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# How a social construct caused scientific stagnation: A neuropsychological case history

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**Abstract:** Paul Broca surprised a meeting of the Societe d'Anthropologie in Paris with the news that speech is left lateralized in the brain. However, to credit the right hemisphere with comparable attributes called for a new paradigm, and this scientific advance had to await a cultural revolution.



**Full Text:** WHAT does it take to revolutionize a science? Before someone has the seminal idea, there are telltale findings, anomalous results that challenge the status quo. Yet the anomalies alone are not sufficient to overthrow the existing view. To the extent possible, the received model is adjusted, revised, and otherwise patched. This continues until a scientist of genius presents a competing paradigm, in the light of which the discrepant facts fall into place and are no longer anomalous (Kuhn, 1962). However, even that powerful insight might not suffice. There is no guarantee that the scientific community will recognize the new paradigm's superior explanatory power. This is because the existing paradigm may hold sway for reasons that range far beyond the evidence on which it is ostensibly based, reasons that are outside the domain of science altogether. It is not enough that a paradigm should fit the data. It must also fit the intellectual climate, the assumptions of the culture, in short, the Zeitgeist. The vicissitudes of the right cerebral hemisphere are a case in point. Why did it take so inordinately long to recognize and acknowledge that, like the left, there are functions for which the human right brain is uniquely specialized? Why was an insight that was recognizable, and recognized, in the mid-nineteenth century, not acknowledged and developed until the mid-twentieth century? Hemisphere Specialization Paul Broca (1861) surprised a meeting of the Societe d'Anthropologie in Paris with the news that speech is left lateralized in the brain. His insight unleashed a tide of investigations that steadily incremented the inventory of skills credited to what was soon called the leading, major, or dominant hemisphere. In sharp contrast, the specializations of the right hemisphere, sporadically suggested, were generally neglected for no less than a century. Few were interested in this topic, and their findings were ignored or interpreted away well into the post-World War II period. I would like to argue that Broca's insight into the left hemisphere, novel though it was, could be contained within the existing paradigm, and that is why, after some brisk skirmishing (Harrington, 1987), it prevailed. But to credit the right hemisphere with comparable attributes called for a new paradigm. This scientific advance had to await a cultural revolution. Were more advanced methods or techniques than those used to establish the specializations of the left brain required for the right? No. The same means that were used to uncover left-sided abilities in speaking, recognizing objects and symbols, and planning movement sequences could have revealed the right hemisphere's responsibility for pattern recognition, spatial orientation and spatial thought, and emotional response. In fact, the deficits in functions later attributed to the right hemisphere were noted over and over again. But they were either gratuitously attributed to bilateral disease, involving both sides of the brain, or minimized as unimportant. Evidence in a form that was acceptable for the left hemisphere was questioned when the topic shifted to the right hemisphere. I argue that the long maintained bias against crediting the right brain with unique skills was due to a constraining social construct that had been imported into neuropsychology from the culture of the time. The bias remained in force until the social construct was finally overthrown. Scientists derive their models from the tools available to them. But do they derive their laws from the laws of the society in which they live? Models of the brain have drawn on analogies based on contemporaneous technology, ranging from the "switchboard" models of the nineteenth century to

cognitive science's reliance today on the digital computer. In view of the powerful effect of social constructs in other domains, it may come as no surprise to social scientists that constructs exterior to science and technology can have as sweeping an influence as here represented. However, neuroscientists might be taken aback by so apparently remote a source of constraints on how they formulate the "laws" that "govern" the manner in which the brain is organized. Yet if it happened then, it is probably happening now. Made in What Image? Why would a question in neuroscience be entangled in extraneous attitudes and beliefs? The reason is that questions about the brain entail questions about the mind. Descartes likened the body to a mechanical device, but used a different metaphor for the mind. How one understands the mind mirrors how one understands oneself in the world. The brain's central ventricular spaces (and, after Thomas Willis, its substance) were at first conceived as essentially a unit. This was because, as Descartes remarked, the soul itself was considered unitary and indivisible. But as society's canonical symbol gradually changed from God to the human self, eighteenth--century faculty psychology partitioned the mind. Taking the next step, Franz Joseph Gall, the originator of what came to be called phrenology, partitioned the thinking brain-the human cerebral hemispheres, the layered white and gray matter that constitutes 90 percent of its substance. In Gall's attributions the force of extraneous constructs on an ostensibly empirical study of brain organization becomes apparent. Gall developed an arbitrary inventory of 27 human attributes, mixing in cognitive faculties and personality characteristics. According to Gall, these attributes subsumed the entire surface of the forebrain. His method was to identify individuals who seemed to him to manifest one or other of these attributes to a high degree, and observe the contours of their heads. He held the cranium to be "a faithful cast of the external surface of the brain." According to Gall, each of the 27 attributes corresponds to a uniquely located area of bone, the prominence of which indicates the degree of development of the part of the brain that lies beneath. Investigations over time showed that Gall's faculties bear no direct relationship to parts of the brain, and in any case, one cannot infer differences in brain development or function from the different contours of people's skulls. His assignments should therefore be randomly distributed across the skull. This was not so. Inadvertently, he assigned functions in an organized pattern that extrapolates constructs that were inherent in the culture. He placed the "forward-looking" attributes in the front of the brain (for instance, sense of language, sense of color). The "highest," static but sublime, he placed on top, in its superior aspect (religious sentiment, firmness of purpose). The "earthy" attributes he located at the back (reproductive instinct, love of offspring). Those considered "base" he located centrally toward the bottom or base of the cerebrum, where it is planted on the brain stem (cunning, destructiveness). All eight of the faculties that he considered most uniquely human he placed in front and on top. The spatial metaphors that characterize human notions of value, higher, lower, forward, backward, became concretely instantiated in Gall's brain map (and the alternative maps offered by the phrenologists who followed, notably his student, Johann Spurzheim). These metaphors expressed a hierarchical assumption that was taken for granted in the societies that harbored early brain science. This is a mindset that organizes reality in terms of power structure, reflecting an authoritarian society. The shift from God to self did not entail any deviation from the hierarchical framework in which both were embedded. Hierarchical organization is apparent in the pyramidal organization of the family, the community, the church, the military, and the government. Each is headed by an individual presumed to be better informed and endowed. For Gall, the best was in front and on top-literally superior, the peak of a pyramid of merit. The metaphors of hierarchy were to have a remarkably durable hold on brain research. Hierarchy went hand in hand with symmetry, a classical ideal. Gall organized his surface map of faculties symmetrically around a front-back axis. The neurologists who first inferred the relationship of brain and behavior from the effects of focal brain damage were influenced by Gall's theorizing (Brown and Chobor, 1992). Their assumption that organization would be symmetrical was so strong that Jean-Baptiste Bouillaud (1825), first to document the effects of brain lesion on speech, disregarded their left-- sided predominance. Marc Dax, who did notice the greater prevalence of left hemisphere lesions, seems not to have had the confidence to make it public. Like Bouillaud, Broca confirmed Gall's claim that the "organ of speech" is located at the front of

the brain. But finally he could not discount the fact that the lesion in all of his eight cases was on the left. He announced this to the Society of Anthropology and hemispheric lateralization entered the public domain. A function could be located on one side of the brain, but not the other. Had the grip of symmetry been overcome? Hierarchy Accommodated to Laterality "Defenders will devise numerous articulations and ad hoc modifications of their theory in order to eliminate any appearance of conflict" (Kuhn, 78). Humans used to base their claims to special status on their exclusive ownership of an immortal soul. Nineteenth-century Darwinism and anticlericalism left the desire for special status in place, but called for a more material rationale. Overall brain size could not be used. Relatively large though our brains are, the brains of several other species are larger still. Instead, distinctions in the relative size of brain parts were invoked. These distinctions were in accord with a principle of hierarchy: the highest in front. In accord with the anterior principle, much was made of the relatively large size of the human frontal lobes as compared to those of animals. The distinction was extrapolated to human groups, according to a subjective scale of valuation. White males were credited with larger frontal lobes than white females and nonwhite individuals of both genders. But gradually the left hemisphere's specializations were shown to extend from fore to aft of that organ of brain, and the emphasis shifted from the front to the side of the forebrain, to lateralization. Since speech is taken to be the quintessential faculty that differentiates humans from brutes, its lateral location challenged the hierarchical principle. Theoretically, this anomaly could have led to a revision of constructs, such as a search for complementary strengths on the other side. Hughlings Jackson (1874) made this argument. He presented evidence that perception and the bulk of mental activity are right-sided, and, what is more, posterior. For him, perception was the "corresponding opposite" to language. His concept anticipated the current idea that the hemispheres underwrite complementary functions. Although respected as a medical scientist, Jackson's argument was simply ignored. Instead of changing the theory, scientists adapted their existing view of the brain to the emerging realities. A conceptual revision of the existing theory was implemented. Although it is not literally in front, the left hemisphere was credited with being in front conceptually, the peak of the hierarchy. The existing paradigm, of hierarchical organization, was preserved. The Left Hemisphere Exalted In accord with this post hoc rethinking of the hierarchical construct, the left was alleged to be the earlier maturing, more developed and heavier hemisphere, more protruding to the front (claims that are empirically false; none was based on more than cursory observation). The left hemisphere was considered to be the peak of the hierarchy, the place where "it all comes together," housing the inner eye that surveys the screens of the Cartesian theater of consciousness (Dennett and Kinsbourne, 1992). Functionally, the right, minor, or subdominant hemisphere was either empty, a cognitive reserve, or it shared with the left the more primitive functions, functions that were not elaborate enough to be expected to be later-alized. At best, it housed the lesser, feminine faculties, emotion and subjectivity. When it was out of control, it engendered madness.1 The right hemisphere played Hyde to the left hemisphere's Jekyll (in the nineteenth century personalities were not yet multiple and value neutral; they were dual and differently valenced). Neurologists were willing to write off nearly half the brain. How could the pressures of natural selection spare a tissue that is so expensive in energy requirement and yet offers so little adaptive benefit? That neurologists were undeterred highlights the power of the hierarchical mind-set. As Kuhn pointed out, the existing paradigm overrides anomalies until a new paradigm has reached enough prominence to be available for comparison. Nor is it enough for the new idea to be articulated. It has to be powered by the momentum of the Zeitgeist. Competing Models "Retooling is an extravagance reserved for the occasion that demands it" (Kuhn, 76). Theoretically, the two half brains could be related vertically or horizontally, or they could be unrelated. If vertically, the higher hemisphere could act as control on the lower, or simply represent activities of which the lower is not capable. If horizontally, the two brain halves could be redundant-each independently capable, complementary-capable when they combined their distinctive part-functions, or both obligatory and indispensable for the relevant function. Nineteenth-century theory threw up the possibilities of redundancy and being obligatory, in the sense of needing to be in balance (e.g., Wigan, 1844), but settled for the vertical relationship in which the higher

hemisphere has additional ("uniquely human") functions not available to the lower. Clearly, the models were not competing on a level playing field. The Era of Mop-Up Work "No part of the aim of normal science is to call forth new sets of phenomena; indeed, those that will not fit the box are often not seen at all" (Kuhn, 24). How did hierarchical thinking fare in the twentieth century? At the turn of the century, the center of gravity in neuropsychology swung to Germany, while the English-speaking practitioners of brain science divided into the neurophysiologists, occupied with subcortical levels of functioning, and the behavioral psychologist, who followed the hierarchical principle without involving brain theory. The German tradition was conservative and dedicated to what Kuhn called "mop-up" operations. It enriched the field with detailed and systematic observation, but adhered to the original model of hemisphere relationship. For some 50 years, the field was largely untouched by progress in the neighboring science of neurophysiology. In particular, the pervasive role of inhibition in the nervous system, well established in neurophysiology by the time of Sir Charles Sherrington's 1906 classic, The Integrative Action of the Nervous System, was not featured in neuropsychological theorizing until about 1970. The traditional model had not made use of this explanatory principle. Neuropsychologists were equally conservative with respect to the right hemisphere. When apparently unique deficits were observed in patients with evidence of right hemisphere damage they were typically written off in either of the following two ways: (1) This deficit can arise through damage of either hemisphere; or (2) The left hemisphere is also damaged, even though this is not evident neurologically. Extreme but representative derogation of the right hemisphere is captured in Solomon Henschen's remark in 1926: "[I]n every case, the right hemisphere shows a manifest inferiority as compared with the left, and plays an automatic role only." The right hemisphere, according to Henschen, was probably a regressive organ, or possibly a reserve organ. A textbook of the time called the right hemisphere the "other" one ("lesions of the other one producing as a rule no recognizable disturbance").2 Hierarchy and the Left-Hander If the hierarchical principle were valid, individual variations that violated it should incur a cost. If someone's left hemisphere "failed to establish dominance," then there should be something wrong with their cognition. Left-handers constituted a test case. It was originally assumed that left-handers were mirror images of the right-handed majority, with a dominant right hemisphere and a subdominant left. Hemisphere hierarchy remains in place, even if the players' roles are reversed. Cumulative evidence demonstrated that in fact many left-handers were left lateralized like right-- handers and most of the rest were bisymmetrical in their lateralization. In the bisymmetrical cases, both hemispheres were involved in the functions under scrutiny and particularly language. This arrangement violates the hierarchical principle. Left-handers as a group must pay some cognitive penalty for housing a large subgroup that deviates from the hemispheric norm. There followed some decades of an intense search for what might be wrong with left-handers, either in language or in some other sphere of cognition, that had to be "pushed aside" by the overly broad bilateral language representation. This search for the sinistral weakness, in tune with thousands of years of negative publicity for the left hand and left-handers, ultimately petered out in failure. No reliable inferiority of the non-right-handed has been established. But the intensity and persistence of the search, and the length of time before the negative outcome was reluctantly accepted, demonstrates yet again the power of the hierarchical assumption. The hierarchical model has implications beyond the effects of brain damage. The "higher" age (adult versus infant), the "higher" gender (male versus female), and the "higher" species (human versus nonhuman, primate versus other mammals, etc.) all should be characterized by greater asymmetry, more lateralization. I will summarize the outcome of an extensive literature in each case. In each domain the answer was initially taken for granted, without significant evidence. To investigate was not to pit one theory against another, but to challenge an established belief that the highest individuals on any scale of presumed merit would be the most lateralized. I first discuss this issue in the context of human development. Hierarchy in Development If having a dominant hemisphere is a hallmark of the human condition, then it would seem logical that those ranked relatively low within that bracket might have weaker or absent cerebral dominance. Conversely, if by some abnormality of development a person has weakened or absent cerebral dominance, he

or she should rank lower in some adaptively relevant attribute. Accordingly, it was broadly hypothesized and even assumed that newborns and infants are "not yet" lateralized, that women are less lateralized than men, and that nonwhite individuals and the impoverished of any race are less lateralized than white middle-- class adults. An intense research effort resulted, with the goal of verifying these assumptions, but without success. Eric Lenneberg (1967) definitively articulated the theory that functions progressively lateralize as the brain matures, from bisymmetrical newborn to asymmetrical adult. Uncritically accepted as correct, it could be dislodged only with difficulty by an effort beginning in the 1970s (Kinsbourne, 1974), and extending over the next two decades. Some investigators still suppose that women are less lateralized than men are (though a more positive spin may be applied-the females have it "more together"). The assumptions about race and socioeconomic status have dropped out of sight. Equally energetic was the effort to show that a wide range of permanent and incurable developmental disabilities-mental retardation, autism, language delay, dyslexia, stuttering-were products, wholly or in part, of a failure of the allegedly progressive lateralization process to run its full course. One by one, these attempted explanations have been discredited, but efforts to put this theorizing into practice were intense in the 1970s and 1980s, when developmentally disabled children were subjected to diverse manipulations intended to foster asymmetry of hemisphere development. These scientifically unfounded therapies have dwindled. Since laterality does not develop, there is no process for them to foster. Hierarchy in Phylogeny If cerebral dominance is a human hallmark, it should not exist in nonhuman animals. That it does not was simply taken for granted, and this view was supported by the absence in most animals of what might count as the nonhuman analog of hand preference, such as paw or claw preference. But in the early 1970s, it was discovered that the song of the chaffinch and the canary is unilaterally controlled in the brain (Nottebohm, 1971). Interestingly, subsequent research showed that parrots, the most intelligent birds, are not lateralized, even though they can learn to speak. Soon after, many investigators studied nonhuman primates, and also monkeys, cats, rats, and other mammals, for evidence of cerebral lateralization. In almost every inquiry, evidence for lateralization was indeed found, on one side or the other. There is no known trend for behaviorally higher animals to be more lateralized. The notion that laterality, the expression of the hierarchical principle, differentiates the behaviorally higher from lower species has had to be discarded. Transitional Period "During revolutions, scientists see new and different things when looking with familiar instruments in places they have looked before" (Kuhn, 110). In the post-World War II period, neuropsychologists were increasingly willing to entertain possible special roles of the right hemisphere rather than reject them a priori. Demonstrations of the hierarchical dominance principle were more apt to be critically scrutinized instead of being taken for granted, as the fate of their application to phylogeny, development, gender, race, and affluence demonstrates. At the very least, the claims were subject to the appropriately stringent scientific test-clear evidence, according to Kuhn, that an alternative paradigm was now at last present and generally available. It was during the cultural turmoil of the late 1960s and the 1970s that the hierarchical principle was totally abandoned by many in favor of complementarity of hemisphere function. Complementarity has taken either of two forms. In one, reminiscent of the early endeavors of Wigan (1844), and eloquently formulated by Bogen (1969), the two hemispheres were seen as harboring alternative consciousnesses, each independently capable of directing and controlling the body. They were separate and equal but not identical. The "relational" functions of the right brain were no longer thought to represent a mentality inferior to the "analytic" bent of the left brain. Some writers even viewed with favor the allegedly more spiritual cast of mind represented in the right hemisphere, which was reminiscent of that "subjectivity" that in the nineteenth century was devalued as feminine. In this pluralistic age, even this polarized model has been largely abandoned for its alternate, a value-neutral complementarity. Each hemisphere harbors particular aptitudes, which when integrated with those of the other, enable fluent and efficient behavior. The emphasis has shifted from the hemisphere as a whole to the more discrete set of modules that constitutes it. Although language and memory are still, as they have always been, the most intensively studied domains in neuropsychology, there has been a surge of interest in lower-profile mental skills,

especially those involving spatial thought as well as emotion. Notions of the organization of the cerebrum are now at an extreme of "modularity," with the assumption of innumerable specialized but democratically interacting, heterarchically organized, facilities. Keeping pace with this diversity is the multiplicity of personalities in multiple personality disorder, which in many patients now number well in excess of a hundred. The New Social Construct Investigators found much that is new, but their quest was fueled by a paradigm shift. Adapting Butterfield's (1949) words, they were "picking up the other end of the stick." Butterfield proceeds: they were "handling the same bundle of data as before, but placing them in a new system of relations with one another by giving them a different framework." A social revolution has liberated more horizontal, egalitarian, models of brain organization as viable alternatives to the previously dominant hierarchical principle. The breakup of empires, the democratization of nations, the retreat from racism to an acceptance of diversity, radically departs from the longestablished principles of hierarchy. In this postindustrial age, the centers of power are becoming more diffused and scattered. Changed brain theory is one of many repercussions of this social revolution. The cerebrum itself has been democratized. It is now recognized as an integrated network, the various specialized parts of which are interactive but not subservient to one another. There is no pyramid of power in the brain (Dennett and Kinsbourne, 1992). The cerebrum is uncentered, unsupervised by any highest level. There is neither a ghost in the machine nor even a supervisory machine. Prospects "If a man will begin with certainties, he shall end in doubts: but if he will be content to begin with doubts, he shall end in certainties" Francis Bacon (1605). Brain science was distorted by prior social constructs. We can be confident that the new constructs supplanting the old are currently also distorting it, in different ways that reflect their different nature. What biases are blinding us today to discoveries that are potentially within reach? Predicting the future is an unrewarding pastime; consider the vast body of science fiction writings that did not foresee the Internet. An overreliance on the digital computer as a model for the brain may be a place to begin. The disanalogies between the neural network and the digital computer are blatant. Future neuroscientists may deplore the extreme fragmentation, the excess of inferred modularity, currently attributed to the human brain. The functionally "encapsulated" modules of today are no more apparent in the neural network than the specific unidirectional connections between specialized areas that the early neuropsychologists invented for purposes of their diagrammatic models. The overemphasis on modularity may come to be recognized as an inadvertent and largely unrecognized by-product of the pluralistic mindset and the current preoccupation with distinctions between groups. In the future, as cultures blend and merge, the emphasis may shift to the integrative aspect of the function of the brain, to a continuity of process rather than a discontinuity of structure. A holistic and microgenetic approach has struggled for recognition for more than a century as exponents of a holistic view of brain function have voiced their views only to have been systematically disregarded. Holistic theories are necessarily more complex than atomistic theories, and in the absence of explicit experimental demonstrations, their exponents are seen as merely, and vaguely, hand waving. The staggering advances in technology applicable to the brain sciences are finally making it possible to record multiple events and their interactions at the same time, and thereby to put larger-scale models of the function of the brain to the empirical test. Unless the biasing effect of our culture is brought into focus, we may have to await yet another cultural shift before this line of advance makes public headway. Coda: Does the Exception Prove the Rule? "They have inferred much from slender premises, and conjectured when they could not prove" J.H. Cardinal Newman My account of the vicissitudes of right hemisphere specialization illustrates the force of Kuhn's generalizations. But it also exposes a gap, and suggests how it may be filled. At some point, as Kuhn repeatedly puts it, "one man has the genius" to see the data in a new light, starting the revision that constitutes a paradigm shift. But, as Kuhn also points out, "more than one theoretical construction can always be placed upon a collection of data" (76). As for anomalies, their very existence pays tribute to the model they appear to infringe. The smug cliche, "the exception proves the rule," is a travesty, but telltale in its frequent use. It is a travesty because, in its original meaning, "proves" meant "tests." The word is derived from the Latin verb probare, to try or test (as in "For God proved them, and found them worthy for

himself," in the "Song of Solomon"), or "Examine me, 0 Lord, and prove me" (Prayer Book, 1662). The exception is, in truth, a test of the rule, a challenge. Yet exceptions can cumulate, and still the rule survives. What determines which scientist of genius sees the data in a new light, and when and whether anyone cares? When the dead hand of a constraining social construct loosens its grip, genius may be freed, and its message heard. Footnote Notes Footnote 1See Harrington (1987: chap. 3) for these and other instances of value-driven lateral polarities. 2For these and similar evidence of disregard of the right hemisphere, see Bogen (1969). References References References Bacon, Francis. Of the Advancement and Proficience of Learning of the Partitions of Science. Oxford: Young and Forreft. [1605]. Bogen, J. E. "The Other Side of the Brain II: An Appositional Mind." Bulletin of the Los Angeles Neurological Societies 34 (1969): 135-162. Bouillaud, M. J. Traite clinique et physiologique de l'encephalite ou inflammation du cerveau, et des ses suites. Paris: Bailliere, 1825. Broca, P. "Perte de la parole. Ramolissement chronique et destruction partielle du lobe anterieur gauche du cerveau." Bulletins de la Societe d Anthropologie 2 (1861): 235-38. Brown, J. W. and K Chobor. (1992) "Phrenological Studies of Aphasia before Broca: Broca's Aphasia or Gall's Aphasia?" Brain and Language 43 (1992): 475-486. Butterfield, H. The Origins of Modern Science, 1300-1800. New York: Free Press, 1985 [1949]. Dennett, D. and M. Kinsbourne. "Time and the Observer: The Where and When of Consciousness in the Brain." Behavior and Brain Sciences 15 (1992): 183-247. References Harrington, A. Medicine, Mind, and the Double Brain. Princeton: Princeton University Press, 1987. Jackson, J. H. "On the Nature of the Duality of the Brain" [1874]. Reprinted in Brain 38 (1915): 80-103. Kinsbourne, M. "The Ontogeny of Cerebral Dominance." Annals of the New York Academy of Sciences 263 (1974): 244-250. Kuhn, T. S. The Structure of Scientific Revolutions. Chicago: University of Chicago Press, 1962. Lenneberg, E. H. Biological Foundations of Language. New York: Wiley, 1967. References Newman, J. H. Selected Sermons. Ed. I. Ker. New York: Paulist Press, 1994 Nottebohm, F. "Neural Lateralization of Vocal Control in a Passerine Bird: (i.) Song. Journal of Experimental Zoology 177 (1971): 229-261. Sherrington, C. S. Integrative Action of the Nervous System. London: Scribner, 1906. Wigan, A. L. A New View of Insanity: The Duality of the Mind. London: Longman, Brown, Green and Longman, 1844.

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