STUDIES IN SPEECH NEUROLOGY—I.*

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INTRODUCTION.

SPEECH neurology may be defined as the study of the phenomena of the nervous system underlying the production of speech. It is based on the registration of speech in such a manner that its factors can be accurately measured and analysed.

The first registrations of speech for the purposes of neurology were made by the author in the Psychological Institute of the University of Munich in 1905 at the suggestion of the Director, Professor E. Kraepelin. From 1906 to 1912 the work was carried on in the neurological department of the Vanderbilt Clinic in New York City. The work was then removed to London where it was carried on for several years in connection with the Out-Patient Clinic of the late Dr. F. E. Batten at the National Hospital. From 1923 to 1928 it was pursued in the Psychiatric Institute of Professor Wagner-Jauregg in connection with the Phonetic Institute of the University of Vienna. From the summer of 1928 onwards it has been continued in connection with the Out-Patient Clinic of Dr. Kinnier Wilson at the National Hospital, London. At the present time similar investigations are being made in the completely equipped speech laboratory of the West End Hospital for Nervous Diseases, London (Director, Dr. C. Worster-Drought; Assistant, F. Janvrin) and in the Experimental-phonetisches Laboratorium der thüringischen Landesheilanstalten, Stadtroda (Director, Prof. W. Jacobi).

Speech neurology had its origin in the application of the methods of registration developed by Rousselot for the purpose of studying languages and dialects. His work led to the development of the science of experimental phonetics; this has now been extended to most branches of the study of speech. In order to afford opportunities for united action of the workers in this science the *International Society of Experimental Phonetics* was founded at The Hague in 1928. A special section for the division of speech neurology was created in 1929 with Dr. Kinnier Wilson as Chairman. Members of this Society receive free of charge: *Zeitschrift für Experimentalphonetik*, *Vox*, *Comptes rendus de la Societe Internationale de Phonetique Experimentale*, *Bulletin of the International Society of Experimental Phonetics* and *Sprachneurologische Mitteilungen*. Applications for membership are to be sent with the yearly fee of 10s. to the *Secretarial Bureau*, 73 Welbeck Street London, W.1. A meeting of the Section is being arranged in connection with the International Congress of Neurology at Berne in 1931.

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MAKING AND INTERPRETING SPEECH INSCRIPTIONS.

The patient speaks into a wide mouthpiece with a rubber air-cushion (fig. 1). The vibrations and movements of the air pass down a wide rubber tube to a membrane of oil-silk in a speech recorder. The movements of this membrane are enlarged by a straw lever and inscribed on a surface of smoked paper stretched around a revolving cylinder. Before or after a series of records a time-line is registered by a fork vibrating 100 times per second. The record sheet is finally removed and fixed.

FIG. 1.

A speech inscription of *ah* spoken rather long by a normal person is reproduced in fig. 2 (E.S.). The height of the line of waves depends on the expenditure of breath. Each wave is the registration of one puff from the larynx. The vertical height of the waves gives some indication of the strength of the puffs. The horizontal length of a wave registers the time from one puff to the next.

Under a microscope the horizontal length of each wave is measured. The results are turned into frequencies, that is, the times with which each vibration could be repeated in one second. Horizontally long vibrations correspond to low tones, horizontally short ones to high tones. The frequencies are then

FIG. 2.

plotted on millimetre or logarithmic-millimetre paper. A line drawn through the dots gives the course of frequency, or the melody plot. The melody plot for fig. 2 (E.S.) is given in fig. 3 (E.S.). The tone on the whole neither rises nor falls but remains at about the same pitch. It is particularly important to notice that the tone never remains exactly on the same pitch but fluctuates continually.

FIG. 3.

EXAMPLES OF SPEECH ATAXIA.

All the patients referred to in the following account were from the Out-Patient Clinic of Dr. Kinnier Wilson at the National Hospital in London.

CASE 1. The inscription in fig. 2 (W.G.) is from a case of *cerebellar agenesis*.

W. G., 24 years old, male, had been affected with shaking of the head and general tremor since childhood. His father, a sister and one brother were similarly afflicted. He holds his head tilted to the right; it shakes intermittently. His hands shake, but he shaves himself and does not spill tea. His tongue does not seem tremulous. There is no disturbance of the eyes. The Wassermann test is negative in the serum. A circle drawn by the patient with a pencil is reproduced in fig. 4.

FIG. 4.

In the inscription in fig. 2 (W.G.) the height of the wave line above the base registers the breath expenditure. In general it is scarcely raised; this indicates a slight expenditure. At one point it rises and falls suddenly; this indicates a momentary increase of breath pressure. The course of the breath expenditure is therefore irregular. Such an irregular result of muscular movements is said to be *hypotaxic* or *ataxic*.

The vertical height of a wave registers to a great extent the amplitude or strength of the puffs from the larynx. In general the waves of the inscription in fig. 2 (W.G.) are of fairly constant height. At the place just considered they suddenly become higher. This is evidently another expression of the disturbed regulation, that is, of hypotaxia.

The horizontal length of a wave in the inscription is a registration of the time between puffs from the vocal lips. The inscription is characterised by the frequent occurrence of great irregularities. This is still another expression of the hypotaxia.

The melody plot in fig. 3 (W.G.) in its general course is a characteristic one for *ah* spoken at great length or sung. The frequency remains fairly constant for long regions at a time; the gradual rise towards the end is not abnormal. The small smooth fluctuations in frequency are always present in normal cases. The fluctuations in breath pressure are the same as in a normal wavy or vibrato voice. The sudden jerks in the plot are due to the irregular waves and are a record of the hypotaxia. The melody shows no abnormality except the hypotaxia.

The amount of the breath expenditure and the loudness of the vowel depend on the action of the breath muscles; the pitch of the vowel waves depends on the tensors of the larynx. These activities depend on the co-

ordination, that is, on the *synergia*, of the agonist and antagonist muscles. The irregularities in the speech, the hypotaxia, arise from defective co-ordination or *hyposynergia*. This is expressed by the kineto-dynamic causal equation

$$\text{hypotaxia} \leftarrow \text{hyposynergia}.$$

This is the motor equation for cerebellar agenesis.

CASE 2. *Disseminated sclerosis.*

A. P., male, 46 years old, complains of losing the use of his legs; they always feel cold, the left leg feels numb; the hands feel cold and he has poor use of them; knee and ankle jerks are increased, the plantars are extensor, the abdominals are absent; there is a very slight nystagmus, the finger-nose test is positive. No optic disc changes. No defect of speech can be heard; the voice seems to have a somewhat melancholy melody, slowing rising or falling. Diagnosis: *disseminated sclerosis* with spastic paraplegia as the most striking manifestation.

An inscription of ah spoken by this patient is reproduced in fig. 2 (A.P.). Long irregular waves appear at the beginning and at the end, that is, when the voice is beginning or ending a tone. The resemblance to the results for the usual finger-nose test suggest that this may be termed an intention tremor of the larynx. The melody plot in fig. 3 (A.P.) shows a rather monotonous melody with sudden changes due to the irregular waves. The condition is one of *hypotaxia* and *hypomelodia*. No other abnormalities are found in the inscription. The hypotaxic waves are due to laryngeal hyposynergia and the hypomelodia to overtension of the laryngeal muscles. The motor equation for the condition is therefore

$$\text{hypotaxia} + \text{hypomelodia} \leftarrow \text{hyposynergia} + \text{hypertonia}.$$

CASE 3. *Friedreich's Ataxia.*

D. D., male, 27 years old, had for six years noticed uncertainty in walking, weakness of arms, and slowness of speech; only lately has he had hesitation in micturition. Disturbance of vision has not been noticed. He is slightly melancholy; a sister is said to be somewhat mentally abnormal; otherwise a normal family history. The muscular power is good. There is marked kyphoscoliosis and also talipes equinus with pes cavus on both sides. The pupils contract to light but widen again. There is no nystagmus; fundi normal. The vibration sense is lacking in legs and arms. The finger-nose and heel-knee tests show ataxia. Adiadocokinesis present. Knee and heel reflexes absent. Plantar reflexes extensor, both sides. Diagnosis: *Friedreich's ataxia*.

An inscription of ah spoken by this patient is reproduced in fig. 2 (D.D.). The height of the general line shows wavering of the breath pressure at the beginning and the end. Strongly irregular waves appear at the end. There is thus *hypotaxia* in both breath pressure and voice tone. The melody plot is given in fig. 3 (D.D.). The irregularities at the end indicate hypotaxia. The general course of the tone shows deficient modulation and flexibility. There is therefore no hypomelodia. The motor equation is:

$$\text{hypotaxia} \leftarrow \text{hyposynergia}.$$

In none of the cases could any abnormality of speech be detected by the ear. The test was therefore ultra-acoustic. Its invariable presence in disseminated sclerosis although undetected except by these methods suggests the

comparison with a chart of results. This is true, for example, with voice ataxia. The peculiar waves that are found in all cases are never present in any other condition. An inscription with such waves automatically gives a diagnosis of laryngeal hyposynergia, leaving to the physician the further decision whether the case is one of disseminated sclerosis, cerebellar lesion, Friedreich's disease, etc. Great value arises from two facts: (1) that the diagnosis is infallible, and (2) that it can be made when no alteration in the voice can be detected by the ear. Of interest is the fact that the presence of such waves in an inscription often prevents an erroneous diagnosis.

The greatest value of speech inscriptions lies in their application to the study of the mechanism of the nervous system. Only a few suggestions can be made here. The first step is to introduce accurate notions and terminology in place of the present confusion. In the preceding account the term 'taxia' has been applied to the regular condition of the movement resulting from the activity and the term 'synergia' to the muscular action itself. Hypotaxic inscriptions result from hyposynergic muscular activity. It is certain that hypotaxic inscriptions may result from hyposynergia arising from lesions at various levels. It is not yet possible to make any final statements; it can only be said that the inscriptions already obtained indicate the possibility of disturbances of synergia in the centres on the floor of the fourth ventricle, in the cerebellum and perhaps in various nuclei. A further step is the investigation of the nervous mechanism itself. The statement that hyposynergia is due to disturbed action of the nerve-cells is not enough. It may be possible to determine the nature of this interaction.

REFERENCES.

For other studies of laryngeal ataxia by speech inscriptions: SCRIPTURE, "Records of speech in disseminated sclerosis," *Brain*, 1916, xxxix, 455; SCRIPTURE, "Grundbegriffe der Sprachneurologie," *Archiv für Psychiatrie*, 1924, lxxii, 223; SCRIPTURE, "Sprachneurologische Mitteilungen," *Archiv für Psychiatrie*, 1930, lxxxix, 828; JANVRIN, "Experimentalphonetische Beobachtungen über die Ataxie," *Zeitschrift für Experimentalphonetik* (in press).

For detailed instructions concerning the making of speech inscriptions: SCRIPTURE, *Anwendung der graphischen Methode auf Sprache und Gesang*, Leipzig, 1928; JANVRIN, "Die Herstellung von Sprachinschriften," *Zeitschrift für Experimentalphonetik*, 1930, i, 1.

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