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Franz Joseph Gall on hemispheric symmetries

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ABSTRACT

Franz Joseph Gall believed that the two cerebral hemispheres are anatomically and functionally similar, so much so that one could substitute for the other following unilateral injuries. He presented this belief during the 1790s in his early public lectures in Vienna, when traveling through Europe between 1805 and 1807, and in the two sets of books he published after settling in France. Gall seemed to derive his ideas about laterality independently of French anatomist Marie François Xavier Bichat (1771–1802), who formulated his "law of symmetry" at about the same time. He would, however, later cite Bichat, whose ideas about mental derangement were different from his own and who also attempted to explain handedness, a subject on which Gall remained silent. The concept of cerebral symmetry would be displaced by mounting clinical evidence for the hemispheres being functionally different, but neither Gall nor Bichat would live to witness the advent of the concept of cerebral dominance.

KEYWORDS

Franz Joseph Gall; Marie François Xavier Bichat; Ludwig Friedrich von Froriep; Philip Franz von Walther; Christian Heinrich Ernst Bischoff; hemispheric differences; laterality; organology; phrenology; cerebral dominance

Prior to the nineteenth century, the prevailing view was that, in one way or another, the soul or mind controlled the brain through underlying structures, such as the ventricles or the pineal body and, at later times, brain stem areas or subcortical white matter. German-born anatomist Franz Joseph Gall (1758–1828) began to challenge these views late in the eighteenth century by studying such things as the brains and behaviors of humans and animals on the great chain of being, developmental landmarks, and individuals with brain damage (Finger and Eling 2019).

Gall's focus on the cortex resonated with many other physicians and anatomists, as did how he circumvented long-held metaphysical constructs and emphasized empiricism in his science (Ackerknecht and Vallois 1956; Finger and Eling 2019; Rawlings and Rossitch 1994). More controversial to his enlightened audiences was his claim of many independent cortical organs, each associated with a highly specific, "concrete" function (e.g., language, music)—that is, his organology. The latter began to take form early in the 1790s, when Gall listened to a five-year-old girl named Bianchi who, without training, could sing and memorize music exceptionally well, while appearing ordinary in every other trait (Eling, Finger, and Whitaker 2017). When he remembered how well some of his classmates with bulging eyes (presumably pushed outward by the growth of the underlying part of the brain) did when memorizing verbal material, his revolutionary theory linking faculties of mind, cortical areas, and cranial features was born.

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In 1796, Gall started lecturing on these ideas at his stately home in Vienna, where he used some of his funds as a physician to support his growing collection of skulls and casts, which focused on exceptional people (e.g., criminals, geniuses, and the insane) and animals. He continued to modify his list of faculties and their associated cortical organs, before settling on 27 faculties for humans, 19 shared with animals, these being what he presented in Paris, where he arrived in 1807 and settled.

Gall believed the faculties are duplicated, one on each side of the cerebral and cerebellar cortices (which housed a single faculty, reproductive drive). After all, the two sides of the brain look very much alike, even when one ascends the ladder of life, give or take small differences that seem inconsistent from one brain to the next when there is no evidence of disease. Even René Descartes (1596–1650) had written how he observed "the brain to be double" (Descartes 1649/1958, 275). Indeed, no one studying the gross anatomy of the brain during the eighteenth century had drawn sustained attention to hemispheric differences in healthy brains, although French physician and anatomist Vicq d'Azyr (1748–1794) had noticed some asymmetries. This remained the case when, in 1800, French anatomist Marie François Xavier Bichat (1771–1802) published the first edition of a book discussing, among other things, what would be called his "law of symmetry."

The attention given to Bichat in his own day and by later historians raises the question of whether Gall derived his ideas about brain symmetry from Bichat or was influenced by him when constructing his own doctrine. In an attempt to answer this question, we have examined what Gall said about both symmetry and Bichat in his early lectures, when presenting his anatomy and his revolutionary doctrine in Berlin in 1805, in his four-volume *Anatomie et Physiologie* of 1810–1819, and in his less-expensive *Sur les Fonctions* of 1825, which deviated in only minor ways from what he wrote in his "great work" (Gall and Spurzheim 1810-1819, 1825). In addition, we looked for what the two men wrote about handedness, as it too could be related to the concept of brain symmetry. We conclude this survey with some discoveries leading to the death of symmetry, a development neither Gall nor Bichat lived to witness.

Early accounts

Gall attracted enthusiastic audiences when he began lecturing at his home during the mid-1790s. Physicians, philosophers, government officials, clerics, students, writers, and others came to hear him. Some took extensive notes and reworked them into publications presenting Gall's doctrine with examples, evidence, and logic (Finger and Eling 2019). There is considerable similarity in the longer accounts, which follow how he covered the material in his courses.

Ludwig Heinrich Bojanus (1776–1827), who studied medicine at the University of Jena, provided one of these accounts. Bojanus had traveled to Vienna immediately after graduating, and he practiced in the General Hospital from 1797 to 1798, where he might have met Gall. He also attended Gall's lectures, taking copious notes that he published in 1801 (Bojanus 1801; see also Sakalauskaitė-Juodeikienė, Eling, and Finger 2017, 2020). His article shows that Gall mentioned hemispheric symmetry when discussing unilateral brain lesions. As stated in the 1802 English translation:

> It might be here objected, that in several cases individuals have lost a considerable portion of the substance of the brain without the faculties being sensibly diminished; but it is to be observed that the greater part of the cerebral organs exist double, and that the observations mentioned are not exact. (Bojanus 1802, 78)

German physician Ludwig Friedrich von Froriep (1779–1847; Figure 1) was another physician who attended Gall's lectures in Austria. After getting his medical degree in Jena, he went to Vienna for six months during 1799. He published his "*Kurze Darstellung*" [Short Presentation] in *Voigts Magazine der neuensten Zustand der Naturkunde* a year later, and two years afterward he came forth with a more detailed account in his *Darstellung der ganzen auf Untersuchungen der Verrichtungen des Gehirns gegründeten Theorie der Physiognomik des Dr. Gall in Wien* [Presentation of the New Theory of the Physiognomy of Dr. Gall in Vienna Based on Investigations of the Brain], which we consulted (Froriep 1800, 1802).

Froriep began by comparing Gall's views to those of Swiss physiognomist Johann Kaspar Lavater (1741–1801), whose ideas about character were well known at the time but were not tied to brain areas. He then discussed the two fundamental assumptions underlying Gall's organology: multiple inborn faculties of mind and distinct specialized organs in the cerebral cortex. Next, he turned to Gall's methods, bringing up diseases and lesions of the brain, and making the point that "a lesion to specific areas may enhance the

Figure 1. Ludwig Friedrich von Froriep (1779–1847).

activity of a given organ or erase it completely" (pp. 44–45). He then presented counter-arguments, one being instances of brain damage that do not seem to affect mental powers.

Froriep (1802) presented Gall's response to this objection in the same way as Bojanus had done:

> The entire brain is split up in half and most parts of the brain are duplicated. If now some tissue of one brain half is lost and the substance on the other side remains intact, it can replace the function of the organ on the other side without it being noticeable. One can object to this double representation that one is superfluous or that our representation should be double, one can point to the external senses where the same is happening. (p. 46)

There is also a footnote at the start of Gall's counterargument about how the organs are duplicated on the right and left cortices. On the basis of this assumption, readers are informed, one can also explain a phenomenon that has been observed several times—namely, that some patients think in a delirious manner with one side of the brain while thinking correctly with the other, such that they can recognize the incorrect thinking from the faulty side (p. 46).

Based on the Bojanus and Froriep accounts, it seems clear that Gall was already convinced about anatomical and functional cortical symmetry in 1799. The two hemispheres are comparable to our two eyes or ears. If only one is damaged, we can still see, hear, or (as now shown) engage higher functions of mind, the surviving organ providing the redundancy that allows this to happen. Froriep faithfully followed what Gall was saying, and there is no mention here of Bichat's name or ideas, or of why most people favor one hand, usually the right over the left.

Philipp Franz von Walther (1782–1849; Figure 2) provided a third account of what Gall was covering in his Vienna lectures. Born in the small German village of Burrweiler near Karlsruhe, Walther went to Vienna in 1800 to study ophthalmology. He published his *Critische Darstellung der Gall'schen anatomisch- physiologischen Untersuchungen des Gehirnund Schädel-baues* [Critical Account of Gall's Anatomical-Physiological Investigations of the Brain and the Form of the Skull] in 1802, a year before obtaining his doctorate from the University of Landshut.

Although covering the same material, Walther's essay is somewhat more philosophical than Froriep's and it uses more of his own wording. After introducing the notion of multiple organs, he turned to organ "dualism," writing:

> For the construction of the brain, nature followed the laws of dualism. All individual brain parts are represented double so that the entire brain mass can be split in two identical halves. Even there, where these connect to each other one can demonstrate the dichotomy of the apparent whole, for instance in the formation of the corpus callosum, the fornix, etc. Consequently, the function of a specific brain site will not be always lost after its disorganization: the specific organ in the opposite hemisphere replaces the defective function. (Walther 1802, 45)

He continued by stating that, as is often the case with double viscera (*Gingeweide*; organs), one is stronger than the other. For instance, the left eye often shows weaker acuity, and the left lung and kidney tend to become infected more often than their counterparts on the right. Similarly, the left side of the head is more likely to be affected by headaches, and the left side of the body by hemiplegia. Walther recognized that the two hemispheres might differ, but he assumed this only relates to the extent to which each might be activated. Indeed, even the two halves of the skull might show some asymmetries in the absence of disease.

Figure 2. Philipp Franz von Walther (1782–1849).

Walther now presented the same argument about the independence of the two hemispheres to which Froriep alluded in his footnote, writing:

> How much the function of a given brain organ on one side is independent from that on the other side, can be observed particularly in the remarkable phenomenon of the delirious speech of some patients with nervous fever, who are only delirious with one hemisphere, and think efficiently with the other, and they are therefore perfectly conscious of the perverted condition of the association of their ideas. (Walther 1802, 46)

Hence, we find Gall continuing to state that the two hemispheres are functionally identical and, with this being the case, a function need not be affected by unilateral damage. Furthermore, the two organs are able to act independently from one another even in brains free of disease. As before, there is no mention of Bichat or of handedness.

In 1805, Christian Heinrich Ernst Bischoff (1781–1861; Figure 3) came forth with his account of how Gall presented his doctrine. Bischoff had been born in Hannover and obtained his medical degree at Jena in 1801. Three years later, he was appointed Extraordinary Professor of Physiology in Berlin, where he worked with his mentor and friend, Christoph Wilhelm Hufeland (1762–1836). When Gall arrived in Berlin (the first stop on his European tour) in 1805 and gave his lectures and demonstrations, Bischoff took notes for a book, his *Darstellung der Gall'schen Gehirn- und Schädel- Lehre*

Figure 3. Christian Heinrich Ernst Bischoff (1781–1861).

[Presentation of Gall's Brain and Skull Theory], which he published that year (an English edition followed in 1807).

After covering the basic assumptions underlying Gall's doctrine, Bischoff addressed the subject of the hemispheres containing duplicate organs. He did this in the same way his predecessors had done, showing Gall was following a fixed schema for presenting his theory and supportive arguments, although the finer details about some of his faculties and organs were still being developed.

He specifically mentioned how considerable parts of the brain could be destroyed, either from an external wound or from some disease, with little effect on the faculties. This phenomenon was explained, as before, by the duplicity of the organs of mind, with a healthy organ maintaining its function following injury to its counterpart. Anyone, he related, can see that the organs of sense and other organs of animal life are double (e.g., the eyes, ears, and muscles), unlike those maintaining vegetative life (e.g., the stomach and liver), which are single. "It is true, the lungs, kidneys, &c. may seem to be an exception, yet they are not, from their inequality, to be considered as completely double, and these organs form a transition from the lower and organic, to the higher and animal life" (Bischoff 1807, 30).

Bischoff continued:

> Against this notion of a duplicity of organs in the brain, the unity of perception and consciousness has been brought forwards, But the analogy of the external senses is a sufficient reply to this objection; the organ is not in the one case, any more than in the

> other, considered as the principle of sensation or perception, it is but the material condition of their exercise.
>
> G. digressed here concerning the use of the double organs; it is enough briefly to observe that he is of the opinion only one eye, one ear, &c, is employed at a time; and that these succeed each other in their operation. Probably, he said, the right side of the brain is the more active, as the right side of the body throughout, head, breast, eye, hand, arm, foot, &c. are generally the stronger. Eight tenths of those, he says, who have a hump, have it on the right shoulder, as the muscles on this side are the most active and strong. He carried these remarks (without laying any stress on them) so far as to observe that, when a boy, he used to ask himself how it came that men seldom walk quite straight; and that he imputed it to the successive use of each eye, by means of which the point of vision is changed. (pp. 31–32)

Thus, Gall did not envision significant anatomical or physiological differences between the cerebral hemispheres, or what we would now call lateralization of function. But he did seem to believe that, for some things at least, one side might be a little stronger than the other. It should also be recognized that what he was saying about duplicate organs of mind made this part of his doctrine unchallengeable. When there are no signs or symptoms accompanying unilateral damage, it is because of organ redundancy, whereas when there are abnormal behaviors, they could always be attributed to real or imagined brain abnormalities or to the unilateral pathology supposedly affecting the natural balance between the two sides. With this position, Gall had a fallback, allowing him to brush off the opposition and explain everything, as some critics would later recognize (Finger and Eling 2019).

Gall and Bichat

Marie François Xavier Bichat was and still is recognized far more than Gall for bringing the concept of symmetry to the fore at the beginning of the nineteenth century. This was partly due to where he worked, his standing in the scientific and medical communities, his widely read books, how he framed his ideas, and the fact that he was interested in the gross anatomy and histology of all organs, unlike Gall, who was focused only on the brain.

Born in the French village of Thoirette, Bichat studied mathematics and physical sciences at the University in Lyon before turning to anatomy and surgery at Lyon's Hôtel-Dieu. In 1793, he moved to Paris, where he was appointed chief physician at its oldest and most famous hospital, Hôtel-Dieu. Bichat's life was, however, short: He died at age 30, just four years after Gall entered Paris, and was buried in the Père Lachaise Cemetery, where Gall's body (although not his head) would be placed 17 years later.

Bichat first presented his treatise on symmetrical and asymmetrical organs in 1800. His venue was a book, his *Recherches physiologiques sur la vie et la mort*, which had a second edition in 1805, and which was translated as *Physiological Researches on Life and Death* (Bichat 1799, 1805/1809). In these editions, he made a sharp distinction between two types of life. Organic life, he opined, is the life of the heart, intestines, and other singular organs regulated via the ganglionic nervous system. In contrast, animal life involves the symmetrical organs of sensation, the passions (emotion), and cognition (understanding, intellect, etc.).

> Two perfectly similar globes [eyes] receive the impression of the light. Sound and odours have each also their double analogous organ. A single membrane is the seat of savours, but in it the

> median line is manifest; and each division marked by it resembles that of the opposite side. … The nerves which transmit the impression made by sounds, such as the optic, the acoustic, the lingual and olfactory are evidently assembled in symmetrical pairs. (Bichat 1805/1809, 8)

Bichat wrote that the brain is symmetrical when he included it with the other organs of animal life. "Those parts [of the brain] not in pairs," he maintained, "are all symmetrically divided by the median line, of which several afford visible traces, as the *corpus callosus*, the *fornix, tuber annulare*, &c." (p. 8).

Bichat linked his anatomy to physiology when he brought up the long-held principle that symmetry in structure indicated symmetry in function.

> Harmony is to the *functions* of the organs what symmetry is to their *conformation*; it supposes a perfect equality of force and action, as symmetry indicates an exact analogy in the external forms and internal structure. It is a consequence of symmetry; for two parts essentially alike in their structure, cannot be different in their mode of acting. (Bichat 1805/1809, 14)

Lauren Harris (1991), who also provided some of these quotations, wrote that Gall followed the same line of reasoning as Bichat, and we agree. Harris did not explicitly attribute Gall's thinking about duplicate organs of mind to Bichat in his 1991 article, but eight years later he seemed to do so, contending: "In this [Bichat's] law of symmetry, Gall (1835) saw an important implication: If one hemisphere is injured, all normal functions could go on as before, supported by the other hemisphere" (Harris 1999, 13). But did Gall draw on Bichat's *Recherches physiologiques sur la vie et la mort* when formulating his own theory?

Gall did not mention Bichat's name in his Vienna lectures, which some of his attendants published as books. This was true for Bojanus, who was in Vienna in 1797–1798, and for Froriep, whose book was based on a lecture series Gall gave in 1799. And from all indications, Gall had been lecturing on the same material since 1796.

As for Walther, he arrived in Vienna in 1800 and could have listened to Gall at that time or during the next year, when Bichat's ideas about duplicate organs were starting to circulate. The book Walther published in 1802 was like Froriep's, in that it did not mention Bichat's name or bring up two types of life. But what he wrote about "the formation of the corpus callosum, the fornix, etc." is reminiscent of Bichat, who had written that these structures "are all symmetrically divided by the median line, of which several afford visible traces, as the *corpus callosus*, the *fornix, tuber annulare*, &c." Hence, there is reason to think that Gall (or perhaps Walther?) might have become familiar with Bichat's treatise soon after it was published.

Bichat's name remained missing from Bischoff 's 1805 publication, which was based on Gall's Berlin lectures (see Bischoff 1805). Nonetheless, they now show more evidence for Gall having read Bichat's book. How Gall mentioned that some "organs form a transition from the lower and organic, to the higher and animal life," would strongly suggest that he had become acutely aware of Bichat's dichotomy and had determined it was in accord with his own thinking about hemispheric duplication, although each of his hemispheres (and not Bichat's) contained multiple organs of mind.

From the chronology of the renditions consulted here, we can conclude that Gall was not initially inspired or guided by Bichat. He had reached his own conclusions about symmetry in the cerebral and cerebellar cortices during the 1790s, prior to reading Bichat's (1800) book. Bichat's two-fold classification of asymmetrical and symmetrical

organs linked to organic and animal life was, in fact, largely irrelevant or tangential to the fundamentals of Gall's doctrine. Still, when he learned what the Frenchman wrote about symmetry early in the new century, he found it supportive of his own observations and thinking about the two sides of the brain. Hence, Gall began to integrate some of what Bichat wrote into his own lectures, although his name did not appear in the published reports of his early lectures.

But did Gall, who was egotistical and protective of his own ideas, mention symmetry and present Bichat's name in this context in his later books? His first set of books, published between 1810 and 1819, and his second set, completed in 1825 and presenting what was essentially the same material without the atlas and detailed neuroanatomy, reveal that he continued to make the case that the cerebral organs of one hemisphere are perfectly duplicated on the other (Gall and Spurzheim 1810-1819; 1825, 1835 trans.). In his words:

> I have proved, in the first volume of my large work, that the nervous systems of the spinal marrow, of the organs of sense, and of the brain, are double, or in pairs. But, as, when one of the optic nerves or one of the eyes is destroyed, we continue to see with the other eye, so when one of the hemispheres of the brain, or one of the brains, has become incapable of executing its functions, the other hemisphere or the other brain may continue to perform those belonging to itself; in other words, the functions may be disturbed or suspended on one side, and remain perfect on the other. (Gall 1835, Vol. 2, 164)

Gall also presented cases of his own and others showing that just one side of the brain could be affected in cases of "mental alienation" before concluding:

> Since, therefore, the state of one hemisphere of the brain may be wholly different from that of the other, this difference must extend to the functions of these hemispheres also; and since all the organs of the primitive faculties of the mind are double, it is possible that, in the severest diseases and injuries of the brain, all those faculties may exist, whose organs have not been paralyzed or destroyed, at the same time, on both sides. (1835, Vol. 2, 166–167)

With regard to providing Bichat's name, Gall referred to him 22 times in his "great work," although some of these citations involved Bichat's (1801, 1801-1803) other writings on histology and pathological anatomy, not what he had to say about symmetrical parts of the brain. Furthermore, some were no more than references or in lists that included the names of other physicians. Even his two direct quotations from Bichat seemed unrelated to hemispheric differences. Bichat was, however, mentioned in connection to symmetry in one of the nine places where we found the word "symmetry" used.

These searches brought us to a section in Gall's works titled, "On the Means of Finding, By the Aid of the Cerebral State, a Measure for the Intellectual Faculties, and the Moral Qualities" (Gall 1835, Vol. 2, 182–222). Here Gall discussed the relations between brain volume and functions, correlations between brain and body volumes, proportions between brain and nerves, and the like. He then asked, rhetorically: What can be inferred from the different forms of the head? More specifically: "Does there exist a form of the head from which the existence of mania can be inferred?" (p. 202).

He began his answer to this question by mentioning what Philippe Pinel (1745–1826) wrote about mania:

> "The opinion is pretty general," says Pinel, "that mental alienation is to be attributed to defects in the brain, and especially to defects and disproportions in the cranium. … But

> observation is far from confirming these specious conjectures; for we sometimes find the most beautiful forms of the head, accompanying the most limited degree of intelligence, and even perfect mania; and, on the other hand, strange varieties of conformation co-exist with all the attributes of talent and genius." (Gall 1835, Vol. 2, 202-203)

Gall contended that Pinel's conclusion about there being no relation between the form of the head and mental alteration was incorrect. Interestingly, he now argued that what is important is not the form of the head but the brain itself. Here he presented some of his own observations, while mentioning Bichat's own asymmetric head and praising him as a genius.

> Want of symmetry in the head is frequently a consequence of rickets, sometimes also of particular cerebral maladies, such as effusion of the cavities of the brain, &c. Hence in an equal number of heads not symmetrical and symmetrical, a larger proportion of the former will be found to have belonged to deranged persons. Haller and Bichat thought, that a want of symmetry in the two halves of the head, was one of the principal causes of mania. But it must not be forgotten, that frequently the most healthy heads, I mean those whose form has not been in the least influenced by disease, have the two halves unequal. … There was considerable inequality between the two halves of Bichat's head, as is shown by the cast taken after his death. Probably he himself was not aware of this deformity: but, who will maintain that Bichat was not a man of genius? (Gall, 1835, Vol. 2, 206-207)

It is important to note that Gall was discussing the relationship between mental disorders and head symmetry here, and that his main objection to Pinel was that he was not examining brains. Pointing to Bichat's own head, Gall warned that, although asymmetry could result from specific diseases, it should not immediately be interpreted as a physical sign of mental derangement.

Accounting for handedness

During this era, human handedness did not necessarily present a challenge to the principle that the two hemispheres, being similar in structure, must function similarly. A popular explanation did not even involve the hemispheres. Instead, it was based on a peripheral difference, one pertaining to different sizes of the subclavian arteries to the two limbs.

Harris (1991, 1999) mentioned this explanation when discussing Bichat's theories, writing that Bichat recognized that the right subclavian artery's "slight excess of diameter" could affect limb use. Nonetheless, Bichat considered this anatomical difference to be inconsequential compared to the symmetry of the limbs themselves, which showed "perfect equality of volume, number of fibers, and nerves." Instead, Bichat argued, "this discordance [between the left and right sides] is seldom or never in Nature, but is the manifest consequence of our social habits." He pointed specifically to writing, maintaining that the way that we write from left to right makes the use of the right hand "better adapted than the left to the formation of letters in this direction" (Bichat 1805/1809, 22; see Harris 1991, 14; 1999, 6–7; quotes from Bichat 1805/1809, 22, 24).

We now know that habits cannot explain handedness, although education could play a limited role in supporting or counteracting natural preferences. Among various sorts of evidence favoring nature over nurture, it has been found that right-hand preferences occur even in societies in which the writing system deviates from the left-to-right direction.

Gall did not concern himself with handedness, although he had to have been aware of this asymmetry common to humans that was not yet thought to be a feature of other animals. His neglect of the subject in his lectures and later sets of volumes would indicate that he did not think handedness was a higher brain function. Whether he might have associated hand differences with blood vessel sizes, as did some others at the time, and what he might have believed about hand preferences being learned or innate were separate issues that did not bear on the edifice he was intent on constructing.

The death of symmetry

The idea that the two sides of the brain are anatomically and functionally similar received few challenges during the first half of the nineteenth century. François Magendie (1783–1855), however, raised one rather muted objection in a footnote to the fourth edition of Bichat's book. He wrote that he found anatomical differences between the hemispheres, but he stopped short of correlating these asymmetries with functional divergences and elsewhere continued to attribute handedness to vascular differences (Magendie 1822/1827, 21, 33; also see Magendie 1838). Another challenge came several decades later from French surgeon Joseph-François Malgaigne (1806–1865). Malgaigne (1859) also noted differences between the hemispheres, which he maintained would make the "organs" of the two hemispheres different; but what he wrote had little or no impact.

Jean Baptiste Bouillaud (1796–1881), who revered Gall (unlike Magendie, who criticized his doctrine and dubbed it a "pseudo-science") is more interesting in this context. The mostly cerebrovascular patients in the Paris hospitals he began to write about in 1825 tended to have a much higher percentage of left-hemispheric than right-hemispheric brain lesions (Bouillaud 1825a, 1825b, 1830, 1839, 1848). Yet, perhaps due to Bichat's deification in the city, Bouillaud remained focused on anterior vs. posterior damage, choosing not to attend to right- vs. left-hemispheric differences that would later be found to be statistically significant, even in his 1825 publication (Benton 1976, 1984).

Marc Dax (1770–1837), a physician in the south of France, was more perceptive of hemispheric differences (Joynt and Benton 1964). He became intrigued with hemispheric damage and speech disorders in 1800, and he continued to amass cases revealing that language impairments are much more likely to involve damage to the left than the right hemisphere. He reported his findings at the Congrès Meridional de Montpellier in 1836, contending that, although not every illness of the left hemisphere will alter verbal memory, when it is affected the cause must be sought in the left hemisphere (Dax 1865b; Joynt and Benton 1964). For reasons unknown, Marc Dax failed to publish this paper; as a result, his compelling evidence for cerebral dominance remained unknown for several more decades.

The concept of symmetry met its demise in the mid-1860s. The single most influential event was Paul Broca's (1824–1880) publications between 1861 and 1865 on what would soon be called *aphasie* or aphasia. As his sample size grew and to his surprise, he recognized that the brain damage associated with severe speech defects in his sample involved the anterior part of the left hemisphere (Broca 1861, 1863, 1865).

The second event was the publication of Marc Dax's *mémoire* by his son Gustave Dax (1815–1893) in 1865. The younger Dax began to present additional support (although, like his father, again without autopsies) for language being a left-hemispheric function at the same time (Dax 1865a, 1865b; Finger and Roe 1996, 1999; Joynt and Benton 1964; Leblanc

2017; Roe and Finger 1996). Neither of the Daxes, however, attempted to account for this phenomenon. In contrast, Broca thought that the left hemisphere receives more oxygen-rich blood than its counterpart, and therefore will develop sooner and assume the leading role in language functions.

Broca did not associate the left hemisphere's supremacy for language with hand preference. Like everyone else, he viewed language as a cognitive function, but not so handedness. Moreover, he could think of no reason why two such different functions should be connected to each other (Eling 1984). Nonetheless, the "entire world" seemed to connect speech in the left hemisphere with right-handedness, at least until relatively recently (Harris 1991).

The most important point for us is that the idea of two equal hemispheres fell by the wayside during the 1860s (Finger 1994; Harrington 1985, 1987; Leblanc 2017; Young 1970). Both Gall and Bichat had been wrong about the hemispheres being functionally (and anatomically) symmetrical.

The earlier literature on symmetry is small relative to that on cerebral dominance, but it is nonetheless intriguing. It is important because it provides information needed for a more thorough and detailed picture of how the neurosciences evolved from the end of the eighteenth century through the long and eventful nineteenth century.

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