of this stimulus a conditioned reflex was formed to the pure tone of 435 cycles. This reaction also was quickly formed. When 68 tone stimuli had been employed, a negative, non-reinforced tonal frequency of 900 cycles was then introduced. The animal was characteristically calm and well-balanced. A reasonably stable differentiation between these two tones was formed within about 4 weeks.

When this had been accomplished a differentiation between rates of the blinking light was next formed, using a rate of 120 per minute, reinforced by shock, and a rate of 37, unreinforced. This differentiation became reasonably stable.

Beginning of January 9, 1931, a variety of conditioned reflex experiments were carried out with this animal. Some of these experiments involved a technique by which the conditioned reflex was deliberately delayed by giving in sequence a large number of stimulations with the tone of 435 cycles and shock, when the tone was sounded for 10 seconds each time. The interval of time, however, which separated the stimuli varied from 1 to 5 minutes. Under these circumstances it was found that the latent period of the conditioned reflex increased in successive stages until finally a response appeared only during the last 1 or 2 seconds of the 10 second stimulation, that is, just before the shock itself was applied. Thus the response was "delayed."

Several long series of such delayed reactions were studied. It was found that the response would not be delayed if equal intervals of time elapsed between one stimulation and another instead of unequal intervals. The response was thus restored by a procedure which was later standardized. No signs of nervousness were apparent, the animal remaining perfectly calm throughout two months of such a rigid system of stimulation.

On October 19, 1931, a conditioned reaction was formed to a constant (non-flashing) light. This light stimulation varied in duration from 3 to 10 seconds. The interval of time between stimulations also varied considerably. It was extremely difficult to form a conditioned reflex to this stimulation. The first response did not appear until after 18 applications of the stimulus. It never appeared with any degree of constancy throughout more than 100 applications.

The reaction was now formed to the sound of the door buzzer reinforced by shock. This reaction was more constant than was the case with the light. On certain occasions both the buzzer and the light were used in the same experiment. These experiments, designed to establish the reaction to a wide variety of stimuli, were discontinued on December 4, 1931.

In 1932 a variety of experiments concerned with the influence of the posture of the body upon the conditioned reflex were performed. The buzzer was used as a stimulus.

During the summer months of 1932, from May 6 to September 2, experiments on the influence of cortin and adrenalin were carried out. For the purpose of these experiments a conditioned reflex was formed to a metronome beating at the rate of 120 times per minute.

When these experiments were begun it was noticed that the reactions to conditioned stimulation were becoming fairly weak. The animal was quiet in the barn as well as in the laboratory. In the experiment cortin and adrenalin produced little or no effect on the reactions of this animal.

When these tests were completed, experiments on the retardation of the response to the metronome 120 were carried out. A series of 22 stimulations, each lasting for exactly 10 seconds, and separated by varying intervals of time, were given. On the next four days similar retardation experiments were performed. In each one the latent period of the reaction became greater and greater until finally no reaction at all appeared.

Experiments were taken up on this animal by R.P. in November of 1934, after a lay-off of two years. Its condition was first tested by leaving it for two short periods in the Pavlov frame, without stimulation. It stood quietly on the stand.

In February of 1935 an attempt was made to build up a discrimination between the door buzzer reinforced by shock as a positive conditioned stimulus and an unreinforced doorbell as a negative agent. This discrimination was not very successfully accomplished since it was quite difficult to elicit any response whatever to the positive stimulus. The animal remained calm and quiet throughout the experiment, except for a somewhat abrupt orienting reaction at the onset of the signal.

In the fall of 1936 the weak and delayed positive reaction was completely extinguished by testing in an outdoor enclosure which communicated with the new laboratory through wide double doors and permitted the animal a very considerable degree of movement near to, or far away from, the stimulating agent. Throughout this experiment, during which it received a succession of positive and negative stimuli, it never showed any signs of excitement and remained quiet during the larger part of the time.

When it was placed in the harness again, on November 20, all signs of the conditioned reflex had disappeared and we have not been able to elicit it except on rare occasions since. In the new laboratory the testing platform was placed within a few inches of the floor but the animal was restrained from walking away by means of the usual straps suspended from an overhead beam. Here it was given a test, in December of 1936, wearing the breathing mask and free in the room. Respiration was found to average 40.3 per minute with a volume of 44.84 liters.

In December of 1937, one year later, it served as the subject of an interesting experiment with the newly perfected cardiotachometer. The positive conditioned stimulus in this case was a metronome beating 60 times per minute, reinforced by shock. The duration of the stimulation ranged from 5 to 10 seconds on the first day and stimulations were separated by irregular intervals of time ranging between 2 and 8 minutes. Nine presentations of metronome and shock were given.

On the 5th of January six more presentations of metronome and shock were made. The first three (10M60 to 13M60) were of 10 seconds duration; the next two of 15 seconds duration; the last of 20 seconds duration. Only one conditioned response was evoked during this time and it was noted, when the duration had been advanced to 15 seconds, that an acceleration of the pulse began at about the 8th second of stimulation.

Testing was continued during the rest of January and February, the duration of the stimulus being progressively extended by 5 second increments. With the conditioned stimulus at a duration of 20 seconds it was discovered that cardiac response had fallen out of step with motor reactions. Since movements of the reaction limb had almost completely disappeared the weak reactions, when they appeared, had to be observed by means of a pneumatic platform upon which the sheep stood and which magnified the movements. When a 20-second stimulation was given the heart accelerated at the 8th second as if in anticipation of a shock at the end of the habitual 10-second stimulation, and then decelerated again to normal after about 14 seconds of the interval had passed. However, the animal was accurately measuring the 20-second stimulation for at the 17th or 18th second from the onset of the signal it invariably turned its head first in the direction of the sound and very obviously put itself in a position to receive the shock.

The stimulus duration was now successively increased to 25, 30, 35 and 40 seconds, but at each advance the acceleration of the heart always preceded the slight motor reaction when the latter occurred at all.

A cardiogram was taken of the animal during the period of 30-second stimulation late in February, and it was found upon examination of the record that the T-wave, which was upright at the beginning of stimulation, became progressively smaller until it disappeared at about the 10th second and reappeared in inverted (negative) form and remained inverted throughout the rest of the stimulation and for several minutes thereafter.

In order to account for the temporal difference in the conditioned cardiac and neuro-muscular responses a study was made of such records as were available at the time and it was found that this animal had received 857 stimulations of which 98 per cent were of 10 seconds duration or less, whereas only 2 per cent had lasted more than 10 seconds. Clearly, the autonomic response had been conditioned on the basis of 10 second stimulation and had not (as yet) become conditioned to longer intervals.

Experiments on this sheep were resumed by O.D.A. on January 30, 1936. Studies of heart rate were now undertaken. The buzzer was used as conditioned stimulus. A rigid time schedule was adopted. Each signal was 10 seconds in duration and was separated from the next by a 5-minute interval. At this point it is interesting to quote from notes made during the experiment of February 13, 1936. "Some signs of nervousness appear for the first time. True spontaneous movements of the reaction leg occur in each interval. Each movement is preceded by a slight premonitory shiver or start and by a considerable acceleration of the heart. Sometimes the cardiac acceleration follows the spontaneous leg movement. When stimulation was over the experimenter touched the leg very lightly above and below the shock bracelet. Each touch evoked a quick flexion of the leg. It was more sensitive below the bracelet than above. At times a touch on the ankle of the hind leg on the reaction side caused a flexion of that leg. Spontaneous startle-reactions were also noted."

During the ensuing month a number of the symptoms of nervousness became manifest. The sheep bleated a great deal in the experiment and when the heart action was studied extra systoles were noted. The rate of the heart was quite variable and more rapid than was usually the case in this animal.

During the months of March, April and May the signs of nervousness were noted to continue unabated. It was noted also that the conditioned reflex was not constantly evoked by a buzzer stimulation. On some occasions it appeared on only one of the four applications of the stimulus.

During the next two and a half years the conditioned motor reaction continued to be exceedingly weak and delayed and indeed, in most cases, it did not appear at all, although every conditioned stimulation evoked cardiac and respiratory acceleration. Mild tachycardia was observed when the sheep was standing still (unstimulated) in the laboratory and in the barn.

The animal died in 1939. The cause of death was leukemia.

SHEEP #4. A SHEEP THAT REMAINED NORMAL UNDER A STRENUOUS TESTING SCHEDULE. CASE UNDER OBSERVATION FOR TEN YEARS.

This sheep was born in the spring of 1930. An attempt was made during that spring to castrate this normal male. The operation was done by a farmer and it happened in this case that the testes were undescended. The animal showed normal sexual activity throughout his life. He is to be classed, of course, as a normal male. Genetically the animal was a hybrid, a cross between the Shropshire and Merino breeds, with the Shropshire predominating completely as far as physical appearance was concerned. The animal was short, rather stocky in build, had coarse wool, smooth unwrinkled skin and the typical Shropshire black nose.

In September of 1930 the animal was first subjected to conditioned reflex experiments. Within the usual time a conditioned motor response was developed readily to a pure tone of 435 cycles, reinforced by shock to the left forelimb. After 80 applications of the tone we judged, from the animal's rather calm, machine-like reactions, that he would do well in differentiation experiments. We accordingly began a study of the differentiation of tactile stimuli. Four Krasnogorski skin stimulators were applied to the left hind limb. Blunt points were pressed against the skin by a pneumatic system on every alternate second during each period of stimulation. The skinspots stimulated were situated about 2 inches apart on the outer part of the left hind leg, beginning at the ankle and extending dorsally. The lowest skin spot, that on the ankle, we chose as the positive spot, the stimulation of which was reinforced by shock. The other spots, the stimulation of which was not followed by shock, were the negative spots. A conditioned motor response was formed to the stimulation of the ankle spot within 6 trials. As soon as the reaction had been stabilized, which was within 39 trials, we began, on December 4, 1930, experiments to form the differentiation, starting initially with the spot furthest from the ankle.

The animal showed clear-cut differentiation between these two spots within a relatively short time. The problem was made more difficult by stimulating the spot one step nearer the ankle spot and the negative reaction was next precisely formed to this stimulation. Finally, stimulation of the negative spot nearest to the positive spot on the ankle also evoked a perfect negative reaction. This was considered to be a very delicate and precise differentiation, since it will be recalled that these last two spots were only 2 inches apart.

During this period as many as 25 stimulations per period were often given. The animal remained perfectly calm throughout and was entirely docile in the barn as well as in the animal quarters and would stand quietly throughout an experiment which often lasted as long as one and a half hours.

This type of experiment was continued (by O.D.A.) until November 12, 1931. The animal was demonstrated to visitors many times during this period and showed not the slightest fear reaction when visitors came into the experimental room and stood about the table.

Work was resumed on sheep #4 after a lay-off of nearly three and a half years, late in April of 1935, by R.P. Using four Krasnogorski prickers, the differentiation between spots on the lower left hind leg was reestablished.

As the work continued during the month of May, 1935, this discrimination was not always elicited, however, and gradually both positive and negative responses disappeared. Work was stopped in May for the summer and was resumed briefly in the following February at which time no conditioned reflex could be elicited except on one or two occasions during the 5 test periods of February, 1936.

In December of 1936 he was brought to the room for breathing tests. Respiration averaged 30.8 per minute, with a volume of 68.39 liters. An attempt was made to condition him to a metronome beating at a rate of 60 per minute in February of 1938, but after 13 stimulations of 5 seconds duration, reinforced by shock, no conditioned reflex was formed. O.D.A. then resumed work on the animal.

On April 21, 1938, the conditioned reflex to a door buzzer and shock was formed. The standardized method of stimulation was used; that is, four conditioned stimuli, each of 10 seconds duration and separated by exactly equal intervals of 5 minutes, were given at each experimental session. This standardized procedure was used in the case of this quiet animal in order that we might study its behavior in comparison or contrast with the more highly nervous animals. The study by means of the rhythmical stimulation procedure revealed the fact that the animal stood without movement at all during each of the rest intervals between stimuli and definitely did not exhibit the nervous spontaneous leg movements, tossing of the head, and altered respiration and heart action exhibited by nervous animals.

Throughout the following summer months this type of stimulation was used several times a week in testing the animal. No nervousness appeared, even under this strenuous regimen. During the latter part of the summer, beginning in July, a study of the influence of metrazol on the conditioned reflex was begun on this sheep. The conditioned reflex was weakened somewhat by the use of this convulsant drug in experiments carried out for approximately three weeks. However, the value of the response returned to normal on cessation of administration of the drug. Following this, there was no sign of nervousness apparent.

On August 6th these experiments were abandoned and the animal was not tested in any experiments until July 19, 1939, when a conditioned response to metronome 120 and shock was formed. As soon as this was stabilized, standardized equal-time-interval tests were adopted in which metronome 72 was chosen as a negative, unreinforced stimulus. As in the buzzer experiments, the interval of time between stimulations was 5 minutes and the duration of each stimulus was 10 seconds. The typical day's procedure was: metronome 120; shock; 5 minutes pause; metronome 72; no shock; 5 minutes pause; metronome 120; shock; 5 minutes pause; metronome 72; no shock; 5 minutes pause; metronome 120; shock; animal released.

We wished to use this standardized procedure because we had found that it was very efficacious in producing evidences of nervous strain in the sheep; and since this animal had resisted all efforts to produce an experimental neurosis we thought that this new method might accomplish this. It did not succeed. No nervousness was shown at any time, although no clear-cut differentiation of metronome rates was built up.

We noticed, however, that the health of this animal was not good during 1938-39. He did not eat well and lost much weight. This may have had a bearing upon the results of the experiments.

The animal was found dead in December, 1939. The autopsy showed a considerable number of lung worms. The testes were undescended.

Dog #929. An Excitatory-inhibitory Case of Experimental Neurosis Showing "pseudo-decerebrate" Rigidity. Case under Observation for Two Years.

This dog was about three years old when brought to the laboratory. It was a male hybrid, a cross between a bassethound and a saluki of the second generation. The dog had the physical appearance and body build of a saluki, that is, he was long-legged, thin of body, and had long hair. The coat color, however, was that of the piebald bassethound.

This dog was shy from the very first and had gradually to be worked into the conditioned reflex procedure. It was very difficult to lead on leash and when given the freedom of the experimental room, as was usually done in training dogs, it tried to hide under tables and chairs. It was known to stay in a crouched position, trembling underneath a table in a dark corner of the room, for as long as an hour. By the end of December it was apparently sufficiently accustomed to us and to the equipment so that the conditioned reflex experiments could begin.

On December 21, 1932, work was begun on the formation of a conditioned motor reflex of the right foreleg to the sound of the metronome beating at a rate of 120 per minute, followed by a shock to the right foreleg. This signal was always sounded for exactly 10 seconds and the stimuli were given after pauses varying from 3 to 6 minutes.

The conditioned reflex was formed in 6 applications of metronome 120 and shock. At first the reaction was very vigorous. The animal stood quietly in the intervals between stimulations. After about 6 weeks of work, during which time the conditioned reflex became stabilized, a negative differential metronome rate was attempted. This stimulus was metronome 42, which was never reinforced by shock.

From January 27 to March 1 a great many attempts were made to establish the differentiation. They were unsuccessful. During this period signs of extreme nervous agitation became manifest. To quote from a protocol of that period: "While waiting for the experiment to begin there are many restless movements of the reaction limb. These spontaneous leg movements continue throughout the entire period of testing, which is about a half-hour. They vary in character. At times the foot was lifted slightly from the floor in quick, tic-like flexions. At other times the reaction leg was held up and again showed slight tic-like movements. The animal was noted in many of the intervals to be trembling. At times he lay back in the harness with hind legs bent under the weight of the body. We went into the room on many occasions to try to calm him and to place the flexed limb upon the floor again. However, as soon as we left the room the leg was held in the flexed position again. There is little or no movement of the head, which is held in a low-drooping position. In this experiment, when the dog was removed from the table and allowed to stand on the floor, we tied his leash to the open door between the experimenter's and the animal's rooms. When the animal tried to move away to a dark corner the door suddenly slammed. The dog immediately went into an astonishingly violent reaction of fear in which he tore and bit at the leash and bit the experimenter who attempted to extricate him. He finally lay on the floor, panting. I have never seen a more violent performance than this in a dog."

Since the animal was entirely unmanageable, we decided to give it a rest. The work was accordingly abandoned on this animal on March 31, 1933, and was not resumed until June 2. On the latter date, when it was brought into the room, it was much calmer than at the last observation. It was led into the room easily and seemed fairly quiet and docile. It came to lick our hand. When put on the platform, however, we noticed an even more marked change in its behavior. The dog was allowed to stand on the table for about a half-hour before the tests were begun, and our notes taken on that day point out that, although the animal stood quiet, the quietness itself was peculiar in that there was little or no movement at all. It was quite apparent then that this excessive quietness was different from the quiet of the calm or phlegmatic normal dog which would lie down or look about in a leisurely sort of fashion rather than stand absolutely without movement. When the tests were begun the metronome 120 and metronome 42 evoked a different type of reaction from that which the animal had previously shown. Each defensive movement of the reaction leg was slowly executed as though the movement were viewed in a slow motion movie. The movements themselves seemed to possess a character of hesitancy. The dog, it seemed, was "afraid" to move.

The next experiment, on June 8, showed clearly that this quiescence was actually complete immobility. On that day the animal was brought into the room and no stimulation at all was given. We wished to study this curious phenomenon. We give here our notes taken during that day's observation:

"When brought into the room the dog was persuaded to eat a little from the food pan. Its movements about the room were partially crouched and each movement was slowly executed. It was placed upon the animal platform. The straps and other equipment were placed about it. It now refused to eat. It took up a set posture almost immediately even while we were in the room standing beside it. The head was held low, forelimbs stiff and partially extended, the hind limbs in a partially crouched position. No trembling was noticed. No movement was seen except eye movements. The eyes followed us as we moved about the room. The animal was allowed to stand for 20 minutes without being stimulated. No movement occurred during this time. It occurred to us to apply certain of the well known tests of decerebrate rigidity to this animal. Accordingly, we shifted one of the forelegs back of the other so that the limbs were in a crossed position. We placed one of the hind limbs in an outwardly extended position. We wished to determine whether or not such an awkward posture could be maintained for any length of time. We went out of the room and watched the animal through the observation window. This posture was held without any variation at all for 22 minutes. We again returned to the room where we passively flexed each of the limbs. With the fingertips pressed against the bottom of the foot, resistance to flexion was encountered. This, however, gave way as we pressed upward, the leg bending slowly until finally a fully flexed position was attained. On withdrawing our hand, the complete flexion was maintained. We then attempted to extend the flexed limb. Resistance to extension was noticed. A partial flexion, when attained, was also maintained. Passive flexion was tried in the case of each of the four limbs and each responded in the way just described. This reaction did not center about the reaction leg any more than about the other limbs."

During the next day's testing, on June 12, similar phenomena were observed. The application of the differential metronome stimuli was carried out. Slow, hesitating responses of the right foreleg (reaction leg) were obtained at each stimulation. Thus the conditioned stimulation interrupted for a brief moment this marked inhibition of the neuromuscular system. Similar observations were made frequently for about one month afterward.

During the ensuing months of August and September, 1933, no tests were made in the laboratory. When the dog was returned to the laboratory on October 19, no sign of this abnormal immobility was noticed. The dog stood erect, moved his head about in a normal manner, ate food when it was offered to him, and appeared generally quite calm. The conditioned stimulation evoked a "normal" type of response seen in earlier tests carried out on this animal. No differentiation, however, of metronome 120 as contrasted with metronome 42 was observed.

The animal was now given a rest from any experiments at all for exactly one year. The tests were resumed on October 21, 1934. We quote from notes taken at that time.

"The dog was brought to the laboratory for the first time in one year. He seemed quite docile, although he showed no inclination to be friendly with us. He did not wag his tail. He trotted calmly along with us, sniffing at the floor and various objects on the way, walked calmly in the room, and stood upon the platform without guidance by us. He immediately started eating food left on the platform. When this was finished he held his head high and stood in an erect posture, which contrasted strikingly with his previous crouched position. He looked calmly about him, shifting the position of his limbs now and then. When the photographer, a stranger to the dog, entered the room to take pictures, the animal showed no excitement at all and calmly watched the preparations. We now tried the same decerebrate rigidity tests used before. That is, we crossed the forelegs and extended a hind leg, flexed the limbs, etc. *These postures were not maintained even for one second.* On being taken out of the straps at the end of the experiment, the animal nuzzled our hands and walked calmly ahead of us out of the room. On the next day tests of conditioned reflex behavior were carried out and the responses to metronome 120 and 42 were characteristic of the early "normal" phase of this animal's behavior. They were vigorous, precise, defensive movements of the reaction leg."

After about one month of testing the crouched posture reaction began to become manifest again. But on continuing the tests, no evidence of complete immobility was apparent. Instead of immobility, the phase shifted to hyper-excitability. The last conditioned reflex experiment on the animal was carried out on February 1, 1935. The observations on that day are typical of the previous excitable phase shown by the animal. We quote below the protocol of that day.

"The animal was standing on the platform waiting for the conditioned reflex experiments to begin. Very frequent spontaneous movements of the reaction leg were noted. There were frequent jerky movements of the head. The posture was partially crouched. Gross tremors and slight swaying were at this time noticed. When the reaction leg was touched lightly, a vigorous flexion reaction was evoked. This was repeatedly noticed. There was no sign of differentiation of metronome 120 and metronome 42. The animal reacted as vigorously to negative as to positive stimulation. Each response was violent. The dog became so disturbed when we attempted to release him from the restraining straps that an attendant and ourselves were bitten."

Dog #868. An Excitatory Case of Experimental Neurosis, in Which the Symptoms were of Brief Duration, the "Cure" Being Associated with an "Easing" of the Differential Problem. Case under Observation for Two Years.

This dog was three years old when the experiment was begun. It was a male hybrid, a known cross between a bassethound and a German shepherd, and was of the second generation of the cross. In appearance the animal was a blend of the two decidedly different breeds. His legs were intermediate in length between the short basset legs and the long shepherd legs. He exhibited the stocky build of the bassethound, but the coat of the German shepherd.

This animal was brought to the conditioned reflex laboratory for the first time on November 7, 1932. He seemed quite lively and unafraid of the investigator, and after a few minutes in the room, in which he was allowed complete freedom of movement, he came to lie down beside the observer's chair. Indeed, from the first the animal showed every sign of friendliness and cooperation. After several days during which it had thoroughly investigated everything within its reach in the laboratory and seemed to be accustomed to its surroundings it was placed on a low platform in the animal chamber and loose straps were fastened about the forelimbs. On successive days more and more of the recording equipment was attached, and the dog became quickly adjusted.

On November 16, 1932, experiments to form a conditioned motor defensive reflex of the right forelimb to the sound of a metronome beating at a rate of 120 per minute (followed by shock) were undertaken. The pause between stimulations was always 5 minutes. The duration of the conditioned stimulus was 10 seconds.

The shock evoked only a slight flexion movement of the reaction limb. It was purposely kept very weak in strength throughout the entire experiment, since it had been previously observed that dogs, as compared with sheep, are extremely sensitive to even a mild electric shock and react very violently to a strong shock.

At the 11th application of the metronome 120 the conditioned response appeared for the first time. From that point on it was evoked constantly.

It was decided at this juncture to establish the conditioned reflex to a variety of stimuli. During November, December and January, the reaction was formed to the presentation of an odor stimulation (separately to turpentine and cloves), to intermittently applied tactile stimulation, and to a red light. All of these evoked vigorous conditioned defensive reactions.

On January 26, 1933, the formation of a conditioned differentiation of metronome rates was attempted. The first differentiation tried was that between metronome 120 (and shock) and metronome 60 (with no shock). After 7 applications of the negative metronome 60 it was evident that the dog could not form the differentiation since reactions were evoked by both positive and negative stimuli. At this point it was noted that the dog's behavior in general was becoming slightly less cooperative and it was evident that restlessness in the intervals between stimulations was present.

We now made the differential situation easier by decreasing the negative metronome rate from 60 to 42 beats per minute. The positive and the negative stimuli were contrasted repeatedly in each experiment. Sometimes as many as 12 stimuli were given at a single experimental sitting, 6 positive and 6 negative. During this month of work no slightest sign of differentiation appeared, the animal reacting to both positive and negative stimulation with equal vigor. On the experiment of February 24, 1933, the following observation was noted.

"The animal was more restless and nervous today then ever before. There was almost continous spontaneous movement of the right foreleg (reaction leg). The head moved about constantly in a quick, jerky fashion. A great deal of whining was noticed. The respiration during the stimulation was markedly disturbed. The conditioned reaction to the positive and negative stimuli occurred with a very short latent period and was extremely vigorous. We had to go into the animal room constantly to attempt to calm the dog. Food was placed before him and his formerly strong feeding reaction was found to be suppressed. He would not eat. He would stay quiet for a few minutes while we were in the room, but as soon as we left the animal alone the excitement returned."

On March 6 we decided to bring the animal into the animal room and let him stand on the platform without any experimental stimulation at all, to determine whether or not the nervousness would appear without such stimulation. Such was the case. The dog was even more nervous than before, showing a great deal of random spontaneous activity of the head and of the reaction limb.

On the very next day we tried the same experiment and obtained the same results. The spontaneous leg movements could be suppressed when we stood beside the dog in the room and patted him on the head or spoke to him kindly. However, as described above, as soon as we left the room the twitching movements reappeared. The previous day's session had lasted only 15 minutes. This day's session lasted nearly one hour. No stimulation at all was presented.

On the 17th of March, 10 days later, the following notes were made in the kennel, which was in no way near, or connected with, the laboratory.

"There was noted today a very clear sign that the behavior of this dog in the kennel is being affected by the laboratory routine. Normally, when we come into the pen with the animal the dog runs up to us, wagging its tail and showing every sign of wanting to be petted. Now the animal seems "afraid" of us. It runs forward a certain distance toward us and then turns and runs away. We approach it closely and it tries to find a place to hide. We reveal the leash which has been held behind our back so that the animal couldn't see it. Immediately the animal dashes past us out through the open door of the pen and escapes. We have not seen this behavior in this dog on a single other occasion."

We now reduced the number of stimulations applied each day from an average of about 10 to only 3, that is to say, the positive metronome 120, the negative metronome 42 and the positive metronome 120, after which the animal was released. We thought that the dog had been receiving too many stimulations at each experiment. During the ensuing months, until August 11, 1933, a period of 5 months, again no sign of differentiation at all appeared. The animal at this time was extremely nervous and highly excitable and his general behavior had undergone a complete change.

We now decided on a course of further easing of the differential "problem." Accordingly, we reduced the rate of the negative stimuli from 42 to 36 beats per minute. This was tried for 3 weeks, again without success in developing the differentiation. Signs of nervousness persisted. We then determined upon a procedure which involved giving the animal a very obvious "cue" as to which one of the metronome stimuli was the negative one. Thus each time the negative metronome 36 was turned on a weak buzzing sound was also turned on. The latter accompanied the ticking throughout the 10 second period of stimulation. After three applications of such a negative stimulation signs of differentiation appeared for the first time. The buzzer was combined with the negative metronome 8 times in 4 days of experimentation. At the end of that time the differential reaction was perfect, that is, the metronome 120 and shock always evoked a vigorous reaction while the metronome 36, combined with the buzzer and no shock, did not evoke a response. At this point the buzzer component of the negative stimulus was withdrawn. The metronome 36 was given alone. The differentiation persisted.

During the ensuing 6 months differentiations were obtained in nearly every case between the metronome rates of 120 and 36. On a few occasions the metronome 42 was tried again. This, however, always evoked a positive reaction. The animal's general behavior during this 6 month period is of interest. The general nervousness, shown during the experiment in the laboratory and in the kennels as well, was markedly diminished. A protocol on the experiment of March 21, 1934 is typical of the animal's general behavior during the latter part of this period.

"While the animal was waiting for the experiment to begin he was sitting quietly, looking toward the experimental room. He was allowed to remain in this posture for 12 minutes. No spontaneous movements of the reaction leg were noted. The conditioned reactions were somewhat sluggish. The movements of the head were those of a perfectly normal, calm dog. They were slowly executed and did not possess the twitch-like character noted during earlier experiments. The dog whined a few times. In the interval between the tests there were few spontaneous movements of the limb and these were not of a type characteristic of the hyperexcitable phase. They seemed to be merely the movements which accompany shifts in the posture of the body. The docility and friendliness observed in the initial experiments was clearly evident."

Dog #881. An Excitatory Case of Experimental Neurosis, Developed in Salivary Conditioned Reflex Experiment. Case under Observation for Two Years.

This dog, a female, was about three years old when first brought to the laboratory. It was a hybrid, a cross between a bassethound and a saluki, of the second generation.

When first seen on November 13, 1932, it was obvious that the animal was excessively shy of strangers and would show no sign of friendliness when the observer approached it. If we attempted to pat the dog it crouched to the floor trembling, and urinated. We let it wander about the experimental rooms on several occasions before beginning the actual experiments, hoping that it would become accustomed to the surroundings and to us. We tried to get it to take food, but it refused. When with the dogs in the kennels, however, it ate readily enough. The training proceeded very slowly and with little progress in getting the animal to overcome its shyness. When placed on the platform where the experiments were carried out in a quiet room it crouched and seemed extremely watchful.

On November 28, 1932 conditioned salivary reflex experiments were started. The metronome beating at the rate of 120 times per minute was the signal for feeding. In the initial phase of the work this metronome stimulation was presented each time for 30 seconds. A 4-minute pause was always allowed to elapse between the giving of one stimulation and another.

At first the animal ate only a little of the food, But, as the weeks passed, it ate rather timidly and hesitantly. The conditioned flow of saliva appeared for the first time on December 3 after 16 applications of metronome 120 and food. The conditioned reflex, however, was extremely weak and in successive tests was very hard to elicit at all. It ranged in value from .01 to .08 cc. in 30 seconds.

On January 2 we attempted to form a differentiation between the metronome 120 and the negative metronome 50 (not followed by food). Following the introduction of this negative signal the already weak conditioned reflex disappeared entirely. After 2 weeks of testing with the negative stimulus we then withdrew it from the experiment and gave only positive stimulations in order to rebuild the reflex. During the next month it returned, but was very weak and easily inhibited. We now wished to strengthen this reflex. Accordingly, we adopted a routine mode of stimulation which was unvaryingly carried out from day to day. This routine was as follows: metronome 120 for 3 seconds; food; 5 minutes pause; metronome 120 for 20 seconds; food; 5 minutes pause; metronome 120 for 3 seconds; food; 5 minutes pause;

metronome 120 for 20 seconds; food; animal released. By this technique, the conditioned reflex was rebuilt in the course of two months.

A negative metronome 42 was now introduced. The reactions were maintained fairly constantly for a time. During the next 7 months, to November 28, 1933, we attempted without any success at all to form a differentiation between the above rates of the metronome. The reflex to the positive metronome 120 disappeared on various occasions during this period, at which time the negative stimulus had to be withdrawn while the positive reaction was rebuilt.

During this 7-month period signs of general restlessness appeared. The animal, on many occasions, attempted to get down from the platform and get out of the room. She would back away from the food dish, hang in the straps, attempt to get her legs out of them, and consequently become almost inextricably tied up in them. This agitated form of behavior was noted to occur frequently after the application of the negative stimulation.

At this point we decided that the attempted differentiation was too difficult for this animal, so the negative rate was reduced from 42 to 36 beats per minute and contrasted with the positive metronome 120. During the winter and spring months of 1933 this differentiation was constantly attempted without success. By February 1934 all sign of the conditioned flow of saliva had disappeared. The reaction could not subsequently be rebuilt. The signs of agitation had gradually become very marked and when the experiments were continued to October 30 1934, the dog was so nervously disturbed that the entire experiment was judged impractical. Behavior notes taken on this date are quoted as follows:

"The animal was very agitated on being taken to the experimental room. She shied away from every slight noise or any strange object in the hallway leading to the room. She slunk along by the wall when on the leash and stood trembling on the platform when the experiment was about to begin. She was given food from the experimenter's hand, but would not take it. She stood without movement until after the stimulation was given. Following the first stimulation, she began to back away from the food dish and tried to extricate herself from the straps. The experimenter tried to calm her. No food had been taken. *No salivary flow appeared at all at any time during the experiment. The mouth was dry.* We then introduced the negative metronome 36 to see what the nature of her reaction to it would be. At its sounding she raised her head in a listening posture and as soon as it was stopped she began again to back away from the food dish and to move to one side of the platform. She succeeded in partially extricating herself from the straps, got behind the food box, shook off the salivary cup, and finally stood trembling hidden away behind this box. When we came into the room she crouched and began to tremble and urinate. The reactions of backing away and extricating herself from the straps were quite vigorous. No whining was heard at this time. In fact, it was rarely heard at any time during the experiment."

Due to the animal's extreme agitation the experiment had to be abandoned.

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