THE KNEE-JERK IN PARESIS.

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The diagnostic import of changes in the character of the knee-jerk in paresis, especially the absence of the reflex, was recognized soon after the description of the reflex by Erb and by Westphal. The conditions of exaggeration, and, much more, of diminution or absence have been taken to indicate the existence and the amount of the pathological changes that occur in this disease, but exact correlation of the character of the reflexes with other symptoms and with the general state of the nervous system have not been made. In a way it is surprising that in this disease, which is known to be a degeneration of the nerve elements, patients are still classified according to the mental picture—exalted or grandiose, depressed and demented—and that so little has been accomplished towards establishing neurological types. It is not unreasonable to suppose that a careful working over of paresis in its physiological aspects may give us types clearer and perhaps more valuable from the neurological view-point, than can long study and correlation of the mental phenomena. It is conceivable and probable that a study of the functional differences will lead to a better appreciation of the nervous changes, and at the same time will serve to produce a better understanding of the course of the disease. It is also likely that the correlations of the various structural and functional changes will assist to make diagnoses more accurate, especially in the earlier stages of the disease, and that the correlation of the findings will show us views of conditions or of combinations of symptoms that will aid in more accurate prognoses. In such a work the reflexes which give so much information regarding the state of the nervous system need most careful investigation, and all the symptoms that can be observed should be correlated with these phenomena.

I. CHARACTER OF THE KNEE-JERK IN PARESIS.

The knee-jerk in paresis may remain normal, or may differ from the normal in any one of three ways—it may be exaggerated, it may be diminished, or it may be impossible to elicit it.

In speaking of the reflex, the term exaggeration is used in a very loose manner. There are a number of ways in which the term may be and is employed, but perhaps for many years the different meanings will be used indiscriminately. Sternberg has described the following different meanings of the term:

1. The reflex threshold may be slightly below the normal; in other words, the threshold of blow necessary to produce the reflex is decreased. This meaning of the term has not been well investigated and there is some doubt that the intensity of the blow, within wide limits, has an influence on the reflex.

2. The latent period of the muscular contraction of the quadriceps muscle or the latent period of the foot movement following the stimulation of the patellar tendon may be decreased. The differences in the rapidity of the reflex are not so well marked as to make it possible for the unaided eye to discover the true differences, and the term "exaggeration" is doubtless seldom used correctly to indicate a real quickening of time.

3. The term is more often used to indicate that the time of the tonic contraction of the muscle is increased or lengthened, for this time varies considerably. Remarks on this time will be made more particularly in the second section of this article.

4. The reflex reaches its maximum in less than, say, in one to two-tenths of a second. If this maximum is reached in less than a normal amount of time, that is, if the steepness of the curve be increased, the reflex may be described as exaggerated, but in clinical work it would be impossible to determine this time accurately.

5. The spreading of the reflex, the movement of many muscles in addition to the quadriceps, is often spoken of as an exaggeration. This use of the term is partly justified, in that the spreading is undoubtedly due to exaggeration of the normal effects of stimuli when transmitted to and transformed in the spinal cord, but it would be best to call this character of reflex "spreading."

6. The amount of movement of the limb or of the muscle may be increased. This appears to me to be the best use of the term exaggerated. In using the term in this way, it must be remembered that there are wide differences of the movement in health, and a number of factors influence the apparent extent of move-

ment. Considering the knee-jerks, for example, if the relative positions of the foot before and at the height of the reflex contraction be taken to indicate the extent of movement, it is obvious that a patient with a longer lower leg will normally have a greater excursion than will a shorter-legged patient. It is clear, therefore, that the angular amount of movement is here the only true measure of the extent.

7. Finally, the reflex instead of being a simple contraction and relaxation may have a tonic, clonic or mixed character. There may be a large movement followed by one or two other movements, usually small, which resemble clonus; there may be a movement persisting for a long period of time, and there may be a combination of the tonic and clonic movements.

The term diminution of reflex may be used to include the opposites of the conditions which are described above in sections 1, 2, 3, 4, 5 and 6.

It is not so easy to determine the absence of reflex as many practitioners believe, for careful testing will often disclose the presence of a reflex which was presumed to be lacking.

In the comparisons that follow, the terms "exaggeration" and "diminution" are considered to be used by all investigators in a similar although loose manner, and it is assumed that the experience and reputations of the different reporters are such as to warrant accepting their use of the terms "absent" and "normal."

In Table I, will be found the records of the character of the

TABLE I.—CHARACTER OF THE KNEE-JERK IN PARESIS.

Reporter and date.	Total number cases.	Number of cases.				Percentages.			
		Absent.	Dimin.	Normal.	Exagg.	Absent.	Dimin.	Normal.	Exagg.
Beatley, 1885.....	70	18	15	11	28	25.7	21.4	15.7	37.1
Siemerling, 1886.....	151	42	5	49	55	27.8	3.3	32.5	36.4
Ziehen, 1887.....	51	11	3	5	32	21.6	5.9	9.8	62.7
Bevan Lewis, 1889.....	87	10	5	5	16	27.0	13.5	16.2	43.3
Gudden, 1894.....	1816	252	55	505	503	19.1	4.2	33.5	38.2
Cramer, 1895.....	198	66	31	31	70	33.4	15.6	15.6	35.3
Baird, 1905.....	199	40	25	89	95	20.1	12.6	19.6	47.7
Hunt, 1906.....	58	17	2	1	38	30.4	3.6	1.8	64.3
Ricksher, 1907.....	65	5	18	7	35	7.7	27.7	10.7	53.8
Franz, 1908.....	158	38	30	20	70	24.0	19.0	12.7	44.3
Totals and percentages.....	2301	499	189	675	938	21.7	8.2	29.3	40.8

knee-jerk in 2301 paretic patients to which I have contributed 158 cases. The results and percentages are classified, it will be observed, as absent, diminished, normal and exaggerated. The work of the different investigators reported in this table I have gone over carefully and have recalculated wherever it was necessary. This table is to be compared with Tables II and III, the results in which will be described below. From this table I have excluded the reports by different investigators of cases "not observed." The totals of cases included only the "observed" cases and the percentages are also based on the total "observed" cases. I have not based the percentages, as some have done, on the total number of admissions which may have been considerably in excess of the total number in which the character of the reflex was recorded. In doing this it has been necessary to change quite freely in some instances the percentages noted by different authors, but wherever this has been done, it is for the reason stated above, or for very special reasons that will be noted below. For example, from Hunt's account of 60 cases examined in the Vanderbilt Clinic, it might be supposed that he gives the percentages of absent, normal, diminished and exaggerated knee-jerks in the total number; but a careful consideration of his percentages shows the percentages are based on a total of 56 cases, although he does not state this explicitly in his article. In a similar way, Cramer apparently reports results from 220 cases of paresis and he gives the following percentages of the different character of reflexes: normal, 14; absent, 23; exaggerated, 30; diminished, 14; slightly exaggerated, 2; unilaterally absent, 7; not determined, 5. Lacking definite statements of the condition in the 5 per cent of individuals which are apparently not reported, we must exclude from consideration at least 10 per cent, namely, 22 cases, which includes the 5 per cent which Cramer reports "not determined" and the 5 per cent of which he makes no mention. When the 10 per cent are excluded, we have to deal with only 198 cases instead of 220, as Cramer appears to do in his article. When the extra cases are eliminated, we find the percentages altered, not much to be sure, but the result of the percentages based on 198 cases are: normal, 15.6; absent, 25.8; exaggerated, 33.3; diminished, 15.6; slightly exaggerated, 2; and unilaterally absent,

7.6. It appears to me to be self-evident that the exclusion of the "non-determined" and the "not recorded" is justified, for unless this be done, we have artificial figures which in extremes become absurd and justify the statement that figures may be used to prove anything. To consider as an example of this vicious method, I may cite the results of my investigations of the reflexes in the 248 paretic patients who died in the Government Hospital for the Insane during the past eight years. Some of the records of the earlier admissions did not contain full accounts of the reflex findings beyond "nothing greatly abnormal"; "reflexes exaggerated"; or "reflexes not elicited," and I do not feel justified in view of these general but unsystematic statements in assuming that the knee-jerks had been specifically tested in each case, and in assuming that in all cases the knee-jerks corresponded in character to the above sweeping designations in the case records. In only 158 of the more recent cases of paresis were the reports sufficiently specific to make it plain that they should be included in the series. The percentages obtained from this number are as follows: absent, 24; diminished, 19; normal, 12.7; exaggerated, 48.8. Had I included in this table, the extra 90 cases, the percentages would be: absent, 15.3; diminished, 12.1; normal, 8.1; exaggerated, 28.2; not determined, 36.3; a thoroughly unjustified and unnecessary proceeding. It is not my intention, therefore, to change the figures of previous authors to support any preconceived notion or personal hypothesis, but solely to obtain the nearest approximation to truth.

The totals show that about two-fifths of paretics have exaggerated knee-jerks; one-fifth absent and one-tenth diminished knee-jerks. In seven of the ten investigations reported in this table, the percentages follow fairly closely these general percentages. In the reports of Ziehen, of Hunt and of Ricksher, the exaggerations are more numerous with a corresponding decrease in the reports of normal knee-jerks by Ziehen and Hunt and a decrease in the report of absent knee-jerks by Ricksher. In all three authors, however, the number of cases is small and the chance variation of two or three in any one figure means a considerable variation in the percentage. Hunt's series is anomalous in comparison with the others, in that so few cases of normal and

diminished knee-jerks were observed. Assuming the accuracy of the observations, this must be purely a chance occurrence, although it may be due to the character of the patients that present themselves at the Vanderbilt Clinic. Such percentages, we know, are not obtained with hospital patients, and in the Moscow Clinic more nearly normal average results were obtained, as will be seen from the results in Table III.

Table II gives the results from 1337 additional cases of paresis recorded by three investigators. In their works, Siemerling, Renaud and Wollenberg group the absent and diminished knee-jerks, and for this reason their results could not be classified in Table I. It is possible that this grouping of absent and diminished knee-jerks is justified, for the diminution and loss of knee-

TABLE II.—CHARACTER OF THE KNEE-JERK IN PARESIS.

Reporter and date.	Total number cases.	Number of cases.			Percentages.		
		Absent and dimin.	Normal.	Exagg.	Absent and dimin.	Normal.	Exagg.
Siemerling, 1887...	345	129	96	120	37.4	27.9	34.8
Renaud, 1893.....	482	68	68	348	14.1	18.7	73.2
Wollenberg, 1894..	510	124	123	263	24.3	24.1	51.6
Total and percent..	1337	321	285	731	24.0	21.3	54.7

jerks may be due to a similar cause or to similar causes, and the differences may be evidence only of the degree of pathological change. This method of grouping, however, needs to be justified by a careful investigation, and at present it is open to criticism. It is not uncommon to find in certain cases variations from diminished to normal, or often from diminished to an exaggerated knee-jerk and the reverse, but it is unusual to find the return of the knee-jerk after it has been lost. That the latter does occasionally occur is known, but the scarcity of these cases and, on the other hand, the facility of change from diminished to normal indicate a functional difference between the diminished and absent knee-jerks which may properly be assumed to indicate a difference in cause of the two phenomena. In comparison with Table I there is a marked difference in the percentages of the exaggerated knee-jerks, the increase in Table II being at the expense of the normal and the absent knee-jerks.

The original articles in which were recorded the results given in Table III, I have been unable to obtain, and the results are known to me only in the records of the work of other authors. The results from the Moscow Clinic by Gaunouchkine are taken from Hunt's article, where it is stated that the percentages are based on "about 500 cases." Taking the percentages as given by Hunt, and assuming that Gaunouchkine reported fully 500 cases, I find that there is a probable total of 459 cases in which the reflexes were observed. von Scarbo's results are calculated from the report of his work in the *Neurolog. Centralblatt* and from the report of the work by Ricksher. Ricksher assumes that von Scarbo found only 15 per cent of normal knee-jerks in his 115 cases (reduced to 99 when the "extras" are omitted), and while I

TABLE III.—CHARACTER OF THE KNEE-JERK IN PARESIS.

Reporter.	Total number cases.	Number of cases.			Percentages.		
		Absent and dimin.	Normal.	Exagg.	Absent and dimin.	Normal.	Exagg.
Gaunouchkine	459	144	62	253	31.4	18.5	55.1
v. Scarbo.....	99	28	17	59	28.2	17.3	59.6
Greppin	26	12	4	10	46.2	15.4	38.5
Totals and percent	584	179	83	322	30.6	14.2	55.1

have used this figure as the basis of my calculation of the number of cases and of correcting the percentages, I believe it is doubtfully correct. In the *Centralblatt* it is stated that von Scarbo found 15 per cent of normal knee-jerks in 38 per cent of absent tendo Achillis reflexes, but it is reasonable to presume that not all normal knee-jerks were found associated with the absent Achillis reflexes.

I have, therefore, grouped the results of these three investigators separately and give them only as confirmatory evidence of the more carefully collected figures in Tables I and II. The results of Table III, it will be noted, confirm in general the results in Table I, but the percentage of exaggerated knee-jerks is reported to be greater and the percentage of normal to be less. In view of the divergence of method in testing the reflexes and of the probable differences of conception of what may be meant by the terms "exaggerated" and "diminished," it appears to me that the differences in the tables are not so marked that they would in-

dicating great differences in the reflexes in peoples of different countries and occupations or that they permit us to assume the observers were not equally good. When the results presented in the three tables are grouped, it is evident that approximately two-fifths to one-half of the cases of paresis may be expected to have exaggerated knee-jerks, and the remainder may be equally divided between normal and diminished (including absent) knee-jerks. The totals for the three tables are: normal, 1035; exaggerated, 1986; diminished and absent, 1178; grand total, 4199 cases; and the percentages of the different reflexes are as follows: normal, 24.6; exaggerated, 47.3; diminished and absent, 28.1.

II. LATENT PERIOD OF EXAGGERATED AND DIMINISHED KNEE-JERKS.

In reports of cases of paresis, the knee-jerks and other reflexes are often entered as "quick." This is probably meant to indicate an exaggerated condition, but observations made by me make it appear certain that the time of the reflex is not easily determined by the eye; and that the validity of the use of the word quick for the word exaggeration needs investigation. In previous work on the time of the reflex in the retardation of manic-depressive insanity, I found from some experiments that the latent period was prolonged, although it was impossible to determine this from simple examination. In this earlier work, the method of investigation was not so good as that employed in the present work, and the average time obtained cannot be directly compared with what has been obtained in this investigation.

In the present research there were selected for the tests eight paretics whose reflexes had previously been determined by the clinical men of this institution. One of the eight showed decreased knee-jerks and the remaining seven had "lively," "active," "quick" or "exaggerated" reflexes. So far as I could determine from eye inspection, all the exaggerated reflexes were quick; and the knee-jerks in the individual in which they were diminished were apparently slow. Short histories of these patients follow:

Bu., age 32. Duration of the disease at the time the experiments were made, about three months. Reported having contracted syphilis one year

previous to entrance, but this statement cannot be relied upon. Patient was confused and unintelligible, irritable and excitable on admission, but since that time, quiet and orderly. He is careless of his personal appearance. Consciousness is clouded and he is disoriented for time, person and place. His memory is very poor. Hallucinations were not admitted, but his actions indicate that they are present. There are delusions of wealth, which are not very prominent, and of an absurd character. There is no insight. Speech is ataxic and there is difficulty in repeating test phrases. There are marked tremors of hands, fingers and lips. There is no apparent impairment of co-ordination, although there is muscular weakness on the right side. The knee-jerks are exaggerated, the left being greater than the right. The tendo Achillis reflexes are absent on both sides. Triceps are exaggerated and no ulnar or radial reflexes are elicited. No ankle or wrist clonus. Plantar and epigastric reflexes are normal. Cremasteric is very slight. The jaw-jerk is exaggerated. Pupils are regular, the left larger than the right; both react promptly to the usual tests.

Hk., age 27. In his case syphilis was denied, but admitted by him at times, and in conversation he has said, "Dr. R. gave me a douche and gave me syphilis." The duration of the disease (paresis) at the time of the experiment was about two years. Memory is very poor. He does not know the people he has seen every day for weeks. Reasoning and judgment are considerably impaired. There is a marked clouding of consciousness and the patient has many complete and absurd somato-psychic delusions. He is restless and often noisy. Emotional tone is lowered. He is very erotic. He takes no interest in things about him. He is as untidy as he can be with the attention of the nurses and attendants. He has no insight. He speaks little and when he does it is unintelligible. His speech is slurring with the omission of words and syllables. There is general weakness of the muscular system. There is a general tremor. There is a marked inco-ordination of the hands and arms. He walks fairly well, but a trifle unsteady. The knee-jerks and tendo Achillis reflexes are exaggerated. The triceps, ulnar and radial reflexes are exaggerated, the left more marked than the right. There is no ankle or wrist clonus. The plantars are equal and well marked and there is no Babinski sign. The cremasterics are diminished and there is no epigastric reflex. The pupils are dilated, equal and react slowly to light and accommodation. Consensual reaction is difficult to induce. He has had two periods of convulsions since entrance to the Hospital.

Hr., age 37. Probably syphilitic. Duration at time of experiments, one year and eight months. Patient was inaccurate in work, and had somewhat faulty reasoning. He was quiet and orderly and assisted on the wards for seven or eight months after entrance, and, although allowed to go to town unattended, was slightly demented. In his case there have been no delusions or hallucinations. He has had no insight and a recent clinical note says that "patient says little except when spoken to, and then is rather non-communicative. He talks in an explosive manner and elides many syl-

lables. He knows the character of the institution; believes he was sent here to be treated for nervousness. He has an excellent memory for past and recent events, his times and places of enlistment in the army, his places of service, the ward in which he has been in the hospital, and he appreciates all that goes on about him. He has no ideas of grandeur or depression." He has had no convulsions or apoplectiform attacks up to this time. Patient shows tremor of the tongue and extended fingers and well marked speech defect. There is considerable ataxia of the legs, more marked in the right one, and when descending and ascending the stairway, right foot wavers and trembles like a clonus when it is lifted. Knee-jerks are exaggerated, but at times diminished.

Hu., age 38. No evidence of syphilis, and infection denied. Duration about five months. Mother was insane and a brother led a wild and dissolute life. At the hospital showed at times a picture of apprehensive depression, and believes people are calling him a horsethief and a murderer. Is careless of his personal appearance and dress. He stays in one place for hours at a time. He walks slowly and rather hesitatingly. There is apparently great mental reduction. When talking his voice is tremulous, uncertain and he omits syllables and leaves off word-endings and there is a decided drawl. Tremors about the lips are prominent when he stumbles over a difficult word. Grip is good and equal in both hands. Co-ordination fair in arms and legs. No Romberg symptoms. Gait is slovenly, but it cannot be said to be ataxic. The tendon and skin reflexes are exaggerated. Pupils, right slightly irregular, both dilated. Reaction to light slow and small in amount. Accommodation reaction slow. There have been no convulsive or apoplectic attacks since entrance to the hospital, and no history of previous ones.

Le., age 31. Syphilitic history; date of infection unknown. Duration of mental disease, three years. Patient is irascible, morose, visionary and incapable of managing his own affairs. At one time there were well marked hallucinations, and delusions which still persist. Facial expression is apathetic. There is clouding of consciousness and memory defect for recent events. Patient has grandiose ideas, but is inconsistent in that he expresses a desire to return to his former employment as a clerk. He is careless of his personal appearance; his habits are dirty. He had for some time parole of the grounds and assisted with the ward work. He is mentally unstable. There is no insight into his condition. His speech defect is marked. He drawls words, syllables and occasionally stammers. His pupils are dilated, both are slightly indented. There is a slow reaction to light. Consensual reflex is practically absent on both sides and there is no accommodation reaction. There are tremors of tongue and lips and recently tremors of the hands have been noted. Knee-jerks are equal, exaggerated. The tendo Achillis jerks are exaggerated. Elbow and wrist-jerks are normal. There is no clonus of the ankle or wrist. Plantar reflexes are normal in amount and there is no Babinski. Cremasteric and epigastric reflexes are normal. The gait is a trifle shuffling, but

not particularly characteristic. This patient has had no convulsions or epileptiform attacks, but he has had crises which may be considered their equivalents.

Mg., age 31. Syphilitic infection ten years ago. Mental disease began four years previous to experiments. Patient is cheerful, exalted, but with no apparent delusions of grandeur. He is irritable at times and occasionally strikes other patients when they do things he does not like. He has a typical dementia relation to his surroundings. He does not seem to care where he is, and the only insight he shows is when his wife and child (three years old) come to visit him and when other patients annoy him. He sometimes throws himself on the floor and kicks as a child does. No hallucinations or delusions have been elicited. Speech is slurring and stumbling, many words are omitted without any attempt at correction, and at times he is nearly incoherent. When excited the thickness of speech is very much pronounced. He writes weekly letters to his wife, which are unintelligible. He has no insight. Pupils, medium in size, left greater than the right. Light reaction absent on the left. No consensual on the left. Both accommodation reactions normal. Light reaction in right is slow and slight in amount, and the right consensual is normal. Muscular tremors are pronounced. Marked ataxia is noted when patient tries to take off or put on his clothes. The knee-jerks are exaggerated. The tendo Achillis reflexes are normal. The triceps and wrist reflexes are exaggerated. There is no clonus of wrist or ankle. Stimulation of the soles of the feet shows Babinski's sign on both sides. Cremasteric reflexes are diminished. The epigastric reflex is normal. There have been no convulsions or apoplectiform seizures since entrance to the hospital, but he had before entrance one apoplectiform attack which shows at the present time by a ptosis of the left eye.

Sg., age 38. Syphilis probable, but not definitely known. At the time of the experiments, duration of the mental disease was about one year and eight months, although five years previous he had had a maniacal attack of some kind, the character of which is unknown, since he was not at that time placed in a hospital. At first patient was talkative and slovenly, but at the time the experiments were made, he was rather non-communicative and rather neat. His memory is greatly impaired; his attention is poor, and his apperception ability is defective. His general attitude is indifferent or a trifle elated. He had some delusions of wealth, but not beyond what such an individual might have—a few thousand dollars. He is not disoriented to person, place and time. He has no insight. He slurs and stumbles over words, elides syllables and leaves off endings. He stammers and at times is unable to pronounce a word, but gives it up without having made any great effort to pronounce it correctly. Test phrases are very badly pronounced. Although he passed through grammar school, he gave incorrectly much of the multiplication table. Some stigmata of degeneration are apparent. Lymphatic glands are enlarged. No muscular aberration, although there are tremors of the face and tongue. Co-ordina-

tion is poor in both upper and lower extremities. The gait is shuffling and a mild degree of Babinski sign is present. The knee-jerks were reported abolished at the time of the first examination, but they were present at the time of the laboratory experiments, although greatly diminished. There are no tendo Achillis reflexes; the triceps normal; no clonus of wrist or ankle. Stimulation of the sole of the foot gives an exaggerated defense reaction and, in addition, a cross adduction reflex. Cremasterics are normal, but the epigastrics are absent. The pupils are of medium size, equal but irregular, and eccentrically placed. Direct and consensual light reactions are absent. There is diminished accommodation reaction. Sympathetic reaction is absent. There have been no convulsions or epileptiform attacks, but he has had occasional crises, after which he appears confused.

Tu., age 50. Syphilitic history denied. This patient shows a considerable degree of dementia and memory is almost a blank. He is disoriented; answers irrationally and incoherently. No delusions or hallucinations could be elicited. He is emotionally indifferent; is quiet and orderly and does what he is told to do. There is no insight. There is coarse tremor of extended fingers, and at times some twitchings of muscular groups. Co-ordination is somewhat impaired, and there is a slight Romberg sign. The gait is ataxic and very unsteady. He has to be assisted to walk about. The grip is diminished. Speech is ataxic, and there are tremors of lips, tongue and facial muscles. Knee-jerks are exaggerated. Tendo Achillis reflexes are normal. Triceps and wrist reflexes are exaggerated. No clonus of wrist or ankle. Plantar, cremasteric and epigastric reflexes are normal. All the patellar reactions are apparently sluggish.

Description of Apparatus.—The patient rested in a comfortable supine position on a couch and the lower legs were allowed to hang freely over the edge of the couch at an approximate right angle to the upper leg. The couch was so high that the lower edge of the patella was 75 cm. from the floor and movement of the leg of the longest-legged individual was not interfered with. Movement of the leg was determined indirectly by means of the contraction of the quadriceps muscle. Before any experiments were made, points were located on the skin over the quadriceps of each leg where palpation indicated a maximum of muscular thickening.¹ These points were marked with an indel-

¹ Bloch and Tschirjew have independently demonstrated that the contractions of the quadriceps take place simultaneously all over, and during the reflex there is no wave of contraction from the tendon upward through the muscle. In placing the tambour, therefore, on the point of greatest contraction the time of the latent period is not artificially increased in these experiments.

ible pencil, later with silver nitrate, and the button of a receiving tambour was always placed at these receiving points. Similar points were also located on the skin over the patellar tendon, in order to keep the place of stimulation constant.

The apparatus holding the stimulating hammer was movable. The framework was constructed similar to that of a guillotine. It was 104 cm. high. In the center of the top and at a right angle, was a piece projecting 24 cm. beyond the frame to hold an electromagnet for retaining and releasing the hammer. The hammer for stimulating the patellar tendon was hung on pivots so as to swing freely. It is 28 cm. from the pivots to a point corresponding to the center of the striking surface. On the handle of the hammer was a piece of iron that makes it possible for the electromagnet to be used for holding and releasing the hammer. The head of the hammer is made of rubber in two pieces, one attached firmly to the handle, the other moving sufficiently to make a contact.³ The moving or contact part of the hammer is attached to a brass head which passes through the larger part of the hammer head. In striking any surface, the lower or contact part of the hammer approaches the upper part and there is a possibility of a movement of about 3 mm. The contacts were so arranged that a very little movement, from a millimeter to a half of a millimeter, sufficed to make the contact and the rest of the movement, about 2.5 mm., was sufficiently large to prevent the breaking of the contact after it had been once made. Wires were carried from the contact through the hammer handle and were attached to binding posts on the framework. From these, wires were led to a signal magnet and a battery. When the contact was made by the hammer striking the tendon, the time was registered on a rapidly moving smoked drum.

The button of a receiving tambour was placed over the point of the leg that was to be tested and the tambour was firmly fixed. This receiving tambour was 6.5 cm. in diameter. Rubber tubing led to the recording tambour which was 5 cm. in diameter and which had about one-third the air capacity of the receiving tam-

³ It may be well to state that Castex found the surface of the percussion hammer had no effect upon the character—exaggeration or diminution—of the reflexes.

bour. A light straw lever attached to the recording tambour magnified the recorded excursions of the rubber membrane fifty times.

The time record was made by the style of a Jacquez chronometer beating fifths of a second. The drum of a Ludwig kymograph was revolved as rapidly as possible; during the revolution the hammer was dropped, made its contact which was recorded on the drum; the knee-jerk was recorded by the tambour; and the time record in fifths of seconds was also recorded. The time of the latent period was determined in individual contraction by averaging the lengths of three successive fifths of seconds and comparing with this average the difference in the time between the stimulation of the tendon, indicated by the signal magnet, and the beginning of the muscular contraction as indicated by the record of the recording tambour. The latent period for the air transmission from the receiving to the recording tambour was determined in a series of experiments, to be .0035 second. In the calculation of results this figure has been subtracted. In arranging the tambour lever, the time record and the signal record, it was found advisable to place the point of the tambour lever some distance ahead in order that there should be no interference, since by placing it either above or below, there was a possibility of interference when the lever moved in the wrong direction. The illustrations which are given show records in which the recording lever has been placed 9.5 mm. ahead of the styles of the chronometer and the signal magnet.

Results of Experiments.—Fig. 1 illustrates the records obtained, and also the general character of the reflex movements. This record gives parts of three curves from *Hk*. The record is to be read from right to left. The tambour curve is below the corresponding time and signal curves. In this record the tambour curve preceded by 9.5 mm. the record of the signal magnet and that of the Jacquez chronometer. It will be noted that at the time the tendon was struck, there is a slight depression in the tambour curve, followed by a correspondingly slight rise to the normal position, then a deep and rather steep decline which corresponds to the contraction of the quadriceps in producing the knee-jerk. The lower part of the curve is wavy. This character I have found

in most of the curves which I have obtained but its significance I do not know. The uppermost of the three curves shows that the lever of the recording tambour rose to a position above its normal, and later returned to the normal position. This part of the record does not show the phenomena so clearly as it is shown in Fig. 2. The curves indicate, however, that there may be, and often is, a tonic relaxation following the contraction. The relaxation is often followed by a second contraction. This is well shown in Fig. 2, in which the record has been made when the drum was revolving slowly. Often a third and fourth contraction have been found.

Fig. 2 is also a record from *Hk.*, and there is the same amount of lateral displacement, namely, 9.5 mm., between the tambour and time record.

In the case of *Le.*, the records indicate clearly that there was a uniform antagonistic action following the knee-jerk. The records show that the relaxation of the quadriceps was greater after the knee-jerk than when the leg hung loosely from the edge of the couch and when the knee was bent approximately at a right angle. This condition is not so well marked in the record which is here produced as in many other records of *Hk.*, but the antagonistic tonic after-effect to a greater or less extent was found in almost all the records of *Le.*, *Hk.*, *He.*, *Mg.* and *Bu.* In *Bu.*, the time of the persistence of the working of the antagonistics was approximately .6 of a second; in *Le.*, it was .4 of a second, while in the records of others, it averaged from .1 to .4 of a second.

The duration of the knee-jerks in the records of *Hk.*, is approximately one-twelfth second, although in Fig. 2, it appears to be somewhat longer. In the records of other subjects, the time varies considerably, sometimes amounting to as much as one-fifth second, and in these cases the term exaggeration cannot be taken to mean a rapid movement, contraction and relaxation.

Table IV, gives the results of the average latent period of the knee-jerk in the eight cases of paresis which I have investigated. In the first vertical column are the initials of the subjects; the second column, note of which leg was used; the third column gives the average time in seconds; then the average variation of the experiments in that particular series, and in the last column,

we have the number of experiments in the series. The average time of all subjects is about .050 second. This is the average of 495 experiments, and in this total we have included the experiments or averages of the one case in which the reflexes were diminished, namely, *Sg.* It will be noted, in looking over the totals, that *Sg.* has an average latent period of .051 second. This is very close to the general average, and is not far from many of the figures which are given by the other subjects, all of whom showed decided increase in the amount of movement of the foot.

TABLE IV.—TIME OF LATENT PERIOD OF KNEE-JERK IN PARESIS.

Subjects.	Leg.	Average time in second.	Average variation in second.	Number of experiments.
Bu.	R.	.057	.0060	16
	L.	.048	.0070	16
Hk.	R.	.051	.0051	42
	R.	.056	.0081	39
	L.	.040	.0038	34
	L.	.037	.0028	30
Hr.	R.	.064	.0068	19
	L.	.064	.0065	30
Hu.	L.	.044	.0042	19
Le.	R.	.056	.0069	45
	R.	.054	.0020	8
	L.	.048	.0054	23
	L.	.046	.0039	33
Mg.	R.	.057	.0041	27
	L.	.039	.0046	46
Sg.	R.	.051	.0057	19
Tu.	R.	.081	.0064	16
	L.	.080	.0073	24
Average and total.....		.050		495

The difference in the time for the two legs came out plainly in the cases of *Hk.* and *Le.*, on each of whom there were two series for each leg, and in both series the same differences were noted. These differences I cannot explain. So far as can be determined, there is no difference in the other characters of the knee-jerk in these individuals to account for the quicker time on the left than on the right. A similar difference is noticeable in the averages for *Mg.* In this case only one series of experiments was made, but the difference is very pronounced. *Hr.*, on the contrary, showed slower time on the left; *Bu.* showed slower time on the right; *Tu.* was approximately the same on both sides.

These results are to be compared with the time measurements of the knee-jerk in normal individuals. Several investigators have found that the time of the latent period of the knee-jerk in normal people is from .024 to .069 second. It should be noted, however, that the methods which were employed in these other investigations differ considerably from those which I have employed, and the results cannot, therefore, be directly compared with the experiments which are here recorded. For the sake of comparison, I made two series on normal individuals, one of 36 experiments in which the average time for the knee-jerk was .04 second, and in another individual, the average time for 51 experiments was .044. If these times be considered normal, we may say that the results obtained from *Mg.* and *Hu.*, and the experiments on the left leg of *Hk.*, are absolutely normal in respect to latent period. It will be observed that the time of the knee jerk in most of the other patients is longer than that of normal subjects. It seems evident, therefore, that the knee jerks in exaggerated condition are not properly always spoken of as quick, and, in fact, that the latent time of exaggerated knee-jerks may be lengthened.

In this connection, the question whether the knee-jerk is a reflex or a contraction due to mechanical stimulation might be discussed, but it need not detain us here to any extent. The great objection which has been raised to considering the knee-jerk a true reflex, is that the latent time is too short, that is, the time from the moment of stimulation until the beginning of the contraction. This conclusion is based upon the determination of the time of transmission of nerve impulses in the motor nerves, especially of frogs, but it appears to me that we are not justified in taking these experiments as a basis for the criticism of the reflex time. The rate of nerve impulse in a motor nerve of a frog has been determined to be from 30 to 33 meters per second. It is likely that human motor nerves have a much faster rate of transmission, and we know that the rate at least in human sensory nerves may be about 60 m. per second. If we take for comparison the lowest probable rate in human motor nerves to be 40 m. per second, the probable rate in human sensory nerves to be 60 m., and then consider the time taken up in the spinal cord to be .012 to .022 sec., in accordance with the recent experiments of

Buchanan, the necessary total time for the reflex—omitting from consideration any inertia in the end organ and the latent period of the muscle, which is very small—would be from .029 to .039 sec.

III. RELATION OF KNEE-JERK TO OTHER CONDITIONS IN PARESIS.

From time to time attempts have been made to correlate various findings in paresis with each other and with the probable duration of life once the disease has been recognized. Some of the ideas put forth will be mentioned in the proper paragraphs, but we may note here that Thurman, for example, concluded from an examination of eye conditions in 116 cases, that the dilatation of the right pupil corresponds to depressive states, and that dilatation of the left is most often accompanied by expansive conditions. The knee-jerks have often been correlated with the mental and physical condition in small numbers of patients. One of the most sweeping generalizations is that of Shaw, to the effect that exaggerated reflexes are associated with marked speech disturbances, with apoplectiform attacks and with comparatively few epileptiform convulsions. All of the conclusions and ideas put forth on these subjects cannot be considered at this time but in the form of a preliminary attempt at some simple correlation I have constructed tables of the relation of the knee-jerk and some other phenomena in paresis.

Knee-Jerk and Ankle Clonus.—Results of the examination of 96 patients on whom tests for both knee-jerks and ankle clonus were made, are included in Table V.

TABLE V.—KNEE-JERK AND ANKLE CLONUS.

Character of knee-jerk.	Absent.	Dimin.	Normal.	Exagg.	Totals.
Ankle clonus present.....	0	2	0	13	15
Number of observations.....	21	15	14	46	96

Ankle clonus is considered to be rather uncommon in paresis, but it would seem that about 15 per cent showed sufficient evidence of this condition, so that it has been recorded. In this case it is likely the true percentage is much lower than 15, since many

examiners are accustomed not to mention clonus unless it is found to be present. It is possible that this has been the custom of those who prepared the records of the cases which I have examined. It will be noticed that a greater percentage of the occurrences of ankle clonus is found in conditions of exaggerated knee-jerks.

Knee-Jerk and Plantar Reflex.—From a study of this subject, Bettencourt concluded that the exaggeration of the tendon reflex is accompanied by the loss or a diminution of the plantars in the majority of cases, but that this is not always so is shown by the tables giving the results of Renaud's and my observations.

TABLE VI.—KNEE-JERK AND PLANTAR REFLEX (RENAUD).

Character of knee-jerks.	Character of plantar reflexes.			Totals.
	Absent.	Normal.	Exaggerated.	
Exaggerated	78 = 24%	132 = 40%	120 = 36%	330
Normal	"As often preserved as exaggerated."			?
Absent.....	39 = 57%	14 = 21%	15 = 22%	68

TABLE VII.—KNEE-JERK AND PLANTAR REFLEX.

Character of knee-jerks.	Character of plantar reflexes.				Totals.
	Absent.	Dimin.	Normal.	Exagg.	
Absent.....	2	6	22	6	36
Diminished.....	2	4	18	1	25
Normal.....	0	0	16	0	16
Exaggerated.....	3	2	41	10	56
Totals.....	7	12	97	17	133

In considering the plantar reflex, we are met with the difficulty that this reflex is not so simple as the tendon, epigastric or cremasteric reflexes. Two different reflexes are present when the sole of the foot is stroked and are called plantar. The stimulation of the plantar surface of the foot is followed by movements of the foot and toes; secondly by extensive movement of the legs, and at times by movements of other parts of the body.

The movements of the legs and other bodily parts, may be spoken of as the "defense" reaction. They usually accompany the peculiar organic sensation or feeling of tickling, and are un-

doubtedly directed toward effecting escape from the irritation. These movements may be widespread, they may be localized in a few muscles, or they may be entirely absent. With these classes of response the reflex may be respectively called exaggerated, normal or absent. Comparative statistics of this kind of plantar reflex, I have been unable to discover.

The downward or flexor movements of the toes is similar in character to the flexion of the fingers and hand of a baby when an object, such as a pencil, is placed across the fingers or palm. It is probably a relic of arboreal ancestry and is a grasping reflex. A marked difference of the reflex, viz., extension, especially of the great toe, is found in many organic nervous diseases, but this cannot be described as normal; in this case the plantar reflex is not diminished, nor is it exaggerated; it is of a different character.

From this analysis of the so-called plantar reflex it will be understood that we are dealing with a complex reaction, and that unless the accounts of the reflexes are full we are unable to differentiate the two or three kinds of reflexes classed under the name of plantar and it is almost impossible to make correlations. The terms exaggeration, diminution and absent may be applied equally well to the flexion or to the tickling reactions, but reports of exaggerated or diminished plantar reflexes must always be accompanied by doubt as to the character of the reaction that is abnormally great, for unless specific mention is made of the kind of plantar reaction that is exaggerated, we are unable to say whether it is the defense reaction or the flexion.

The figures in Tables VI and VII, are open to the above criticism. It should be noted as significant, however, in both of Renaud's tables and in the reports which I have correlated, the normal knee-jerk was never found to be associated with diminution or absence of the plantar reflex.*

Knee-Jerk and Cremasteric Reflex.—The cremasteric reflex is often absent or diminished in paresis, and the tentative examination of the relation of the changes in this reflex with the different character of knee-jerk is given in Table VIII.

*I have here assumed, although it is not expressly stated that Renaud found no diminution or absence of the plantar associated with normal knee-jerks; for he says, in speaking of the normal knee-jerk, that in association with this condition, "the plantars are as often observed (normal) as exaggerated."

TABLE VIII.—KNEE-JERK AND CREMASTERIC REFLEX.

Character of knee-jerk.	Character of cremasteric.			Totals.
	Absent.	Dimin.	Normal.	
Absent.....	6	7	8	21
Diminished.....	3	3	11	17
Normal.....	2	2	7	11
Exaggerated.....	5	7	30	42
Totals.....	16	19	56	91

In none of the case records which I have examined has the cremasteric reflex been described as exaggerated. In the case of this reflex, we have no standard by which to judge exaggeration unless we consider the time of the apparent rapidity of the reflex. Complete measurements and statistics of the cremasteric reflex are not known to me. In view of the high percentages of cases in which it was noted as absent or diminished, it should be carefully investigated. It will be noted that the cremasteric was absent or diminished in about 35 per cent of all cases in which specific mention was made that tests were made of this reflex.

Knee-Jerk and Pupillary Reaction.—It is very properly said that the combination of Argyll-Robertson pupils, absent knee-jerks and signs of dementia in an individual of twenty-five to forty-five years of age, indicates over 99 per cent probability of a diagnosis of paresis, if other known organic nervous disease is not evident. Carefully collated statistics are wanting of the occurrences of this combination in other mental diseases not of known organic origin. It is probable that the diagnosis of paresis would be justified, not only from a combination which is mentioned above, but from simpler combinations, such as changes in the knee-jerks and the loss of sympathetic or consensual reflexes. These different combinations, however, have not been carefully gone over.

TABLE IX.—KNEE-JERK AND PUPILLARY LIGHT REACTION.

Character of knee-jerk.	Character of light reaction.			Totals.
	Absent.	Dimin.	Normal.	
Absent.....	18	9	6	33
Diminished.....	4	13	7	24
Normal.....	3	6	11	20
Exaggerated.....	15	23	15	53
Totals.....	40	51	39	130

Light Reaction.—In Table IX, is given an account of the relation of normal, diminished and absent direct light reaction with the different characters of knee-jerks. The percentage of loss of the direct light reaction in paresis is quite high. If we combine the diminution with the absent conditions it is approximately 70 per cent.

TABLE X.—KNEE-JERK AND NORMAL LIGHT REACTIONS.

Recorders and dates.	Totals.	Number of cases.			Percentages.		
		Absent.	Normal.	Exagg.	Absent.	Normal.	Exagg.
Siemerling, 1886.....	49	6	25	18	12	51	37
Wollenberg, 1894.....	210	31	64	115	15	30	55
Franz, 1908.....	46	12	11	23	26	24	50
Totals and percent..	305	49	100	156	16	33	51

Table X, in which are included the results of Siemerling and of Wollenberg, gives the association of the normal pupillary reactions to light with different characters of knee-jerks. This table gives the result of 305 observations and it shows that normal light reaction is less often associated with absent knee-jerks than with conditions of exaggeration and normal. In this table I have grouped all my observations—6 absent and 6 diminished—under the heading of absent, as Siemerling and Wollenberg have doubtless done. From Renaud's work, I have found that in 166 cases of normal pupillary light reaction, 18 were found associated with

TABLE XI.—KNEE-JERK AND ABSENT LIGHT REACTIONS.

Recorders and dates.	Totals.	Number of cases.			Percentages.		
		Absent.	Normal.	Exagg.	Absent.	Normal.	Exagg.
Siemerling, 1886.. ...	94	36	24	34	38	26	36
Renaud, 1893.....	316	50	24	242	16	8	76
Wollenberg, 1894.....	249	80	64	105	32	26	42
Franz, 1908.....	36	17	8	16	47	8	45
Totals and percent..	696	183	116	397	26	17	57

absent knee-jerks; 42 with normal knee-jerks; and 106 with exaggerated knee-jerks. These figures give percentages similar to those given by Siemerling and by Wollenberg.

In Table XI are given the results in which knee-jerks are associated with light-stiff pupils. It will be noted that the greatest number is found associated with exaggerated knee-jerks. In this

table the results of my observations are given of only those cases in which no light reaction was obtained. From the statistics given by Siemerling, by Renaud and by Wollenberg it appears that they have included among their light-stiff pupils those cases in which a minimum or a diminished reaction was observed. If a similar procedure were followed in connection with my cases, instead of being 17 with absent knee-jerks, 3 with normal knee-jerks and 16 with exaggerated knee-jerks, there is a total of 70 cases of which 25 light-stiff pupils were found associated with absent knee-jerks, only 8 with normal knee-jerks and 37 with exaggerated knee-jerks. If, in addition, under the general heading of absent knee-jerks there be included the diminished knee-jerks, there would be a total of 87 light-stiff pupils, of which number 42 were associated with absent and diminished knee-jerks; 8 with normal knee-jerks and 37 with exaggerated knee-jerks.

TABLE XII.—KNEE-JERK AND ACCOMMODATION REACTION.

Character of knee-jerk.	Accommodation reaction.			Totals.
	Absent.	Dimin.	Normal.	
Absent.....	5	7	20	32
Diminished.....	6	16	13	35
Normal.....	0	2	17	19
Exaggerated.....	9	15	30	54
Totals.....	20	40	80	140

Accommodation Reaction.—Results of the correlation of the observations of the accommodation pupillary reaction with the knee-jerks in 149 cases are given in Table XII. Here also it will be noted that the least percentage of absent accommodation reaction is associated with normal knee-jerks, the greatest with absent and diminished knee-jerks.

TABLE XIII.—KNEE-JERKS AND PUPILLARY REACTIONS.

Character of knee-jerk.	Argyll-Robertson.		Diminished light and accommodation.	Absent light and accommodation.	Normal light and accommodation.	Totals.
	Complete.	Incomplete.				
Absent.....	13	5	3	4	6	31
Diminished.....	1	3	10	3	6	23
Normal.....	3	3	2	0	11	19
Exaggerated.....	10	8	13	6	23	60
Totals.....	27	19	28	13	46	133

Argyll-Robertson Pupils.—In Table XIII, are found statistics for the correlation of Argyll-Robertson pupils with the different characters of knee-jerks. I have included in this table the cases in which there is complete Argyll-Robertson pupils, the incomplete Argyll-Robertson, in which accommodation is normal and the light reaction diminished or slowed; the combination of diminished light and accommodation reactions, absent light and accommodation reactions, and normal accommodation and light reactions. In conjunction with this table, it should be mentioned that Renaud has found 242 cases of complete or incomplete Argyll-Robertson pupils among 348 cases of exaggerated knee-jerks; 24 cases among 66 normal knee-jerks, and 50 cases among 68 absent knee-jerks. The table shows that the Argyll-Robertson pupil, both complete and incomplete, absent or diminished light and accommodation reactions are seldom associated with normal knee-jerks. They are most often associated with absent and diminished knee-jerks. Fifty-eight per cent of the cases showing normal knee-jerks also showed normal light and accommodation reactions. No case was found in which the normal knee-jerks were associated with the absence of both light and accommodation reflexes, there were 6 cases in which the normal knee-jerk was associated with complete or incomplete Argyll-Robertson pupils and only 2 cases associated with diminished accommodation and light reactions. Of the total 133 cases examined, 35 per cent gave normal reactions to light and accommodation; 21 per cent gave diminished reaction to both light and accommodation; 10 per cent did not react to light or accommodation; and 14 per cent showed incomplete and 20 per cent complete Argyll-Robertson pupils. When we compare these figures with the percentages found in exaggerated reflexes, we find the percentages to be almost exactly similar—38 per cent normal; 22 per cent absent for both reflexes; 13 per cent incomplete, and 17 per cent complete Argyll-Robertson pupils. It appears, therefore, that in relation to the exaggerated knee-jerks the distribution of the anomalous eye conditions in the exaggerated patellar reflexes follows the same sort of distribution as if the eye reflexes in paresis be considered as a whole. In connection with the absent patellar reflexes, however, we find considerable alteration, for we have only 19 per cent of these cases showing normal light and accommodation reaction;

10 per cent diminished and 13 per cent absent light and accommodation reflexes; 16 per cent incomplete and 42 per cent complete Argyll-Robertson pupils. It is certain, therefore, that there is a much closer association or correlation between the absent knee-jerk and the Argyll-Robertson pupil than between the latter and any other condition of knee-jerk.

Knee-Jerks and Mental Symptoms.—Mention has already been made of an attempted correlation between reflexes and mental conditions. Rouillard has reported that in paresis the exaggeration of the tendon reflexes appears in the expansive form and the abolition of the reflexes in the depressed form. On the other hand, Marandon de Montyel affirms that the knee-jerks are more often exaggerated in the depressed form of paresis. Renaud ex-

TABLE XIV.—KNEE-JERKS AND MENTAL TYPES.

Character of knee-jerk.	Mental types.			Totals.
	Exalted.	Depressed.	Demented.	
Absent.....	9	10	13	32
Diminished.....	14	1	11	26
Normal.....	10	8	5	18
Exaggerated.....	24	18	25	67
Totals.....	57	32	54	143

amined 107 cases for this correlation and found exaggerated knee-jerks in 66 per cent of expansive cases of paresis and in 68 per cent of depressed cases. Normal knee-jerks were found by him in 13 per cent of the expansive form, and 17 per cent of the depressed type; while absent knee-jerks were found by him in 21 per cent of the expansive cases and in 15 per cent of the depressed cases.

In 143 cases which I have gone over I find approximately 40 per cent were exalted or expansive, 22 per cent were depressed, and the remainder were of the demented type of paresis. I have left out those few cases in which there were alternations of exaltation and depression. It will be found in looking over the table that there is no special correlation between the knee-jerks and the mental condition. This conclusion is brought out more clearly when the figures for the absent and the diminished knee-jerks are combined.

Knee-Jerk and Duration of the Disease.—There appears to be more of a correlation between the character of the knee-jerks and the duration of the disease. It is impossible in every case to determine the duration of the disease before entrance to the hospital, but it is fair to assume that on an average all types and characters of patients are brought to the hospital at approximately the same stage of the disease.

In Table XV I give the average duration of the disease in this hospital in 148 individuals in whom the knee-jerks were also examined. In view of the uncertain time of the previous duration, the accuracy of the reports depending upon the sincerity and helpful attitude of the patients' relatives, I have preferred to take the hospital residence, since this is accurately determinable. The table shows very clearly that the average duration of life of pa-

TABLE XV.—KNEE-JERK AND DURATION OF DISEASE.

Character of knee-jerk.	Absent.	Diminished.	Normal.	Exaggerated.	Average.
Average duration in months.....	18.6	19.3	21.9	20.2	19.4
Number of cases.....	36	30	19	69	148

tients with absent knee-jerks, after they enter the hospital, is a little over a year. Those in whom the reflex is only diminished, live about a year and a half, and about the same time for the exaggerated reflexes. Those patients who showed normal knee-jerks live approximately two years. The average variation of these figures is, of course, very large. I have not calculated this, but some idea may be gathered from the fact that the upper and lower limits in the different conditions are as follows: the patients exhibiting absent knee-jerks lived from 0.5 to 53.5 months; those with diminished knee-jerks from 0.5 to 85 months; those with normal knee-jerks from 1.5 to 36 months; those with exaggerated knee-jerks from 1.0 to 110 months. An examination of the original figures shows that should the exceptionally long-lived individuals be excluded, there would be a quite marked diminution in the expectancy of life in the individuals who, on entrance to the hospital, have absent knee-jerks. With so few cases it may, perhaps, be more justifiable to consider the median observations closer approximations to the expectancy of life than the averages

which are given in the table. It may be well to state that the median value for patients with absent knee-jerks is 11.25 months; with diminished knee-jerks, 13.25 months; with normal knee-jerks, 15.5 months; and with exaggerated knee-jerks, 15.5 months. In these cases the correlation is more likely one of the relation of general bodily conditions on entrance to the hospital. We are dealing probably with the correlation of the amount of involvement of the brain and spinal cord, which is supposed to be greater in conditions of absent knee-jerks than in conditions of diminished, exaggerated or normal knee-jerks. These figures are to be compared with the statements of Cramer, who, however, does not give averages or specific figures for any of the different conditions. This author states that the absence of knee-jerks in paresis makes possible a prognosis of long duration and few and slight stages of agitation. On the other hand, the averages which are here reported make probable a prognosis of short duration in absent and diminished knee-jerks and of a longer duration in normal and exaggerated reflexes.

CONCLUSIONS.

1. In over 4000 patients, the percentages of different character of knee-jerks are as follows: normal, 24.6; exaggerated, 47.3; diminished and absent, 28.1.
2. The antagonistic muscular action following the knee-jerk is greater than the agonistic action.
3. In many cases of paresis, the knee-jerk is clonic in character.
4. The time of the knee-jerk, i. e., the continuation of the muscular contraction, is from 0.1 to 0.6 second.
5. The average latent period of exaggerated knee-jerks in cases of paresis is slightly longer than in normal individuals.
6. The average latent periods in conditions of exaggeration and diminution do not appreciably differ.
7. There is often a difference in the latent period of the knee-jerk of the two legs of a subject, which is not distinguishable clinically, and which is not yet correlated with other functional or with structural changes in the nervous system.
8. Fifteen per cent of the patients that were examined showed ankle clonus in one or both legs.

9. Ankle clonus was not found associated with normal or absent knee-jerks.

10. No special relation was discovered between the condition of the plantar reflexes and the knee-jerks, although with normal knee-jerks the plantar was never diminished or absent.

11. There is a decided correlation between Argyll-Robertson pupils and absent knee-jerks. There is also a decided negative correlation between the alternation of pupillary reactions and normal knee-jerk, in that the pupillary abnormalities are less often found associated with normal knee-jerks.

12. There is no relation between the character of the knee-jerk and the mental symptoms, although a relation has previously been reported by at least two other investigators.

13. It appears that on entrance to a hospital the expected duration of life of paretic individuals with absent knee-jerks is about 13 months; that of patients with diminished knee-jerks is about 19 months; and that of patients with exaggerated or normal knee-jerks, about 20 months.

REFERENCES.

- Baird: Jour. Ment. Science, 1905.
 Beatley: Brain, 1885.
 Bettencourt: Thèse de Paris, 1885.
 Bevan Lewis: Text-book of Mental Diseases, 1889.
 Buchanan: Quart. Jour. Exper. Physiol, 1908.
 Castex: Revue Neurol., 1905.
 Cramer: Münch. med. Wochensch., 1895.
 Eulenburg: Neurol. Centralbl., 1882.
 Eulenburg: Ztsch. f. klin. Med., 1882.
 Greppin: Allg. Ztsch. f. Psychiat.
 Gudden: Arch. f. Psychiat., 1894.
 Hunt: Medical Record, 1905.
 Marandon de Montyel: Ann. Méd. Psychol., 1898.
 Mayhew: Jour. Exper. Med., 1897.
 Renaud: Thèse de Paris, 1893.
 Ricksher: Amer. Jour. Insan., 1907.
 Rouillard: Gazette de hôpitaux, 1888.
 v. Scarbo: Neurol. Centralbl., 1904.
 Siemerling: Neurol. Centralbl., 1887.
 Sternberg: Die Sehnenreflexe und ihre Bedeutung f. d. Pathol. d. Nervensystems, 1893.
 Wollenberg: Arch. f. Psychiatr., 1894.
 Ziehen: Diagnos. Bedeutung d. Kniephänomens, 1887.

FIG. 1.—Curves of movement of quadriceps muscle in knee-jerk. To be read from right to left. The upper line of each curve gives the time in fifths of a second. The middle line shows the time when the patellar tendon was struck. The lowest line gives the time of the contraction of the quadriceps. The contraction curve is 9.5 mm. ahead of the time curve.

FIG. 2.—Curve of movement of quadriceps muscle in knee-jerks. For description see the legend to Fig. 1.