Marie-Jean-Pierre Flourens (1794–1867) and Cortical Localization

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Abstract

The child prodigy Marie-Jean-Pierre Flourens received his medical degree at Montpellier when aged 19. As a young promising physician Flourens was asked to investigate Gall's controversial views on cerebral localization. To test Gall's assertions, Flourens developed ablation as a procedure to explore the workings of the brain. By removing anatomically defined areas of the brain of an animal and watching its behaviour, he thought he might localize certain functions. Flourens did not favour the idea of cerebral localization and concluded that the brain functioned as a whole and thus arose the concept of 'cerebral equipotentiality'. This culminated in his 1824 *Recherches expérimentales sur les propriétés et les fonctions du système nerveux*. His techniques were, however, crude and imperfect, and his experiments were mainly on birds. Much criticism and debate ensued. A gifted man, Flourens also advanced the physiology of the vestibular apparatus and described the anaesthetic properties of ether.

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Born on 15 April 1794, in Maureilhan, near Béziers, France, Marie-Jean-Pierre Flourens (fig. 1) was something of a child prodigy. He enrolled at the famed Faculté de Médecine at Montpellier when he was only 15

Fig. 1. Marie-Jean-Pierre Flourens (1794–1867).

years old and received his medical degree aged 19. Shortly thereafter, while Franz Gall (1758–1828) was at the height of his career in Paris, Flourens himself moved to the capital and under Georges Cuvier started to investigate brain functions and localization [1]. Gall's work was questioned in some circles, and the Paris Academy of Sciences, acting on order of the Emperor Bonaparte, asked Flourens to investigate the matter. On the basis of his 1824 *Recherches expérimentales sur les propriétés et les fonctions du système nerveux* [2], he was elected to membership and eventually on Cuvier's dying request was ap-

Fig. 2. Flourens's *Recherches expérimentales ...*, 1824.

pointed Perpetual Secretary of the Académie des Sciences, to become one of France's most revered scientists (fig. 2).

Before Flourens began his animal experiments, Gall had developed relatively new ideas of brain function [3], which proved important:

'that the cerebral cortex represented the highest level of the brain and that the development of this area characterised mammals and man.'

He tried to analyze and localize cerebral functions physiologically. His work moved 'away from the concept of the insubstantial Cartesian soul to the concept of more material nerve function', and in doing so 'was wrong only in detail and in respect of the enthusiasm of its supporters' [4]. His later ideas of phrenology [5] brought much of his work into disrepute, and physicians neglected his earlier significant advances. Nevertheless, as Edwin Boring wrote: 'The theory of Gall and Spurzheim is ... an instance of a theory which, while essentially wrong, was just enough right to further scientific thought' [6]. To test Gall's assertions, Flourens developed ablation as a procedure to explore the workings of the brain. By removing anatomically defined areas of the brain of an animal and watching its behaviour, he thought he might localize cer-

tain functions. For example, by removal of the cerebellum, the animal could no longer coordinate movements. In 1823, he stated that the cerebellum regulates motor activity and a year later provided details of his ablation experiments on birds and lower vertebrates to study behaviour. By making discrete lesions in the medulla, near the posterior ventricle, he reported (cited in Changeux, p. 16, [7]):

'he disturbed certain vital functions, such as respiration.'

Flourens did not favour the idea of cerebral localization and concluded that the brain functioned as a whole when he wrote:

'a large section of the cerebral lobes can be removed without loss of function. As more is removed, all functions weaken and gradually disappear. Thus the cerebral lobes operate in unison for the full exercise of their functions ... The cerebral cortex functioned as an indivisible whole ... [housing] an "essentially single faculty" of perception, judgement and will ... the last refuge of the soul' (Flourens, cited by Changeux, p. 17, [7]).

However, Flourens's experimental technique was not accurate, and his behavioural studies were both crude and rudimentary for the adequate investigation of the faculties recently catalogued by Gall and Johann Spurzheim (1776–1832). Flourens related loss of function to the extent of damage. However, he adopted a holistic concept, with an understanding that the brain was composed of areas of specific functions, but specific areas interacted to work as a whole:

'All sensations, all perceptions, and all volition occupy concurrently the same seat in these organs. The faculty of sensation, perception, and volition is then essentially one faculty' [2].

Thus arose the concept of 'cerebral equipotentiality'.

While previous researchers had lesioned the brain through a trephine that made it impossible to localize damage accurately or to track haemorrhage, Flourens completely uncovered and isolated that portion of the brain to be removed. He tried to minimize operative trauma and post-operative bleeding and infection which might confound analysis. His ablation experiments led him to conclude the presence of a motor centre in the medulla oblongata and coordination in the cerebellum. Although his treatment of sensation was still rather confused, by the time the second edition of the *Recherches expérimentales* (1842) appeared, Flourens had clearly distinguished sensation and perception, treating perception as the appreciation of the meaning of a sensation. He thought that several sub-cortical structures were responsible for sensory function. However, his slicing of the hemispheres produced diffuse damage with resulting im-

pairments of varied degree involving perception, intellect and will. The resulting damage varied with the extent of the lesion. After small lesions function might be restored, but total ablation caused permanent loss of function. Flourens concluded that while sensory-motor functions were localized to sub-cortical structures, higher mental processes were represented diffusely in the brain, all working as one.

Gall and Flourens were vehemently opposed to each other's work and ideas. Gall noted that Flourens's procedure 'mutilates all the organs at once, weakens them all, extirpates them all at the same time'. In fact, ablation by successive slices was a poor technique for demonstrating cortical localization and he was rightly reluctant to deduce general conclusions from lower organisms to primates and man. Flourens [8] attacked Gall's efforts at localization and in contrast founded his theory of cerebral homogeneity that anticipated Lashley's [9] much later concept of mass action and cortical equipotentiality. However, Flourens did concede that Gall had adduced detailed evidence of correlation between function and structure within the brain, and had established that the brain was the organ of mind. This was to be Gall's most important contribution.

Further Developments

Clinical localization was propounded by Jean-Baptiste Bouillaud (1796–1881) [10] and Auburtin [11]. The psychological studies both of Alexander Bain and Herbert Spencer influenced the many advances of Hughlings Jackson.

Precise localization remained, however, in dispute. On 4 April 1861, the Société d'Anthropologie held a meeting. Paul Broca [12, 13] provided his now famous communication, which related partial destruction of the left frontal lobe to aphasia (aphemia) [14]. Jackson developed the concept that motor and sensory functions must be represented in an organized, hierarchical fashion. Fritsch and Hitzig, in 1870, showed in the dog that circumscribed cortical areas controlled movements of the contralateral limbs and that ablation caused weakness. Their findings confirmed the clinical localization of motor function. Testing Jackson's notions, David Ferrier [15] used both ablation and electrical stimulation to produce topographical localization of function in several species. Published in his acclaimed *The Functions of the Brain*, Ferrier [16] had thereby mapped sensory and motor areas across several species, thus expanding

both understanding and localization of movement and sensation [17].

A celebrated debate in 1875 at the Société de Biologie in Paris between Charcot and Brown-Séquard illustrated the controversies of the day [18]. Charcot held an anatomical approach to localization of function. He relied on human pathological material primarily from isolated cerebral hematomas to establish the role of the cortex and subcortical white matter fibre tracts to motor and sensory function. By contrast, Brown-Séquard held a physiologist's opinions, which disagreed fundamentally, arguing that since the brain consisted of complex networks, isolated lesions had no direct bearing on the localization of cerebral function. Though Brown-Séquard's approach was to be vital in the evolving 20th-century concepts of brain function, it is generally agreed that in 1875, Charcot won the debate.

In 1909, Korbinian Brodmann [19], stimulated by Oskar Vogt, described the different cytoarchitectonic structure of the gyri and showed that the human cortex is organized anatomically in the same way in man and other mammals. Brodmann's discrete cortical areas [20] were, however, scorned with arguable justification by Henry Head.

Other Contributions

Flourens [21] made other discoveries. In 1825 he observed that when a pigeon's horizontal semi-circular canal was destroyed, the bird continued to turn in a circle, thus demonstrating the function of the vestibular labyrinth. He also showed that since destroying the medulla oblongata caused death of his animals, the medulla was responsible for circulation and breathing. In 1847, he described the anaesthetic properties of ether [22].

Amongst Flourens's pupils were Edmé Félix Alfred Vulpian (1826–1887) and Gabriel Gustav Valentin (1810–1883). In 1840 he was elected to the French Academy, in preference to Victor Hugo. In 1845 he was created a commander of the légion d'honneur, and in the following year a peer of France. With the revolution in 1848 he withdrew from political life and in 1855 accepted the Professorship of Natural History at the Collège de France. He died at Montgeron, near Paris, on 6 December 1867.

Appendix

Besides numerous shorter scientific works, Flourens published:

- Essai sur quelques points de la doctrine de la révulsion et de la dérivation (Montpellier, 1813)
- Expériences sur le système nerveux (Paris, 1825)
- Cours sur la génération, l'ovologie, et l'embryologie (1836)
- Analyse raisonnée des travaux de G. Cuvier (1841)
- Recherches sur le développement des os et des dents (1842)
- Anatomie générale de la peau et des membranes muqueuses (1843)
- Buffon, histoire de ses travaux et de ses idées (1844)

Fontenelle, ou de la philosophie moderne relativement aux sciences physiques (1847)

- Théorie expérimentale de la formation des os (1847)
- Œuvres complètes de Buffon (1853)
- De la longévité humaine et de la quantité de vie sur le globe (1854), numerous editions
- Histoire de la découverte de la circulation du sang (1854)
- Cours de physiologie comparée (1856)
- Recueil des éloges historiques (1856)
- De la vie et de l'intelligence (1858)
- De la raison, du génie, et de la folie (1861)
- Ontologie naturelle (1861)
- Examen du livre du M. Darwin sur l'Origine des Espèces (1864)

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