Luciani, Luigi

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Luigi Luciani and the Localisation of Brain Functions

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Luigi Luciani (Figure 1) was born in Ascoli Piceno, Italy on 23 November 1840. After completing his secondary school studies from 1860 to 1862, he devoted himself as an amateur to politics, literature and above all to philosophy. At the end of 1862 he moved to Bologna, where he studied the history of medicine and disease with De Meis. He then completed his medical studies, obtaining a degree there in 1868. From 1868 until 1874 he worked as assistant professor at the Physiological Laboratory with Luigi Vella, a pupil of Claude Bernard, who gave him the idea to practice physiological research in close connection with pathology, a distinguishing feature of Bernard's method. In the meantime, from March 1872 to November 1873, he worked at the Physiological Institute of Ludwig in Leipzig and attended the Congress of Physicians and Naturalists in 1872.

Figure 1: Luciani with his students.

The period he spent in Leipzig had a profound influence on Luciani's experimental and scientific thinking; he always recognized in Ludwig his "real master". In Ludwig's laboratory Luciani performed a series of experiments on the isolated heart of the frog; he discovered the so-called 'Luciani phenomenon', and published the results of his research into autonomous cardiac activity in the article *Eine periodische Function des isolirten froscherzens* (Luciani, 1873).

Upon returning to Italy he devoted himself to university teaching and research in physiology: first in Bologna and Parma – from 1873 to 1879 – where he worked with Augusto Tamburini and Giuseppe Seppilli on the localization of brain functions and on epilepsy (Tamburini, 1876; Luciani and Tamburini, 1878, 1879; Seppilli, 1881; Luciani and Seppilli, 1885). Later he was in Siena – from 1880 to 1882 – then in Florence, from 1882 to 1893, where he succeeded Schiff as director of the Institute of Physiology. In Florence he selected the best pupils in his laboratory and founded a school of skilled experimental physiologists foremost among whom was Silvestro Baglioni, who was to succeed Luciani as head of the physiology department at the University of Rome. It was during his stay in Florence that he carried out his famous studies on the physiology of the cerebellum (Figure 2).

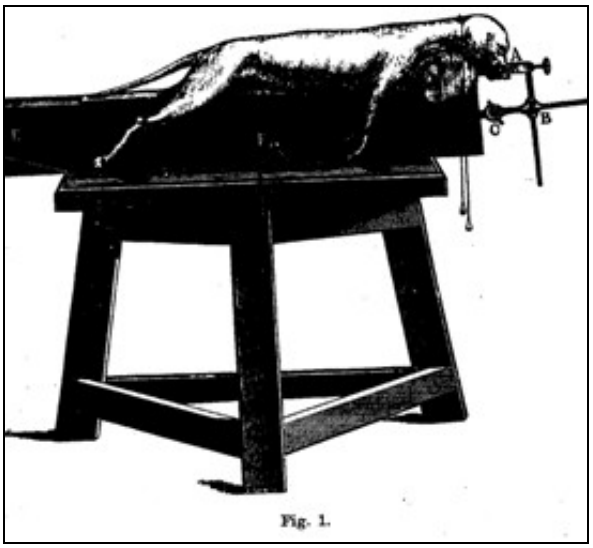

Figure 2: A special table devised by Luciani to do experimental research on the brain of the dog.

In 1893 he was appointed Professor of Physiology and Director of the Physiology Institute at the University of Rome, where he succeeded J. Moleschott. In Rome he worked until 1917 and published his best-known work, the classical treatise on human physiology (Luciani, 1901), which had no less than six editions in Italy and has been translated into Spanish, German, English and Russian.

Luciani died in Rome on 23 June 1919, after having held numerous and prestigious public offices: from 1895 he was a member of the Reale Accademia dei Lincei, which awarded him its highest honour, the 'Premio reale', for his *Cerebellar Physiology* (Luciani, 1891). In 1902 he became a member of the Societa Italiana delle Scienze detta dei XL; in 1905 he was nominated Senator of the Reign. He was Rector at the University of Rome in 1898-9; he also was member of some of the most prestigious academies in Italy and abroad (among these, the Leopold-Caroline Academy, the Royal Medical Academy of Belgium, The Viennese Medical Society, The Academy of Science of Gőttingen, and above all the Royal Society of London).

In 1885 Luigi Luciani published, in collaboration with Giuseppe Seppilli, *Le localizzazioni funzionali del cervello* (Functional Localisations in the Brain), a book rich in epistemological reflections, historical information, experimental data and critical evaluations, because the authors wished to make their scientific knowledge available to a vast public without oversimplifying or distorting its historical and theoretical import (Luciani and Seppilli, 1885). The central part of the book contains a comparison of the most recent findings in cerebral localisations and on the function of the nervous system in general, findings that had been obtained in the most advanced European research centres of the second half of the nineteenth century (Figure 3). It includes results of Luciani's experiments first performed in Reggio Emilia and then later in Florence. In addition to Luciani's section on experiments and physiology, Seppilli – a doctor at the lunatic asylum in Reggio Emilia – wrote a section on clinical medicine, drawing a sweeping picture of all the most recent medical literature on the subject as well as providing a series of hitherto unpublished clinical case studies.

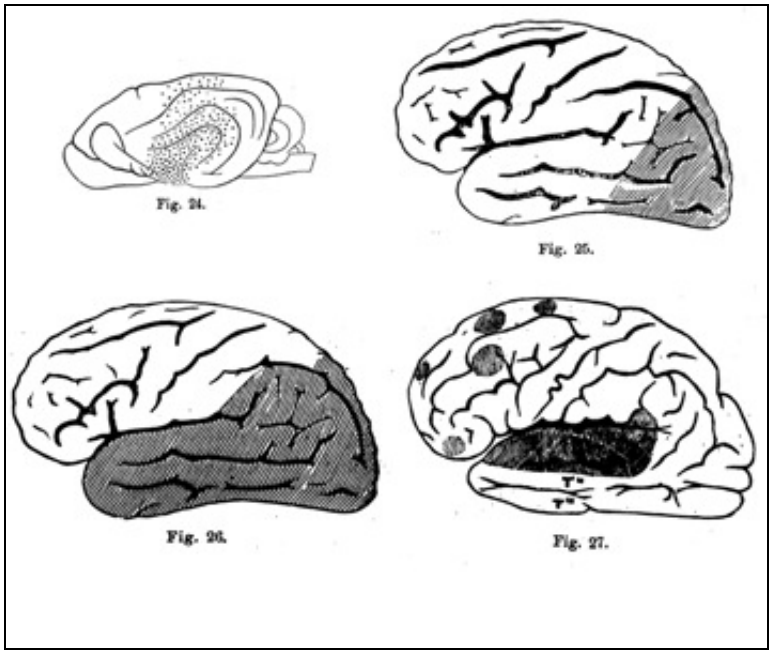

Figure 3: Diagrams illustrating specific areas of experimental intervention or damaged areas taken from clinical practice. The numbers are the same in the original edition of Luciani and Seppilli book on cerebral localizations, *Le localizzazioni funzionali del cervello* (1885).

Luciani begins by applauding the "happy rebirth of studies on the cerebral cortex", which came in the wake of Fritsch and Hitzig's discovery (Fritsch and Hitzig, 1870). Yet he adds that recent work published in Germany, above all by Goltz (1881) and Munk (1881) "have confused thinking on cerebral localisation". Describing the experiments of Goltz, which the German physiologist had interpreted from an anti-localisationistic standpoint, Luciani shows how profoundly aware he is of that critical moment when a scientist makes an interpretation; this is also true for his own experiments, which "are in harmony with those of Goltz", even though they have been interpreted differently and guided by diametrically opposed theories. Luciani clearly states how important theory is for the interpretation of facts; even prior to this, theory affects the very choice of the methods that will be adopted. In a certain sense theory and method go hand in hand in creating data.

He proceeds to set out the terms of the problem according to which "once a certain part of the cerebral cortex has been destroyed or excited either through experiment or disease, the task is to determine and compare the effects which result on the individual senses and movements". Thus, once he has posited an experimental methodology that is largely the same as that used in the rest of Europe (electric stimulation by means of Faraday current, destruction by cauterisation or by means of a water jet, ablation), Luciani is extremely careful when observing and interpreting the phenomena that result from experimental intervention. "It is very difficult to distinguish between effects which are truly related to the absence of function in the destroyed part (deficiency phenomena, or in Goltz's terminology Ausfallserscheinungen or paralytic phenomena) which also change gradually, and those effects which represent a functional disturbance of the surviving centres caused by the trauma and the disease process which follows (collateral or irritative phenomena, Nebenwirkungen in the words of Wernicke)" (p. 3).

There is a period in which the latter should be expected to disappear and only the deficiency phenomena should remain. But when does the transition occur between the first and the second period? Moreover, it is difficult to determine a phase in which all the irritative or collateral effects have completely disappeared while only the deficiency or paralytic phenomena fully persist without any degree of attenuation. As time passes, the very distinction between transitory and permanent phenomena becomes blurred: careful observation reveals that all phenomena change over time. In the wake of lesions that are not very extensive, both types of phenomena recede until it becomes difficult to distinguish an animal that has been operated on from an intact one. On the other hand, after extensive bilateral lesions, collateral phenomena "sometimes diminish and sometimes increase

progressively" during the animal's life.

According to Luciani, it is above all in the calculation of this variable that the greatest differences in theoretical approach arise: Goltz (1881), for example, emphasised the importance of collateral effects (thus providing a more homogeneous and drastic picture of phenomena that follow experimental intervention), and he underestimated the importance of gradual compensation "because he was concerned with extending the individual functions to the entire brain" (p. 10). In the majority of cases, however, phenomena are more complex and more variable than Goltz had maintained, and more than Ferrier (1876) had affirmed.

Luciani's model was sharply characterised by this concept of variability, which was connected to the idea of collateral effects and compensation. It is necessary to observe carefully the *entire course* of the disturbances that follow experiments and conduct the observations according to "a code of inductive logic applied to the experimental research on the functions of nervous centres" (p. 21). Establishing logical criteria that can serve as a basis and constructing firm epistemological foundations for reflection on methods and procedures are therefore the most important requirements for a thorough and precise observation.

After the methodological and epistemological premises Luciani provides a summary of the main experimental results obtained by the most famous researchers in Europe. The essential reference material is Ferrier's functional topography. He then goes on to describe his own experiments, which, besides definitively proving functional localisation in the brains of monkeys, also add a series of new elements that aid in clarifying a situation rendered confusing by divergent opinions. Luciani runs rapidly through the different experimental work that came after Fritsch and Hitzig, when scientists attempted to determine the functional significance of the so-called 'excitable zone'. He divides these experimenters into two essentially opposed groups: the first is represented by Fritsch, Hitzig and Ferrier, who held that the excitable zone mediated exclusively motor functions; the second current of opinion, whose leading exponent was Schiff, held that this zone was also exclusively sensory and that it basically included sensory fibres of the skin and muscles.

Alongside these contradictory theories, Luciani offered his own "conciliatory doctrine", which may be defined as 'sensory-motor' in that it supported the idea of a 'mixed' nature of the so-called motor cortical centres. Agreeing with Jackson and Ferrier, Luciani invokes the concept of corticalisation in order to explain interspecific variability in functional recovery. Paralytic effects that follow ablation have varying degrees of intensity in different mammals and compensation is inversely proportional to the level the organism occupies on the animal scale. In addition to this, if we take the study of reactions to electric stimulation of different points on the anterior cortex (the method used by Fritsch, Hitzig, and Ferrier), together with that of partial excisions (adopted by Munk), a partial diffusion of effects is always observed and therefore a localisation not easily circumscribed within the centres of the excitable zone. This may be explained by the *gear model* and by the partial confusion of individual cortical centres. "(I suggest) this concept of the gears of the visual centre intermeshing with other centres of the cortex, it does not have *sharply and precisely delimited* confines but the confines are vague and between the centre and periphery there is a *partial confusion* with neighbouring centres" (p. 153).

From these words the conceptual structure of his thinking – his reference paradigm – becomes clear: the association model of nervous and psychic functions. Interlocking gears between different centres (although they may be to a greater or lesser extent localisable) therefore correspond physically and anatomically to Luciani's associationistic assumptions. Association as a mechanism to explain nervous and psychic functioning has its physical substratum in the material organisation of the cortex that reveals on its surface different sensorial spheres that are partially overlapping. On the other hand, nervous functions and psychic functions are conceived in a rigorously parallelistic fashion. The paradigm is the same that Ferrier used to plan, perform and interpret his studies. Luciani, however, modifies it in order to reconcile the interpretation of his own results, which were based on more careful and rigorous experimental procedures and antiseptic measures; in fact, the survival time of the animals on which he had operated was much longer than for the animals used by Ferrier (which generally lived only a few days after the operation: all the experiments performed by Ferrier in 1873-6 were done without adopting

antiseptic measures). Luciani was able to construct his model for the functioning of the brain precisely because he had based his work on survival times that were long enough to allow him a more prolonged observation of more or less extensive functional recovery. Thus he was able to introduce a temporal variable as well, his model being essentially based on the capacity for compensation.

As for the general idea of localisation, Luciani put forward his 'intermediate doctrine' against the two opposing theories on whether single cortical segments could be differentiated or not. Luciani stated that of the first theory (Ferrier's) that what was true was that functional localisation really existed because it had been clearly demonstrated by experiment that different segments of the cortex had different functional natures; with regard to the second theory (Goltz's), however, it was also true that these different functions pertained to the cortex as a whole and were closely interconnected. "Each functional sphere has a territory of its own and territories in common with neighbouring spheres. The territory which is proper to it is the central focus and corresponds approximately to the cortical areas which react to electric stimulation producing movements executed by peripheral organs influenced by the excited region; on the other hand, the territories which are common to more than one functional centre represent the irradiation zone of those very centres. Thus there is a mutual interaction, a gear, and their partial confusion or overlapping" (p. 347).

The gear represents something different from a mere mutual interaction. There are functionally specialised centres which, being different from one another, are nevertheless closely connected spatially (anatomically) and temporally because they are all active in performing a certain function. Jackson (1884) had made use of a metaphor that was essentially sociological so as to give a sense to this cooperation. Spencer had referred to the functioning of the brain in terms of division of labour between different zones (terms themselves derived from sociology). Luciani adopted his technical metaphors and expressed his essentially positivistic *weltanschaung*, superimposing over the brain's anatomical and physiological organisation an image taken from mechanical engineering, that of the gear, which performs a certain function by means of the differentiated activation of specific centres.

The existence of functionally specialised centres - which are at the same time diffused and yet closely connected one with the other within the context of a specific functional zone, the sensory-motor area - is at the centre of Luciani's brain theory. This model contributed to the debate over the motor or sensory nature of the so-called excitable zone (this was the term used by Fritsch and Hitzig, 'motor' in Ferrier's terminology and 'sensory' for Schiff). It also suggested a 'mixed' sensory-motor nature based on the co-existence, in the anterior part of the brain, of closely interconnected though perfectly differentiated motor and sensory centres. Furthermore, this co-presence had been proven experimentally and clinically. Finally, even in the case of the localisation of different sensory centres, Luciani proposes his interpretations of experimental data as a 'mediation' between those researchers who wanted credit for having determined an exact localisation (in the case of vision, for example, this was between Ferrier and Munk).

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