

## Translation of Broca's 1865 Report

### Localization of Speech in the Third Left Frontal Convolution

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• Modern texts continue to cite Broca's 1861 study of a single patient, Tan, as the first definitive localization of a cerebral function, specifically, articulate speech. We describe the development of Broca's theory from his initial support in 1861 for Bouillaud's view that speech is localized in *both* frontal lobes to his description in 1865 of a center for articulate speech in the third left frontal convolution. We have translated Broca's 1865 French report. Despite the revival of "classical" anatomically based concepts of discrete aphasic syndromes, numerous clinicoanatomical correlation studies have failed to confirm the specific language impairment described by Broca. Broca's own descriptions of language development in the third right frontal convolution following left hemisphere damage also raise questions about the validity of theories of brain-behavior relationships based on punctate localization of specific mental functions.

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Modern texts continue to cite Broca's initial 1861 report of the patient Tan as evidence of his localization of a center for speech motor functions in the pars triangularis of the third left frontal convolution. Although a departure from Flourens' prevailing antilocalization, antiphrenology views, the 1861 report represented only the first step in the evolution of Broca's eventual localization of a center for articulate speech in only one cerebral hemisphere.

In the February 1861 meeting of the Anthropological Society, Broca, in the tradition of Flourens, was holding forth on the relationship between

brain volume and intelligence.<sup>2</sup> In rebuttal, Aubertin cited his father-in-law Bouillaud's studies and repeated claims that speech was localized in the frontal lobes. Aubertin's rebuttal prompted Broca's challenge on April 12 that should the patient Tan not have the specified frontal lesion, would Aubertin then forever renounce his father-in-law's doctrine? Aubertin demurred and insisted on first examining the patient. However, after examining Tan and confirming the loss of speech, Aubertin accepted Broca's challenge. Tan, assuring his place in history, died on April 17. Broca performed the autopsy and, while noting widespread cerebral disease and considerable loss of brain substance, he declared, "The loss of speech... was a consequence of a lesion of one of the frontal lobes."<sup>1(p71)</sup>

Broca concluded, "Our observation confirms thus the opinion of Mr Bouillaud, who places in these [the frontal] lobes the seat of the faculty of articulate speech."<sup>1(p71)</sup> Although he acknowledged Bouillaud's precedence, Broca observed:

The principle of localization by convolution is not yet firmly established.... It is a much more doubtful question to decide whether the faculty of articulate language depends on the whole frontal lobe or specially on one of its convolutions; in other words, to know whether the localization of cerebral faculties takes place by faculty and convolution or by groups of convolutions. In order to solve this problem, further observations must be collected.<sup>1(p72)</sup>

In the same report, Broca introduced the term *aphémie* to describe the loss of articulate speech (subsequently described as expressive aphasia). Broca wrote:

The general faculty of language persists in these patients... the oratory apparatus is intact... they have all their intelli-

gence... the patients understand completely articulate and written language... those who can write... bring their ideas well on paper. What is lost, therefore, is not the faculty of language, is not the memory of the words nor the action of the nerves and of muscles of phonation and articulation. It is a particular faculty considered by Mr Bouillaud to be the faculty to coordinate the movements that belong to the articulate language, or, simpler, it is the faculty of articulate language; for without it, no articulation is possible.<sup>1(pp51-52)</sup>

In 1863, Broca described over 25 patients with *aphémie*, all with lesions of the left hemisphere and all but one with pathologic involvement including the third left frontal convolution. Although Broca had just converted to Bouillaud's thesis, the accumulating findings prompted Broca to consider whether the faculty of speech was localized not in both frontal lobes but specifically in the third left frontal convolution. Broca cited Parrot's report of a patient with a lesion in the third *right* frontal convolution without *aphémie* as a requisite "counter-proof" to support his refinement of Bouillaud's concept.

Responding to Broca, one of the discussants, Laborde,<sup>3(p386)</sup> stated that he found it difficult to admit that two parts of the same organ, whose situations, size, and detailed anatomical structures were absolutely identical and symmetrical, could have completely different functions.<sup>3(p386)</sup> Laborde pointed out that such an admission "would imply a serious exception to the law of organic duality and functional unity." Earlier, Bouillaud had applied this "law" in support of his localization of speech in both frontal lobes.

Thus, Laborde's dissenting voice reflected a growing constituency, which now included even Flourens, who accepted Bouillaud's symmetrical

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model. Broca also struggled to reconcile the contradictory findings reported in Charcot's *aphémique* patient. Broca had been present at the autopsy and was stunned when both frontal lobes proved to be intact. Instead of in the third left frontal convolution, the lesion was located in the left parietal lobe adjacent to the Sylvian fissure. Broca wondered if he should modify his theory.<sup>4</sup>

Thus, in attempting to gain acceptance of his new theory, Broca had to overcome and redirect the growing support for Bouillaud's doctrine. Ironically, it was Broca's initial studies that gave credence to Bouillaud's theory, which had languished in the anti-localizationist atmosphere that prevailed after Gall's phrenology fell out of fashion.

Broca also had to reconcile the exceptional findings in Charcot's patient. During the discussion of the Parrot case, Broca first noted that loss of speech alone was not sufficient to establish the diagnosis of *aphémie*.

He then suggested that this case might also be explained if "the seat of articulate speech, instead of being exclusively localized in the posterior part of the third frontal convolution, did not also extend to the outer parietal convolution, which is directly contiguous with it."<sup>5(p383)</sup>

Despite the counterproof of the Parrot case, Broca could not readily dismiss Charcot's case and was not ready to directly challenge the "law" of organic duality and functional unity. Thus, in 1863, Broca again emphasized the need for further evidence before the validity of his claim could be confirmed.

A year later, at a meeting of the Surgical Society of Paris, Broca presented Duval's<sup>6</sup> description of two patients with traumatic *aphémie*, both with left-sided head injuries. Broca again pointed to the mounting evidence for exclusive localization of speech in the left hemisphere and again called for more confirmatory findings.

Numerous observations gathered during the last three years have a tendency to indicate that lesions of the left hemisphere are solely susceptible for causing *aphémie*. This proposition is no doubt strange, but however perplexing it may be for physiology, it must be accepted if subsequent findings continue to indicate the same viewpoint.<sup>7(p53)</sup>

In their review of *La Naissance de la Neuropsychologie du Langage*, the late French neuropsychologist Hécaen and his colleague Dubois<sup>8</sup> included Broca's historic 1865 paper. It is in this report that, for the first time, Broca finally localized the motor speech center in the third left frontal convolution and declared, "*Nous parlons avec l'hémisphère gauche.*"<sup>9(p114)</sup> In rendering our English translation of Broca's 1865 report reprinted by two of his compatriots, Hécaen and Dubois, we have included their evaluation and comments over a century later.

#### 'ON THE SITE OF THE FACULTY OF ARTICULATED SPEECH' BY PAUL BROCA

The subject of the localization of the faculty of articulated speech, which I ask your leave to discuss for a little while, has for the last few months given rise in the Academy of Medicine and in the medical press to a lengthy discussion, which is not yet concluded and in which I was personally implicated. As I was away from Paris during the greater part of this discussion, I kept up with it from afar and in an inadequate fashion. It appeared to me that my opinions were not exactly represented; however, these almost personal points would have little interest to you. Moreover, it would not be fair to start here a debate that is still stirred up elsewhere. Therefore, I will confine myself to disclose here, without discussion, my point of view on one of the most peculiar items of this complex issue.

During the sessions of April 2 and 7, 1863, I reported ten observations of *aphémie* in which diverse lesions in the third frontal convolution were found at autopsy. Since then, similar events came to my own attention, and many observers have reported a good number of such cases. It was suggested that some of these cases appear to be contradictory. I shall perhaps get back to this particular matter some other time. I must say that the contradictions that came to my scrutiny were far from being as conclusive as they seemed to be in the first place;

on the contrary, all of them seemed to me subject to controversy, so that I persist in thinking, until further details are available, that true *aphémie*, that is, the loss of speech without the paralysis of the organs of articulation and without the destruction of the intellect, is linked to lesions of the third left frontal convolution. But this is not what I had intended to discuss here. My disclosure is relative to the singular partiality of lesions of *aphémie* for the left hemisphere of the brain.

You remember, no doubt, that in all the cases I mentioned in 1863, the lesion was located on the left. I remarked on this fact without coming to any conclusions (*Bulletin de la Société d'Anthropologie* 1863;4:202), and I added that, before groping for the implications of a finding so strange, one has to wait for new findings.

Since then the facts have presented themselves in great numbers, and almost all have pointed in the same direction. Those cases in which the lesion of *aphémie* was found to be on the right have been rare exceptions. Further, it has been observed that in a great number of living *aphémiques*, there existed a paralysis of the right side, which was unequivocal proof of the existence of a lesion in the left hemisphere. (As you know, the action of the brain is crossed.)

On the other hand, deep lesions of

the third frontal convolution in the right hemisphere were found in the autopsy of persons who were in no way *aphémiques*. Some of these observations were even published with a view to proving that the third convolution is not the organ of speech. But these observations actually corroborate my opinion, since I had localized the capacity of speech in the left third frontal convolution and not the right one.

Since I reported this peculiarity, the son of Mr Dax has forwarded a memorandum to the Academy of Medicine in which he indicated that his father had long since recognized that the lesions which destroy the faculty of speech were always localized in the left hemisphere of the brain. Mr Dax had even recorded the result of his observations on the subject in a paper that was read at the Congrès Méridional de Montpellier in 1836. This handwritten paper was discovered by the son of Mr Dax, who featured it in his recent memorandum to the Academy.

I do not like the discussions of priority, and I would have avoided indicating that the discovery of Mr Dax, unpublished as it was, was a nonevent from the viewpoint of history, if several people had not given me to understand that I ought to have cited the opinion of Mr Dax (the father), when I, in turn, pointed out the special influence of the left hemisphere of the

brain on the faculty of speech. I do not wish to let you believe any longer that I have sinned through ignorance or by voluntary omission. The existence of Mr Dax's dissertation, before it was mentioned to me by his son, was as unknown at Montpellier as it was in Paris. After having vainly searched in all the newspapers of 1836 for any trace of this paper, I asked Mr Gordon, librarian of the faculty of Montpellier, to conduct a little inquiry into this matter. Mr Gordon has not been more fortunate than I. The Congrès Méridional held its third session at Montpellier from July 1 through July 10, 1836. No papers were published and there remains no trace of its minutes. The Congrès had Professor Ribes as its presiding officer and Dr Trinquier as its secretary. The newspaper, *La Revue de Montpellier* (1836, vol 2, pp 51-53) published an outline relative to the subjects of medical philosophy that were taken up during the Congrès. However, the question of language is not mentioned here. Mr Gordon has personally questioned 20 doctors who were at Montpellier at the time. He learned that they were not aware that the memoir in question was read at the Congrès or published somewhere. Such is the information that I was able to gather. However, I am not prepared to challenge the authenticity of this paper. It would not have been impossible that the paper, although it was prepared for the Congrès, was not presented there. But I wish to establish that it was impossible for me to guess the existence of a paper that was brought to light two years after my first publications on the subject of *aphémie*.

I will deal now with the theoretical difficulties that arise from the fact of the special influence of the left hemisphere on articulated speech—and probably also on speech in general.

Highly intensive statistical studies conducted by various authors and particularly by two doctors of the Salpêtrière Hospital, Messrs Charcot and Vulpian, have determined that in general the diseases of the right hemisphere are as frequent as those of the left hemisphere; yet, nevertheless, the vast majority of *aphémiques*, perhaps nineteen twentieths, exhibit a lesion in the left hemisphere.

Is there then a functional difference between the two halves of the encephalon? If this proposition should be accepted, it would disrupt our understanding of physiology. It is well known that the two hemispheres of the brain are perfectly similar; if the cerebral convolutions present slight

and incidental variations from person to person, there are none that are appreciable from one side of the encephalon to the other. Now there is one physiologic law, which everywhere else [in the body] is without exception, namely, that two organs that are equal and symmetrical have the same attributes, and it would be quite strange that this law should present here a marked exception. Most certainly, observation is superior to theories, and sometimes one must yield before a fact, however inexplicable and paradoxical it would seem to appear to us. But before making such a sacrifice, one must see if this fact would not be susceptible to reconciliation with the general truth that it appears to contradict. This is what I will attempt to do for the particular case which concerns us. To do this, I will proceed from the simple to the complex, and I will deal first with the motor functions of the encephalon.

A great many mechanical actions are controlled mainly or even exclusively by the left hemisphere of the brain. There are a certain number of left-handed individuals everywhere, but almost all men are right-handed. Whence comes that preference accorded to the right hand? No doubt, education and imitation contribute greatly to that preference. It would be worthy to note that in functions that are complex and subtle, which require long and altogether special training, such as writing, drawing, and playing most musical instruments, the division of labor between the two hands is always the same, with left-handed as with right-handed individuals. But in this division, the most difficult part, that which requires the greatest ability, precision, expression, or strength, briefly, that is to say, the preponderant part, is very generally assigned to the right hand, and if we could say that this usage has come to us from our forefathers, it must be admitted that the originators must have been guided in their choice by causes linked to the organization itself. If, in effect, we put aside action that requires special training, if we consider only those that we carry out spontaneously, such as throwing a ball, hitting with our fists, handling a stick, or lifting a weight, we find that with the exception of a very small number of persons, designated as left-handed, everybody naturally uses their right hand to which the left hand is nothing but the auxiliary.

Will it be said that this is a phenomenon of imitation? But then how

is it that all the people (sic) are right-handed, even those who never seemed to have any communication with the others? If it was chance that had determined the choice of the right hand, we would have certainly discovered left-handed peoples. The polygenists will admit it as well, since they recognize that the separation of certain human groups goes back to an era prior to the invention of the most rudimentary arts. Besides, there is a circumstance that does not permit us to attribute the choice of the right hand to imitation: it is that everywhere there are some individuals who despite all their efforts, all their perseverances, remain left-handed. For such people, one is bound to admit the existence of an organic predisposition, which is inverse, against which imitation and even education cannot prevail.

This organic predisposition is further revealed in the unequal strength of the two hands. Experiments conducted with a dynamometer disclose that with right-handed individuals the right hand is much stronger than the left hand. The difference is considerable; generally, it varies between one fourth and one third of the pressure strength of the right hand. If this inequality was prevalent only with manual workers, we might suppose that it is the result of their profession and attribute it to the well-known fact that exercise develops muscular strength; but this inequality is as much pronounced with men devoted to intellectual professions.

Finally, our late colleague, Gratiot, had pointed out a finding, which was recalled a few months ago by Mr Bertillon and very recently by Mr Baillarger in his address to the Academy: it is that in the development of the brain the convolutions of the left hemisphere are developed earlier than those of the right hemisphere. The former are already apparent at a time when the latter are not yet discernible. The left hemisphere, which controls the movement of the right extremities, is therefore more precocious in its development than the opposite hemisphere. Therefore, one understands why, from the early days of life, the young infant shows preference for the extremities with the more perfect innervation, why, in other terms, he becomes right-handed. The superior right extremity, being originally stronger and more adroit than the left, is called on by this very fact to function more often; and from that time, the young infant acquires a superiority of strength and dexterity,

which increases with age.

Heretofore, I have designated right-handed persons as those who preferably use their right hand and left-handers as those who preferably use their left hand. These impressions are derived from the external manifestations of the phenomenon, but if we should consider the phenomenon with regard to the brain and not in relation to its mechanical agents, we would say that most men are naturally "left-brained" and that, by exception, some of them, those called left-handed, are, on the contrary, right-brained.

I proceed now to the much more complex phenomena of articulated language. I will leave out all that which concerns the articulation itself, a phenomenon that is purely muscular, and also the motor function, which, starting from the cerebral organs that are involved in movement, is transmitted via the intermediary of the motor nerves to the muscles of the tongue, lips, soft palate, etc. Articulation depends on the two cerebral hemispheres, since it is brought out simultaneously and uniformly by the muscles of both sides, associated in their movements.

But it is not in the muscles, motor nerves, or the cerebral motor organs, such as the optic striata or the corpus striatum, where the essential phenomenon of articulate speech actually resides. If one had nothing but these organs, no one would talk. They exist sometimes perfectly healthy and perfectly formed in individuals who have become completely speechless or in idiots who never could learn or understand any language. This articulated speech depends on the part of the encephalon linked to intellectual phenomena and of which the cerebral motor organs are, as it were, just the agents. Now, this function of the intellectual order, which controls the dynamic element as well as the mechanical element of articulation, seems to be the nearly constant privilege of the left hemisphere convolutions, since lesions that result in *aphémie* are almost always localized in that hemisphere.

That is tantamount to saying that we are left-brained with regard to language and also for actions that are much simpler and cruder, which I will discuss below. Just as we control movements in writing, drawing, embroidering, etc., with the left hemisphere, so we speak with the left hemisphere. It is a habit we acquire in our early childhood. Articulate speech is perhaps the most difficult of all things that we are obliged to learn.

Our other faculties, our other actions exist, at least in rudimentary state in animals, but, although animals have certain ideas, and although they know how to transmit them by a true language, articulate speech is beyond their reach. It is this complex and difficult thing that the child must learn at a most tender age, and he manages to succeed after long, tentative efforts and following cerebral efforts of the most complicated degree. Well! This cerebral exercise is imposed on him at an age very close to these embryonic periods in which the development of the left hemisphere takes place before the right hemisphere. Consequently, we are not reluctant to admit that the more developed and precocious cerebral hemisphere should be, rather than the other, in a fit state to guide the execution and coordination of actions, which are both intellectual and muscular and which constitute articulate speech. The tendency to speak with the left hemisphere is thus born, and this disposition ends up by being so well a part of our nature that, when we are deprived of the functions of that hemisphere, we lose our capacity to make ourselves understood by the spoken word. This does not mean to say that the left hemisphere is the exclusive center of the general capacity of language, which consists of establishing a determined relationship between an idea and a sign, nor even of the special capacity of articulate speech, which consists of establishing a determined relationship between an idea and an articulate word. The right hemisphere is no more a stranger than the left hemisphere to this special faculty, and the proof is that the person rendered speech disabled through a deep and extensive lesion of the left hemisphere is, in general, deprived only of the faculty to reproduce the sounds of articulate speech; he continues to understand what one says to him, and consequently, he understands perfectly the connection between ideas and words. In other words, the capacity to conceive these connections belongs to both hemispheres, and these can, in the case of a malady, reciprocally substitute for each other; however, the faculty to express them by means of coordinated movements, in which the practice requires a very long period of training, appears to belong to but one hemisphere, which is almost always the left hemisphere.

Now, just as there are left-handed individuals, in whom the native preeminence of motor functions of the

right hemisphere bestows a natural and irreversible preeminence to functions of the left hand, in like manner, we conceive that there could be a certain number of persons in whom the native preeminence of right-hemisphere convolutions will reverse the order of phenomena that I have detailed; with these individuals, the capacity to coordinate the movements of articulate speech will become the definitive preference of the right hemisphere, in keeping with a habit acquired from early childhood.

With respect to language, these exceptional people will be comparable to what left-handed individuals are with regard to the functions of the left hand. Both of these groups will become "right-brained." But I do not wish to conclude that there must be coincidence between these two categories of exceptions, for it does not seem to me by any means necessary that the motor part and the intellectual part of each hemisphere should be responsible for one another, considering the precocity of their respective development in the two hemispheres.

The existence of a small number of people who, by exception, are able to speak with the right hemisphere would explain very well the exceptional cases in which *aphémie* is the result of a lesion in that hemisphere.

It follows from the preceding that a patient whose normal center of articulate speech, namely, the third left frontal convolution, was atrophied from birth, would learn to speak and would continue to speak with the third right frontal convolution, as a child who was born without a right hand would become as capable with the left hand as one would ordinarily be with the other.

Without a doubt, that is how one must explain a remarkable case that was observed last year at Salpêtrière Hospital in the department of Mr Moreau from Tours. It was observed that during the autopsy of a 47-year-old patient, epileptic from a very early age, that the third left frontal convolution was lacking, along with the inferior parietal convolution and the superior temporosphenoidal convolution. In other words, one noted the absence of the entire part of the left hemisphere bordering on the fissure of Sylvius, which constitutes, in the nomenclature of Mr Foville, the convolution that encloses the fissure. Yet this patient was not *aphémique*, and she should have been if the third left convolution had been the exclusive and constant site of the faculty for the coordination of the articulation of

words. Furthermore, the missing parts had not been destroyed as a result of a disease. It was easy to recognize that these parts were never developed; in effect, the location of the convolution was occupied by a little, sinuous fold that was as large as rat gut and which exhibited exactly the normal connection and the relationships of the convolution. This then was a case of congenital atrophy, a real arrest of development, which was due perhaps to the congenital absence of the left sylvian artery, of which no trace could be detected. The remainder of the left hemisphere appeared to be healthy, but it was far from normal because all of its components, the convolutions as well as the striated body, the optical striata, and the peduncle were much less voluminous than the corresponding parts of the right hemisphere. They weighed 540 g without the membranes, whereas the other weighed only 297 g. The 243-g difference appears all the more considerable, as the entire encephalon with membranes weighed 1045 g. Therefore, it is no wonder that the functions of the left hemisphere were imperfect. The two extremities of the right side were very weak and showed only a dull sensibility; furthermore, they were less long and voluminous than those of the opposite side. The almost useless right hand was bent at the forearm, and there was an obvious lameness in the walk. This anatomical and functional disparity of the two halves of the body was evidently the consequence of the congenital disparity of the two halves of the brain, and the proof of this was that in the face, where the nerves originate over the intersection of the bulb and where the innervation is consequently direct and not crossed, the atrophy of the flesh and the skeleton showed up only on the right side.

No doubt, the intellect must have been affected from the defective condition of the brain. But the invalid was by no means an imbecile. She had received only a very rudimentary education. Nevertheless, she could read, keep herself busy with works of her trade, and by the way, she served with her left hand; finally, she spoke fairly well and expressed her ideas without difficulty.

This fact led me to ponder. The opinions that I submit to you today had already come to my mind, but they were not yet set. During the course of my study of brains of *aphémiques*, many times before, I had determined that the lesion of the third left frontal convolution was not

always in direct relation to the intensity and the impairment of language. For example, I had observed that speech was completely wiped out as a result of a lesion with a size of 8 to 10 mm, whereas, in other cases, lesions that were tenfold more extensive had only partly impaired the capacity for articulate speech.

I had already concluded that, in all probability, both hemispheres collaborated in language and could more or less substitute for each other according to the conditions, although the third frontal convolution of the left hemisphere was the principal site of the function. But this was the first time that I noted that this convolution of the language was lacking, *in all its extent*, in a non-*aphémique* subject. Here, it was perfectly evident that the third right convolution had compensated for the absence of the left. And I asked myself immediately, how it was that this did not occur in all cases of *aphémie*.

Actually, it seemed that, if the two hemispheres contribute to the function of language, a lesion in only one hemisphere would not be enough to cause *aphémie*. Just as one can see with one eye, hear with one ear, so one should be able to speak with one hemisphere. Even admitting that the left hemisphere plays a preponderant role in articulate speech (and it is impossible to deny this evidence), it seems that the right hemisphere, when healthy, must always assume the function of speech instead of the left hemisphere that has become powerless because of a lesion. For example, that is why with a man who has lost his right arm the left hand acquires a great dexterity and even manages to write. How is it, then, that the person who has become *aphémique* through a partial or total destruction of the third left frontal convolution cannot learn to speak with the right hemisphere?

To this query, I will answer that the man who lost an arm preserves all the integrity of his intellect, while in most *aphémiques* there exists more or less extensive lesions, which result in notable damage without abolishing intellect. When the lesion is very circumscribed, it could be that language is affected and the intellect remains intact, that is, at least as much as we can judge; I have observed such a case that was quite decisive. These facts clearly demonstrate that the faculty of speech is entirely independent of other cerebral capacities; but such cases are rare. More often, the anatomical change is of an extent consid-

erable enough to cause serious impairment to the properly so-called intellect. It follows that most *aphémiques* have weakened minds, and this condition prevents them from learning to speak exclusively with the right hemisphere, which up to now had played only an accessory role in the function of expression by means of articulated speech.

Then, how do we know that the *aphémique* is not capable of learning to speak with the remaining right hemisphere? Have we tried to train him? Have we given him lessons at all days, hours, moments, by which aid a child is made to speak in the long run? As far as I am concerned, I am convinced that considerable results can be obtained with restoring to *aphémiques* the part of their intellect that perished with a part of their brain. These results can be achieved by exercising sufficient perseverance, by treating them with the tireless patience of the mother who teaches her son how to speak.

When I was at Bicêtre, I kept in my wards an *aphémique* for several months. During visitations, I would often spend a few minutes with him, and in that manner I was able to notably expand his vocabulary. But what is a lesson that is so short? Do you think a child would make much progress if he was made to speak only a few moments daily? And in this connection, do not believe that the education of an adult would be easier than that of a child; on the contrary, it is much more difficult. There are things that you can never learn well beyond a certain age. A case in point is the movements of writing, although they are guided by the eye and consequently infinitely less automatic than the movements of articulation. A person who has lost his right arm will learn to write with the left hand. But his writing will never acquire the precision, the firmness, the quickness that it possessed before; and a person who is awkward with his speech, as that person is with his writing, will be looked on as an *aphémique*. It is not only a question of muscular agility; it is probable that the adult and child follow different procedures to reach the goal. The child restricts himself to imitation; he utters a sound haphazardly until he finds the sound that is asked of him—and he starts again compliantly as often as we desire.

The adult does not have that patience; he cannot disregard what he knows or what he believes he knows; he discusses the process; instead of complying naively, he seeks in himself

the ways and means; and the knowledge he already possesses, far from bringing him help, on the contrary, prevents him from profiting from the practical lessons that are given to him. For example, it is much more difficult for him to express himself in a foreign language than it is for an adolescent, because the system of pronunciation for the two languages is essentially different. Often, it is altogether impossible for him to learn to pronounce certain consonants.

With respect to the *aphémique* who was under treatment at the Bicêtre Hospital, which I mentioned earlier, that patient was deprived not only of spoken language but also of written language. No wonder he could no longer write, *since his right hand was paralyzed* (italics added); but he no longer knew how to read; he did not even know the letters of the alphabet. I handed him an alphabet and for a while tried to make him spell. He soon managed to identify all the letters. Then we asked him to put the letters together, and we began to have him do that to form syllables. After a few lessons, he got to know a good number of syllables; for example, when we asked him to point out with his finger the syllables, *ba, pa, co, mo*, etc, he was seldom wrong. I thought then that the time had arrived to have him put together the syllables, but here I failed completely. Nevertheless, I did not give up the idea to have him read words of several syllables. I tried then to show him these words without breaking them up into syllables, and I succeeded in teaching him a good number of them, but I soon realized that he did not recognize them through their syllables or letters. It was only their general form, their length, their appearance that registered; and, for example, when we changed one or two letters within a word, by replacing them with letters of the same length, as *m* for *u*, *e* for *s*, *p* for *q*, *l* for *t*, he did not even notice it. In other words, he could recognize a word as one would a face or landscape, the details of which had never been analyzed. It was clear, therefore, that this *aphémique* was learning to read through a process that was essentially different from that he went through during his youth.

Thus, the common failure in efforts to get the *aphémique* to speak does not prove that the healthy hemisphere is unable to compensate for the hemisphere that is defective. For example, I am convinced that a lesion of the third left frontal convolution, which is enough to cause a definitive

*aphémie* in an adult, will not prevent a young boy from learning to speak. In all probability, the epileptic patient in the wards of Mr Moreau was able to speak although she was, since birth, deprived not only of the third left frontal convolution but also of all parts of the great convolution of the region of the fissure of Sylvius. She was like those individuals who are born without arms and who learn to write, to sew, [and] to paint with their feet. Never could an adult, after losing his arms, achieve such a similar outcome. It is important to recall that this woman was left-handed. The left hemisphere being inadequate, it was with the right hemisphere and, hence, with the left hand that she developed the ability to work as well as to speak.

In summary, the two halves of the encephalon, being perfectly identical from an anatomical point of view, cannot have different functions, but the more precocious development of the left hemisphere makes us prone, in our first groping ways, to execute with that half of the brain the manual and intellectual actions that are most complex. Among such actions, one must certainly include the expression of ideas by means of language and, more particularly, articulate speech. Far be it from me to think of dividing man into two distinct beings, as was done in another point of view by Meinard Simon du Pui in his paper entitled "de Homine dextro et sinistro" (Leyden, 1780). The habit we develop from our early childhood to allot work between the two hemispheres and to preferably assign the most difficult operations to the left hemisphere, ends up becoming second nature. But this specialization of functions does not imply the existence of a functional disparity between the two halves of the encephalon.

#### REVIEW BY EDITORS HÉCAEN AND DUBOIS

The report of 1865 is in all respects more important than that of 1861. It is neither because P. Broca points out his priority on the works of Dax (senior), nor that he confirms the localization of articulated speech, always differentiated from the intellect, in the third frontal convolution, but because he crossed a landmark in the history of that localization and that he implies a new orientation in the functional study of the two hemispheres.

1. On the basis of these cases and those that were made available to him during all the years of debates

between 1861 and 1865, P. Broca concludes that articulated speech is localized in the third frontal convolution of the left hemisphere. This prevailing characteristic is inferred not only from verified anatomical cases but also by the reciprocal fact, namely, that patients with lesions of the third frontal convolution of the right hemisphere were not subject to *aphémie*.

2. P. Broca strives to link this functional difference of the two hemispheres to hand dominance. It appears to him that the fact that mankind is right-handed does not stem from acquired customs but from a universal fact, in time and space, leading to an ontogenic proof (the convolutions of the left hemisphere develop more rapidly than those of the right). The fact that left-handed people are much fewer in number would vouch for manual dominance. With a twofold argument, P. Broca then takes up the question of the cerebral localization.

(1) If there exists a manual dominance, would there not be also a functional difference between the two hemispheres; are there not right-handed and left-handed persons with regard to the brain and is that difference related to right- and left-handedness with respect to the hand? In other words, is there a relationship between the cerebral and manual dominance?

(2) Once this functional difference is established, could each hemisphere not compensate for the other in a function that was destroyed?

3. After having ascertained that articulate speech is located on the left side, P. Broca justifies the cases of right-sided *aphémie* either by congenital atrophy (speech being then supported by the right hemisphere) or by the fact that the person must have been right-brained. But why do such compensations not take place in all cases of left-sided lesions? With the necessary terminologic transposition, the arguments put forth by Mr Broca are always worthy.

(1) Extensive lesions of the left hemisphere could bring about an impairment of the intellect, independent of the articulation of speech.

(2) Compensation is easier in young children than in adults, as is demonstrated by the different capacities to learn a foreign language.

(3) Intensive efforts at reeducation of *aphémiques* have never been undertaken. P. Broca cites his particular experience to affirm that he was able to obtain some improvement with some *aphémiques*—learning of forgot-



ten words or verbal sounds, of writing, pronunciation of syllables. Once the functional differences of the two hemispheres are recognized and global function of the brain affirmed by the phenomenon of compensation, P. Broca states, there is no obvious correlation between cerebral and manual dominance.

4. It is interesting to note that as far back as that time, the very idea that reeducation should be conducted not in accordance with the processes of learning language but in accordance with different strategies. His observations on the way his patient relearns to write constitute a model of penetrating insight and, beyond the

phenomenon itself (reading through the form or shape of the entire word and not by the knowledge of written verbal signs), suggests another question, The functional compensation by the other hemisphere presents superficial analogies, but is this not a profound difference in the method itself that the language was relearned?

#### COMMENT

Although a facile writer and eloquent speaker, like most investigators, Broca was a prisoner of his time and the prevailing zeitgeist. For example, Gardner, cited by Critchley,<sup>7(p136)</sup> pointed out that "in 1871, Paul Broca, a French neurologist with a broad skull, wrote five volumes to prove that the broader the head, the better the brain and that the French had particularly broad heads." Broca also applied the "science" of craniometrics to "prove" the intellectual superiority of men over women as well as the white races over blacks.<sup>8</sup>

Broca denied interest in establishing priority. Yet he conducted extensive inquiries attempting to show that Marc Dax's 1836 paper describing the association of motor aphasia with left-sided lesions had never been presented or published. Dax died a year later in 1837, and the paper was belatedly published in 1865 by his son Gustav Dax.<sup>9,10</sup>

The initial impact of Broca's localization of speech based on meager studies of a few aged patients with extensive cerebrovascular disease was enormous. In a review of aphasia studies and language theory in the 19th century, Marx<sup>11(p147)</sup> noted that von Monakow listed over 3000 papers on aphasia in his bibliography, described as "mostly highly inadequate studies."

Economy and focus preclude review of the voluminous subsequent literature, the contemporary and historical controversies on the nature of aphasic language disturbances, and so-called classical anatomically based differentiations of presumably discrete aphasic syndromes according to the specific sites of circumscribed lesions within the "language zone" of the left hemisphere. However, in view of these persisting 19th century concepts, it is important to point out that Broca had indicated the role of the right hemisphere in comprehension of speech as well as in reorganization of speech in children and adults following destruction of "Broca's area."<sup>6</sup>

Despite the recent resurrection of

the "classical" views of discrete localization of speech in the third left frontal convolution by Geschwind<sup>12</sup> and others, numerous studies have questioned the validity of Broca's clinicoanatomical inferences. Broca had argued, "If... it were demonstrated that the lesions which abolish the speech constantly occupy the same convolution, then one could hardly help the admission that this convolution is the seat of the faculty of articulate language."<sup>11(p153)</sup>

Broca's contemporary, Jackson, agreed that the left hemisphere played a leading role in speech. However, he maintained that no hypothesis of the integrative functions of the cortex could be built on "abrupt geographical localizations."<sup>13(p120)</sup> Moreover, Jackson pointed out that "to locate the damage which destroys speech, and to locate speech are two different things."<sup>14(p51)</sup>

Subsequently, in an 1891 monograph, *On Aphasia*, a young neurologist, Sigmund Freud,<sup>15(p105)</sup> reflected Jackson's views, "It appears to us... that the significance of the factor of localization for aphasia has been overrated, and that we should be well advised once again to concern ourselves with the functional states of the apparatus of speech." Marx<sup>16</sup> observed that although Freud's monograph on aphasia was limited by the absence of a "neurophysiology" on which he could draw, Freud had pointed out the illogicality of constructing an anatomical model on the basis of a psychologic concept, thus identifying one of the major fallacies inherent in the principal psychophysical formulations of the time.

After sharply criticizing the growing claims of localization of discrete functions in cortical mosaic centers by Broca, Wernicke, and others, Freud<sup>15(p104)</sup> concluded, "I have endeavored to demolish a convenient and attractive theory of the aphasias, and having succeeded in this, I have been able to put into its place something less obvious and less complete." Thus, it is not surprising that in the famous

1868 Jackson-Broca debate in London, Jackson's dynamic but "less obvious and complete" view was rejected in favor of the simpler mosaic model, which Broca so eloquently espoused.<sup>17</sup>

Jackson's views never achieved the widespread acceptance of Broca's. However, Walshe<sup>13(p120)</sup> noted that Jackson's views "have been kept alive... primarily because of their correspondence with so many of the facts of clinical experience."

At the turn of the century, the validity of Broca's claims was again challenged, this time by a compatriot, Pierre Marie.<sup>18</sup> Based on clinicoanatomical studies of over 50 aphasic adults, Marie presented evidence contradicting Broca's widely accepted conclusions. In his 1906 report titled "The Third Left Frontal Convolution Plays No Special Role in the Function of Language," Marie, also an eloquent speaker, wrote:

Such is my concept of aphasia based on facts observed without any preconceived notion, without intervention of any hypothesis. However different this may be from the classical doctrine, I have the conviction that this conception is the truth. Moreover, this conviction is corroborated by the fact that a part of the evidence which I give has been verified in passing by different authors; to the contrary, this opinion surprised some observers who are just as distinguished. The authors did not know how to separate themselves from the pernicious influence which is always excited by doctrines considered as classical. These doctrines are seen as facts; they are not interpreted with enough independence of spirit. Certainly, the famous motto of Montaigne "What do I know?" ought to be practiced by each person. And when it is a question of dogmas, whatever their nature, established or transmitted by men who have gone before, is it not just to apply to these men, fallible as we ourselves are, and yet more ignorant, the same motto, and to ask one's self: "What did they know?"<sup>11(p147-70)</sup>

Marie, as did Jackson, concluded that previously described presumably discrete syndromes of aphasia reflected varying manifestations of a defect in the basic process underlying

all language functions. Thus, Marie declared, "Aphasia is one." He also emphasized the difference between aphasia and anarthria and pointed out:

The only notable difference between the aphasia of Wernicke and the aphasia of Broca is that in the first patients speak more or less badly, while in the second they do not speak at all . . . the aphasia of Broca is none other than aphasia complicated by anarthria.<sup>18(p3)</sup>

Our continuing follow-up studies<sup>19</sup> since 1972 of over 400 chronically aphasic patients with comprehensive neuropsychologic, audiologic, and language assessments showing varying degrees of deficits in all four language modalities are strikingly consistent with Jackson's earlier views and Marie's<sup>18</sup> subsequent report that "aphasia is one." Broca defined *aphémie* as an isolated defect in articulate speech with preservation of reading, comprehension, writing, memory, and intelligence. However, as Head<sup>20</sup> pointed out, Broca had never tested writing. In describing the patient Tan, for example, Broca noted that he could not write due to paralysis of the right hand.

Marie pointed out that the specific disorder Broca described as *aphémie*, consisting of loss of articulation of

language, with sparing of reading, writing, comprehension, memory, and intelligence, is more consistent with severe dysarthria and/or oral apraxia than what is currently described as Broca's aphasia.

Consistent with Marie, Mohr<sup>21</sup> reviewed numerous studies contradicting Broca's claims. Mettler's<sup>22</sup> more recent, remarkable, but often overlooked studies revealed consistent absence of speech disturbances following psychosurgical lesions, which included destruction of Broca's area.

The enormous proliferation of experimental animal and clinical studies focusing on definitions of brain structure-function relationships have failed to provide support for the classical concepts of punctate localization of cerebral functions. Citing Lashley's<sup>23(p386)</sup> similar views, Sherrington<sup>24</sup> observed:

To suppose that the roof brain consists of point to point centres identified each with a particular item of intelligent concrete behavior is a scheme oversimplified and to be abandoned. Rather . . . the contribution, which the roof brain, in collaboration with the rest of the brain and spinal cord, makes toward integrative behavior will, when they are ultimately analyzed, resolve into components for which we at present have no names, having no such conception of such processes.

Despite his limitations, Broca, as did Marie, recognized "the superiority of facts over theories." Thus, however reluctantly, he finally rejected two long-established concepts of cerebral function. As a result of his autopsy findings in the patient Tan, he eventually disposed of Flourens' doctrine of cerebral equipotentiality. With the accumulation of additional cases, Broca finally rejected Bouillaud's application of the "law" of functional unity and organic duality to human brain functions.

Despite remarkable advances in neurologic, radiologic, and other diagnostic techniques in the 120 years since Broca localized articulate speech in the third left frontal convolution, current concepts and attempts to elucidate brain-behavior relationships remain controversial. As in Broca's time, concepts of brain function tend to take on the authority of fact when cited in medical textbooks. Broca, Marie, and others have demonstrated that prevailing theories and accepted doctrines must be periodically reexamined. They await correction and refinement by those who will heed the following admonition (K. Goldstein, MD, oral communication, 1953): "If the patient doesn't agree with the book, throw the book away; the patient can never be wrong."

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