Introduction[1]

It is noteworthy the remarkable divergence between the conceptions of the physiology of the nervous system and those of brain pathology, due to the lack of physiological basis of the current brain theory, based on an anatomical criterion.

The brain-injured cases presented here are totally incompatible with the brain theory currently in use in brain pathology. By studying the phenomena in detail, this research has spontaneously led to a strictly physiological conception. Thus, the whole pathological process has been understood on the basis of very simple conceptions and laws of nervous excitability, within the laws of the general physiology of the nervous system. Phenomena that at first seemed exceptional and unacceptable in brain pathology, duly studied, become the general rule of brain functioning in man, these phenomena constituting an *experimentum crucis* that has determined the basis of brain activity.

Establishing a fundamental concept through a few cases is justified when the analysis of these cases has been deep enough to get to the roots of the issue. According to the theory of localization of brain functions, the character of each pathological case depends entirely on the specific site –damaged by the lesion– that houses a given function. However, when the physiological laws governing the general functioning of the brain are established, we see that in different cases, the different pathological manifestations are variants of a general type differing from each other quantitatively, and a gradual transition from one case to another can be observed. The discovery of the phenomena of dynamic action in the cases presented here (modifications of brain excitability by subordination and repercussion

[1] Considering here the two volumes as a whole and in order to avoid some repetitions, this introduction is a synthesis of the following original texts written by the author: preface and introduction at the beginning of Vol. 1 (1945) and preface and final Note of Vol. 2 (1950). Such final Note is a summary of the research carried out up to 1950. Yet, sections 1-3 of Vol. 1 provide a detailed introduction to this research and its meaning. In addition, a summary of the research contained in these two volumes is given in sections 1-6 of the 1952 article (Supplement I).

effects, asynchronism, summation actions, etc.) entails such an essential change that it leads to the establishment of a new conception of brain theory. This conception is *brain dynamics*, in which the functional unity resulting from the interrelation of the whole brain mass is crucial. Moreover, the singular dynamic conditions of nervous excitability, originated by a brain injury, open the way to the experimental method, which is the only way to properly address the mechanism of brain functions and their quantitative evaluation by determining the level of excitability of each brain process.

The dynamic conception constitutes a physiological conception. The static conception hardly leaves the simply anatomical approach. The physiological conception is broader and simpler than the anatomical one. The latter, rightly considered, is only valid for a small number of cases of a given type and, even then, only as a first approximation. For many other cases it is insufficient, its generalization being an abuse of the relationship between a given function and the anatomical structure that presumably houses it. Such a relationship is extremely complex and problematic, and could only be established in extreme cases. The transition from a static to a dynamic conception, i.e., from topographical anatomical consideration to physiological functional understanding by changes in nervous excitability in the brain, falls within the natural development of sciences, where purely static explanations must give way to functional or dynamic ones.

Within the back and forth that the scientific process sometimes presents, old ideas that have already been discarded regain relevance, and thus the ideas of Flourens (1824) on brain activity might now be rehabilitated. These ideas propose the functional unity of the cerebral cortex, which implies a firm opposition to anatomical localizations as in the phrenology of his time. However, no conception is completely excluded in the course of scientific development. Different theories are rather constructions based on incomplete observations and extreme views of a same thing. Rather than an absolute return to old doctrines already forgotten, it is matter of considering them under new and more precise aspects of a more general scope. The problem of brain localization, which has almost completely dominated brain theory, has always given rise to numerous discussions, considerably exacerbated over time. Thus, numerous authors from very diverse sectors have expressed their opposition to the anatomical criterion of brain localization and in favor of the functional or dynamic point of view, such as Bethe and Fischer (1931), Monakow (1914 a, 1914 b), Head (1918, 1920, 1923), Goldstein (1910), Stein (1928, 1930), Weizsäcker (1923, 1931), Lashley (1929, 1933, 1937) etc., among the most significant up to the time of presenting this research. But it should also be noted that on the side of the supporters of localization we have the great work of Kleist (1934), of the purest orthodox character as regards anatomical localizations and construction of brain maps. This proves that this is not such an easy question to resolve. A brain theory of functional character, opposed to the localizations, was developed by Jackson (1884) when studying the evolution and dissolution of the nervous system. The fact is that a sufficiently clear and coherent solution has never been reached. It should be noted that Goldstein (1910), known for his profound analyses of brain functions and his justified and important arguments against the anatomical theory of localiza-

tion, has missed the exceptional opportunity presented to him in one of his patients to provide compelling arguments, as will be analyzed here.

The two most notable features of the localization theory, the specific centers and the nosological syndromes, both the result of anatomical and psychological "atomism," are not capable of giving a correct interpretation of known facts. If we add to this the dynamic manifestations found in our cases, which force a functional and physiological interpretation, the classical traditional theory remains, at best, very insufficient. In the brain dynamics that we shall describe, brain activity constitutes a functional unit in which there is no room for autonomies, since cortical lesions affect the entire brain system, according to certain laws of nervous organization.

As for the structure of sensory activities and the nervous mechanism underlying them, the traditional classical theory always refers to the principle of the specificities of the centers which, by themselves or by their associations, account for all types of structures. The result is the primary and secondary identifications of Wernicke (1874, 1895), the associative disorders such as agnosia, aphasia, apraxia, etc., as a means of explaining the alteration of the most complex brain functions. On the other hand, in some studies that focus more on the functional analysis of symptoms, there is a tendency to consider sensory activity as the result of a progressive differentiation without resorting to any kind of associations. However, nothing is indicated regarding the conditions of the nervous mechanism that performs such differentiation.

The task of dealing with sensory organization in its two aspects, phenomenological and physiological, fills the major part of the research presented here, and probably constitutes the most original contribution together with the theory of the dynamic brain system, evidenced by the type of overall repercussion of the lesions.

With regard to the nervous mechanism in brain activity, the notion of isochronism of Lapicque (1934 a) is applied with great benefit. Within the physiological conception, a pathological alteration only results in a reduction or simplification of the brain function, i.e., a lower level of organization due to a lower synchronization, but still governed by the same laws of nervous excitability. The difference between normal and pathological thus results from purely quantitative variations. The dynamic conception of the brain presented here aims to unify and synthesize aspects belonging to disciplines such as brain pathology, sensory physiology, experimental psychology, etc., on the common basis of nervous physiology.

An attempt has been made here to establish brain activity in man on a physiological basis, thus filling the important gap hitherto existing between brain pathology and the physiology of the nervous system.

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The development of the research presented in these two volumes has been carried out without interruption over more than ten years. A simplified chronology of some of the findings is as follows:

In 1938, inverted vision was observed in patient M and clinical data was obtained on him. The important dynamic action phenomena (excitability, asynchrony,

facilitation and repercussion) were found in 1939. In 1941, an unpublished communication was presented to the Spanish National Research Council [Consejo Superior de Investigaciones Científicas],[2] where important experiments, the principle of *magnitude and position* of the lesion, and fundamental concepts of brain dynamics are exposed, all of which systematically developed in the present book. Progress was relatively rapid at the beguinning; subsequently, it has been slow and laborious, given the multifaceted nature of the topic. Experimental work from 1942 onwards took much longer than expected, both because of the extent and complexity of the issues, and because of the difficulty of obtaining the most indispensable experimental instruments. In 1942, the effect of the magnitude of the lesion was verified on patient T, and greater quantitative precision was obtained in various phenomena (excitability curves) in M and in T. This led to the characterization of the *central syndrome,* which presents a bilateral and symmetrical disorder. In 1943, the recruitment logarithmic curve was determined for visual image orientation, extending the Fechner-type law to sensory pathological phenomena. In 1944, the effect of binocularity was measured by means of visual image orientation curves, important for understanding summation effect by different facilitations. Curves for touch and hearing were determined, and some cases of *paracentral syndrome* (asymmetric disturbance) were studied. In 1945 the problems of tactile space were addressed, and in 1946 both tactile inversion and auditory inversion were discovered in patient M. Systematic research on spatial inversion led to the formulation in 1947 of a *spiral development* of the sensory field. In 1948 concepts such as residual field, sensory dimensions, functional growth, etc., were introduced.

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The first volume presents some fundamental findings as well as general concepts of brain dynamics, followed by the systematic study of visual functions on the new basis.[3] A multitude of pathological phenomena, many of them new, as inverted or tilted vision, are analyzed for the first time on the basis of nervous excitability (excitability level, asynchrony, facilitation, summations, etc.), supported by quantitative determinations of intensity-duration excitability curves as well as those of sensory recruitment, which complement each other. The starting point is the dynamic action phenomena in nervous excitability, thus providing a simple and unified interpretation of our two cases, M and T, and the discussed Schneider case of Goldstein and Gelb (1918, 1919). These cases belong to the central syndrome characterized here, whereas for the usual theory they constitute limit cases that are im-

[2] As mentioned in a footnote in the Preface, Justo Gonzalo submitted in 1941 a 95-page report to the Spanish National Research Council [Consejo Superior de Investigaciones Científicas] entitled: *Investigaciones sobre Dinámica Cerebral. La acción dinámica en el sistema nervioso. Estructuras sensoriales por sincronización cerebral* [Investigations on Brain Dynamics. Dynamic action in the nervous system. Sensory structures by brain synchronization].

[3] At the beginning of the part devoted to *Sensory Dynamics* (first visual and then tactile), J. Gonzalo states that the research described is original, and whenever a precedent exists, it is duly indicated.

possible to resolve. On the other hand, the most typical syndromes of brain localization theory are considered in the brain dynamics here exposed as limiting cases (marginal syndromes) compared to the central syndrome. In them, rather than cortical lesion of gray mass, there is a lesion of projection pathways. The various syndromes that are usually described in more central cortical areas would instead belong to some extent to the more or less pure central syndrome. The effects of a cortical lesion depend on its magnitude and position. A sensory system is always altered as a whole when a cortical lesion is involved, but if the magnitude of the lesion is small, it may falsely seem, on an inaccurate examination, that only the most superior activity (gnostic type) is involved.

The second volume, on tactile functions, deepens on several general issues and, above all, initiates a new theoretical stage in the brain dynamics presented here by considering spatial inversion at the center of the sensory organization. The research, as in Vol. 1, is original (see footnote 3), the most relevant topics to the new conception being *tactile space* and perceived *tactile orientation,* with the findings on tactile localization phenomena and tactile space inversion. New dynamical concepts are stablished, such as sensory dimensions (intensity, space and time) dependent on the active brain mass (i.e., on the magnitude of the lesion), residual sensory field where the dimensions are reduced, functional individuality derived from organization, central action, functional growth by brain recruitment, etc. All this together with the generalization of inverted perception (in touch and hearing) has led to establish a principle of *spiral development* of the sensory field, susceptible to account for all kinds of pathological sensory phenomena. Inversion is related to the anatomical configuration, whereas size and re-inversion (organization) are related to brain mass, to functionality. The sensory organization presents a development as a whole from which the various functions arise by differentiation. Therefore, it is necessary to focus on the degree of differentiation (functional level) of the sensory system, which can be properly expressed by the dimensions of the sensory field. Between mere sensory function and gnostic activity there is a continuity over the same pattern of organization, and therefore gnosis (or schema function) is determined by the dimensions of the field.

Finally, we would agree with Priestley (1777), who already in his time stated that physics should be applied to the nervous system.

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We are grateful to the Cajal Institute for funding this work since 1942.