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Emil du Bois-Reymond on "The Seat of the Soul"

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The German pioneer of electrophysiology, Emil du Bois-Reymond (1818–1896), is generally assumed to have remained silent on the subject of the brain. However, the archive of his papers in Berlin contains manuscript notes to a lecture on "The Seat of the Soul" that he delivered to popular audiences in 1884 and 1885. These notes demonstrate that cerebral localization and brain function in general had been concerns of his for quite some time, and that he did not shy away from these subjects.

Keywords du Bois-Reymond (Emil), seat of the soul, cerebral localization, popular lectures, history of neurophysiology, German science (nineteenth century), mind-body problem, consciousness, limits of science

Introduction

> If physiology is the most elevated of theoretical sciences, inasmuch as it encompasses the loftiest of all problems, the origin of consciousness, the portion of physiology that has to do with the proximate conditions of consciousness on the other hand appears to be not only the loftiest but also the hardest. (E. du Bois-Reymond, 1880/1912a, p. 607)[1]

In the spring of 1877, the physiologist Emil du Bois-Reymond (1818–1896) embarked on a series of itinerant lectures. Tensions in South America had ruined the value of his investments, and with a large household to maintain, a salary that had stagnated, and costs that continued to rise, he found himself in need of extra income. Not that du Bois-Reymond was daunted by the prospect of addressing popular audiences: He regularly attracted crowds of hundreds to his classes at the University of Berlin, and his occasional discourses as Permanent Secretary to the Prussian Academy of Sciences and Dean and Rector of the university had made his name as an orator throughout Germany. Encouraged by this celebrity, he arranged a tour of scholarly societies in the rich towns of the Rhineland and the Ruhr. "Met with immense success here," he reported to his wife in English following his first performance, "but I'm fairly knocked up by 'those midnight carousals'" (E. du Bois-Reymond to J. du Bois-Reymond, March 31, 1877).[2]

Du Bois-Reymond's hosts were particularly interested in neuroscience; indeed, half the topics they requested dealt with the subject in some manner (du Bois-Reymond, 1884–1885a). To meet this demand, he worked up a discussion *Über den Sitz der Seele, nach*

[1] All translations are my own unless otherwise noted.

[2] Du Bois-Reymond was quoting Bulwer Lytton (1844, p. 161).

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neueren Forschungen [On the Seat of the Soul, According to the Latest Research], which he held on his final tours, initially at Coblenz on March 26, 1884, and then, as his last itinerant address, at Hamburg on October 26, 1885 (Richter to du Bois-Reymond, February 21, 1884; Eyssenhardt to du Bois-Reymond, August 20, 1885). His words never appeared in print, but manuscript notes and newspaper reports can be found among his papers (du Bois-Reymond, 1884–1885b; Anonymous, 1884; NN, 1885). These warrant our attention. Du Bois-Reymond has generally been considered silent on the subject of the brain, and what he said in these lectures on the history of cerebral localization—as well as what he *didn't* say—evidences the long thought that he, as one of the preeminent neuroscientists of his day, had given to the subject.

Who Was du Bois-Reymond?[3]

Emil du Bois-Reymond is surely the most important forgotten intellectual of the nineteenth century. Born in Berlin to a family of Huguenot émigrés, du Bois-Reymond's star has fallen a long way from its zenith in the *Kaiserreich*, when his picture could be seen hanging for sale in the windows of bookstores alongside those of the Prussian Royal Family (Laforgue, 1996, p. 166). Contemporaries called him "the foremost naturalist of Europe" (Binns, 1880, p. 261), "the last of the encyclopedists" (Waller, 1902, p. 225), and "one of the greatest scientists Germany ever produced" (Anonymous, 1906, p. 489). "Gentlemen," he would tell his students only half in jest, "there are two outstanding physiologists in the world; the other one is at Leipzig" (Brooks, 1964, p. 221).[4]

Today, most people remember du Bois-Reymond as the standard-bearer of a mechanistic conception of life. During his lifetime, however, he was most famed for his research in neurophysiology. Du Bois-Reymond pioneered the use of instruments in the study of the nervous system, discovered the electrical transmission of nerve signals, linked structure to function in neural tissue, posited the improvement of neural connections with use and suggested a chemical means of synaptic communication. Although his theories soon fell by the wayside, his techniques remained in use well into the 1940s and paved the way for Alan Hodgkin (1914–1998) and Andrew Huxley's (1917–2012) elucidation of action potentials (Huxley & Hodgkin, 1952).

Du Bois-Reymond's discoveries translated into enormous prestige. He worked as a professor, dean, and rector at the University of Berlin, then the leading institution of higher education, where his stature as director of the Institute of Physiology and secretary of the Prussian Academy of Sciences attracted students from all over the world. Most came to listen to his popular surveys of anthropology and other recent sciences, but those who trained under his supervision went on to fill nearly every German professorship in physiology. The effect of this leadership was to center neuroscience in the curriculum of modern medicine (Kevles & Geison, 1995).

When he passed 40, du Bois-Reymond took up a second career in public speaking. Equally elegant in German, French, and English, he impressed listeners across Europe with his insight and erudition. Much like his mentor Alexander von Humboldt (1769–1859), du Bois-Reymond came to understand that popularizers of science "persist in the public mind as monuments of human progress long after the waves of oblivion have surged over the originators of the soundest research" (du Bois-Reymond, 1888/1912, p. 354). To this end,

[3]This section draws from the introduction to my forthcoming biography of Emil du Bois-Reymond.

[4]Referring to his friend and rival Carl Ludwig (1816–1895).

he developed a course of lectures that seized on energy conservation and natural selection as the unifying principles of the age; other addresses introduced Darwin's theory to German audiences, rejected the inheritance of acquired characters and fought the specter of vitalism.

The most famous of his speeches addressed the mystery of consciousness. In 1872, in a keynote presentation to the Congress of German Scientists and Physicians on "The Limits of Natural Knowledge," and then in 1880, in a formal discourse to the Prussian Academy of Sciences on "The Seven Enigmas" of the universe, du Bois-Reymond insisted that science could never translate the workings of the brain into an account of conscious experience (du Bois-Reymond, 1872/1912, 1880/1912b). "*Ignorabimus*," he asserted—*we shall never know.*

Few of his contemporaries appreciated du Bois-Reymond's expression of resignation. Scientists chafed at the restraint of his outlook, clerics rejected the logic of his argument, philosophers resented the provocation of his inquiry, and journalists disparaged the caution of his pronouncements (Finkelstein, forthcoming). Ernst Haeckel (1834–1919) went so far as to brand him a traitor (Haeckel, 1874, p. 131; 1876, p. 24). Du Bois-Reymond's "seemingly humble but actually presumptuous *Ignorabimus*," the German naturalist proclaimed at the height of the *Kulturkampf*, "is the *Ignoratis* of the infallible Vatican and of the 'Black International' which it heads" (Haeckel, 1874, p. xiii).[5] William James (1842–1910) was only slightly more charitable. It was absurd for scientists like du Bois-Reymond "to indignantly deny that they are materialists," James declared in an early lecture in Boston, "merely because they admit that the servile relation of mind to matter that they so strenuously affirm to be the truth, is an incomprehensible truth" (James, 1878/1988, p. 23).

Du Bois-Reymond's talks on "The Seat of the Soul" concluded just as pessimistically as his earlier lectures on "The Limits of Natural Knowledge" and "The Seven Enigmas." Their main innovation was in their mode of analysis: Rather than consider the theoretical limits to science, they reviewed the history of ideas about the brain. This shift of focus is important. On the one hand, it elevated induction over deduction and, by implication, science over philosophy. And on the other hand, it rooted du Bois-Reymond's reflections on consciousness in a tradition of physiological dissent from religious orthodoxy (Henry, 1989; Thomson, 2004, p. 166). The very titles of du Bois-Reymond's lectures, with their emphasis on materiality and ignorance, reflected his skepticism toward the pieties of his day.

"The Seat of the Soul" in 1884 and 1885

Du Bois-Reymond began the first of his addresses with a review of classical conceptions of the soul. The Greeks and Romans equated it with breath, an identity could be seen in the terms *animus* (will or mind) and *anima* (air or life), both of which recalled ἄνεμος, or wind. In the same way, the modern word *spirit* derived from the Latin *spīrāre*, to breathe, an association of life and air still present in the French expression *une femme spirituelle* (a witty woman) or in the folk custom of opening a window when someone dies (Smith et al., 2012).

The belief that the soul was located in the chest was reinforced by the fact that emotion made the heart pound, the diaphragm heave, and the stomach turn. Du Bois-Reymond

[5] "If a savant happens to let fall conciliatory words, if he makes some remarks a little humbling to science, as Du Bois Reymond did at the Leipsic Congress; . . . he is assailed as if he were some traitor to the cause of science who had gone over to the enemy and become an ally of the Jesuits" (Anonymous, 1878, p. 4).

recalled lines that Johann Wolfgang von Goethe (1749–1832) wrote on his own visit to Coblenz more than a century earlier:

> *Sieh, diese Senne war so stark,*
> *Dies Herz so fast u. wild,*
> *Die Knochen voll von Rittermark*. . . (Düntzer, 1883, vol. 1, p. 249)
>
> [Lo, these sinews were so strong,
> This heart so high and wild,
> These bones filled with nobility. . .]

This alliance of passion with the body led Aristotle (384 BC–322 BC) to locate sensation in the heart, in contrast to Alcmaeon (fifth century BC), Plato (424 BC–348 BC), and the Hippocratic physicians (460 BC–370 BC), who associated thought with the brain (Smith et al., 2012).

Plato's idealism reappeared in the writings of René Descartes (1596–1650), who famously divorced the mental from the material everywhere but in the pineal gland, or "the seat of the soul" (Finger, 2000, p. 78; Lokhorst, 2008; Bassiri, 2012). The French *savant* never quite spelled out how the mind interacted with the brain, though, which prompted one of his followers, Nicholas Malebranche (1638–1715), to posit God's continual intervention as the source of all change. In an alternative conception, Gottfried Wilhelm Leibniz (1646–1716) pictured the realms of mind and matter as essentially separate, correlated only by a harmony established at Creation.

Du Bois-Reymond considered all of these seventeenth-century philosophies—Descartes's dualism, Malebranche's occasionalism, and Leibniz's pre-established harmony—to be "patently untenable constructs" (du Bois-Reymond, 1884–1885b, Bl. 2r; Harrison, 2009). Their primary value lay in the impetus that they gave to the study of vertebrate anatomy, a tradition that left no doubt that the brain is the location of the mind. What was more, the neural tissue of lower organisms resembled that of the higher animals, a homology that pointed to the role of evolution in the origin of mind.

To illustrate this idea, du Bois-Reymond listed the relative weights of various brains in a ladder of species. As his audience might have suspected, fish, salamanders, and turtles ranked behind doves, rats, and apes. Pride of place among the animals, however, went to the canary, with a brain that commanded as much as a fifteenth of its total mass. Just as little could be concluded from absolute measures: horses had smaller brains than oxen, and men trailed elephants. Moreover, Rudolph Wagner (1805–1864) found that the brain of "a dull-witted day-laborer" weighed more than the brain of the mathematician Carl Friedrich Gauss (1777–1855), "one of the keenest minds of all time" (Broca, 1873, p. 38, quoted by Gould, 1996, p. 119). Similarly, Paul Broca (1824–1880) and Rudolf Virchow (1821–1902) showed that members of "lowly races" often possessed brains of considerable size (Virchow, 1888, p. 80; Hagner, 2003, pp. 209–214). There was no necessary relation between cerebral mass and mental ability.

Du Bois-Reymond then pointed out that the brains of mammals resembled those of people in nearly every aspect, except for the depth and number of their convolutions (La Mettrie, 1994, p. 36). Scientists attempted to correlate intelligence with these folds, but it turned out that the cortexes of dogs and foxes were smoother than those of cattle (Hagner, 2003, pp. 206–207). This did not dissuade Franz Joseph Gall (1758–1828) from claiming that the size, and hence the power, of various "cortical organs" could be read from the outlines of the skull (van Wyhe, 2004). Unfortunately, Gall's system was notoriously bad at predicting character: By his lights, Hermann von Helmholtz (1821–1894) should

have lacked mathematical talent and du Bois-Reymond any sense of reason. August von Kotzebue (1761–1819) was entirely right to satirize the phrenologist in his play *The Organs of the Brain* (Kotzebue, 1806; Cumston, 1909).

Du Bois-Reymond reminded his listeners that, for all the problems of Gall's theory, it had linked mental activity to the cerebral cortex (Swazey, 1970, p. 219). Evidence for this connection was overwhelming: Encephalitis gave rise to delirium, pressure on the brain brought about syncope, ablation of the frontal lobes produced somnolence, and microcephalism resulted in idiocy (Zimmerman, 2001, pp. 75–77). These observations, combined with inferences from comparative anatomy, led Carl Gustav Carus (1789–1869) to postulate that the forebrain governed thought, the midbrain mood, and the hindbrain will (Feremutsch, 1951; Hagner, 1997, pp. 314–320; Verplaetse, 2009, pp. 49–53). Carus's midcentury cranioscopy proved to be little better at isolating mental function than Gall's; still, it did anticipate Broca's discovery that damage to the left frontal lobe impaired the power of speech (Jacyna, 1999, p. 9; Finger & Roe, 1999).[6]

Additional correlations of brain and mind followed suit. In 1870, Gustav Fritsch (1838–1927) and Eduard Hitzig (1839–1907) located a portion of a dog's cortex that induced muscular twitches when stimulated by electricity, and in 1878 another one of du Bois-Reymond's students, Hermann Munk (1839–1912), ascertained that damage to the occipital lobes rendered dogs and monkeys blind (Fritsch & Hitzig, 1870; Munk, 1881). Munk described two forms of visual impairment: "psychic blindness," in which the animals could see but not recognize, and "cortical blindness," in which they could not see at all. These findings, du Bois-Reymond explained to his audience, accounted for atrophy of the visual cortex in brains of the sightless (Polyak, 1957, pp. 149–152, 179–184; Gross, 1999, pp. 69–71).[7] What was more, Munk had identified areas of the cortex responsible for hearing, even down to the pitch of the sound (du Bois-Reymond, 1884–1885b, Bl. 4; Munk, 1881, pp. 54, 92; James, 1890, vol. 1, pp. 41–65; Finger, 1994, pp. 131, 141, 172–173, 184).

Such progress in cerebral topography begged the question of how the "material soul," as du Bois-Reymond phrased it, received sensations and initiated movement. Scientists knew that neural signals altered the metabolism of cerebral ganglia, but the relationship between cortical activity and mental experience remained a mystery. As Leibniz famously stated, even if the machinery of our brain were enlarged in all its proportions, "so that we could go into it as one might a mill, we would still find nothing but parts jostling each other, and never anything by which perception could be explained" (du Bois-Reymond, 1880/1912b, pp. 77–78). "In a world made up of matter in motion," du Bois-Reymond asserted, "the movements of the cerebral molecules are like a dumb show" (du Bois-Reymond, 1872/1912, p. 460). Nothing in their behavior could ever transport us into the realm of consciousness. The seat of the soul was therefore beyond our ken (du Bois-Reymond, 1884–1885b, Bl. 4v).

Reception and Significance

> Signs are small measurable things, but interpretations are illimitable. (Eliot, 1872, p. 16)

Du Bois-Reymond's lecture on "The Seat of the Soul" generated two extensive reviews. The first, which appeared in a Catholic daily from Coblenz, paired his admission of

[6]Following his student Eduard Hitzig, du Bois-Reymond designated Broca's area as "the back part of the third frontal convolution on the left." Like Hitzig, he credited Dax in this history of aphasia but misspelled his name "Dakse" (1884–1885b, Bl. 5v).

[7]As well as homonymous hemianopsia.

ignorance with a colleague's opposing claims that the mind "could be bound mathematically hand and foot" (Anonymous, 1884, citing Jäger, 1884–1885, vol. 1, p. 406).[8] Such offhand scientific judgments, the author contended, only fostered a "shallow and empty skepticism" (Anonymous, 1884). The second article, which appeared in a Liberal newspaper from Hamburg, restricted itself to a simple description of du Bois-Reymond's remarks, a wise policy for retaining conservative readers in a time when Bismarck was realigning his policies towards the Right (NN, 1885; Mommsen, 1993, pp. 560–602).

These reviews of du Bois-Reymond's lecture indicate the degree to which neuroscience divided the public at the end of the nineteenth century. Catholics in Austria and France attacked phrenology for undermining the Cartesian doctrine of the unity of the soul, and radicals in France and Britain championed Broca's discoveries for offering a material basis to consciousness (Clarke & Jacyna, 1987, pp. 234–307; Jacyna, 1981; Harrington, 1987, pp. 35–49). The debate over neuroscience polarized scientists in Germany as well: In Berlin, Eduard Hitzig endorsed an autocratic system of cerebral hierarchies, whereas in Strassburg, Friedrich Goltz (1834–1902) espoused a more democratic model of neurological competence.

Du Bois-Reymond took a moderate position amidst all the controversy. He plainly favored the localization of sensory and motor centers, but he backed away from the suggestion that the mind could be resolved into the functions of the brain. In this regard, his lecture belies Philip Pauly's contention that neurological ideas in Imperial Germany reflected a division between the authoritarian Germany of the Prussian bureaucracy, on the one hand, and the liberal Germany of provincial culture, on the other (Pauly, 1983). Despite working his entire career in Berlin, du Bois-Reymond felt little enthusiasm for Bismarck. The "Theory of the Two Germanies" did not extend to the brain (Meinecke, 1915, p. 628; Digeon, 1959, pp. 364–365; Savage, 1970).

"The Seat of the Soul" is instructive for what it did not say as much as for what it did. Du Bois-Reymond did not discuss British investigations, and, apart from a brief mention of Broca, he ignored French research as well. These omissions were deliberate. The Scottish neurologist David Ferrier (1843–1928) initially refused to acknowledge fully the precedence of Fritsch and Hitzig, and Claude Bernard (1813–1878) was notorious for spurning the work of foreigners (Gross, 1999, p. 88; 2009, p. 108; Finkelstein, 2003, pp. 298–300). As far as du Bois-Reymond was concerned, French and British neuroscience remained mired in provincial ignorance (du Bois-Reymond, 1855, p. 736; Sechenov, 1965, p. 80; Brazier, 1959–1960, Vol. 1, p. 21). Interestingly, his opinion was often seconded abroad (Donders, 1880, p. 19).[9] "Paul Bert's misfortune," the neurologist Jules Soury confided to Maurice Barrès over dinner, "is that he ignored German. There's no progress in science for those who ignore German" (Barrès, 1929–1957, vol. 1, p. 81).[10] Similarly, Darwin's physician, Henry Bence Jones (1813–1873), despaired of how little his compatriots knew of du Bois-Reymond's work (Bence Jones to du Bois-Reymond, December 28,

[8]Jäger also championed wearing woolen underwear, a practice that du Bois-Reymond ridiculed (Du Bois-Reymond to Singer, April 18, 1884, in Singer, 1885, pp. 3–4).

[9]"Here [in Berlin] it's astonishing to read in French journals of the discovery of facts long known in Germany and professed in all its universities. Everything done in France is known perfectly here, since a researcher can only claim to be one in Germany if he knows French and English (and those like [Johannes] Müller who know Italian and Swedish in addition aren't uncommon)" (Claparède, 1971, p. 17, my translation). Trips to conventions in France and Britain did nothing to change du Bois-Reymond's opinion (du Bois-Reymond, 1884, p. 63; du Bois-Reymond, 1882/1912).

[10]The physiologist and politician Paul Bert (1833–1886) was Claude Bernard's best student.

1852, Bl. 139–141). "The fact here is that we don't love science" (Bence Jones to du Bois-Reymond, May 1, 1853, Bl. 153–155). Du Bois-Reymond agreed. "There is something rather pleasant," he wrote back to his friend, "in the thought that in Germany we have a whole department of science, teeming with discoveries of the deepest interest, of which not a soul, excepting you, has an idea in England" (du Bois-Reymond to Bence Jones, July 24, 1863, Bl. 70–71). He was even plainer in letters to his wife. "Divine people, these English scholars—a lack of critical insight and factual knowledge that beggars all understanding. A Prussian schoolmaster has more clue than the entire Royal Society" (E. du Bois-Reymond to J. du Bois-Reymond, March 6, 1853). Du Bois-Reymond saw little point in touting foreign findings to his German audience.

The most significant aspect of "The Seat of the Soul" was its narrative of neuroscience. Du Bois-Reymond began with classical anatomy, touched on French medicine and ended with German physiology, a radical simplification of the history of the field. He made no mention of the physiologist Sigmund Exner (1846–1926), for example, even though his best friend, Ernst Brücke (1819–1892), repeatedly praised Exner in letters sent from Vienna (Brücke to du Bois-Reymond, September 17, 1880, November 23, 1880, July 17, 1880, May 28, 1882, March 22, 1885, in Brücke, 1978, Vol. 1, pp. 230–231, 232, 234–235, 238–239, 258; Exner, 1881; Coen, 2007, pp. 102–104). Neither did he discuss Carl Wernicke (1848–1905) or Theodor Meynert (1833–1892), psychiatrists who traced pathologies of speech and thought to the cellular structure of the brain. He also ignored John Hughlings Jackson's (1835–1911) work on syphilis, aphasia, and epilepsy, despite the evidence that they provided for cerebral localization (Steinberg, 2009). Unlike Bernard, du Bois-Reymond ranked experiment over observation, and Prussian experiment ranked highest of all (Bernard, 1957, p. 199; Jardine, 1992, 1997; Finkelstein, forthcoming). There was nothing particularly remarkable about his bias: du Bois-Reymond's colleagues all presented histories of neuroscience in their own image. The difference is that we have tended to take du Bois-Reymond's version at face value. Most neuroscientists continue to repudiate metaphysical dualism, just as most presume a relation between neural structure and mental function. And as to the larger question of whether understanding the brain will ever elucidate consciousness, du Bois-Reymond's doubts have yet to be quelled (Smith & Whitaker, forthcoming).

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