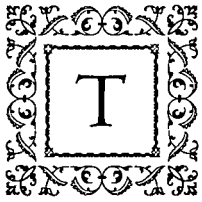


The First Theory about Hemispheric Specialization: Fresh Light on an Old Codex

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I. HEMISPHERIC SPECIALIZATION



HE human brain is double, just like that of all other living creatures.” With these words the anonymous author of *The sacred disease* started his description of the brain.¹ The fact that the brain consists of two hemispheres is, indeed, its most conspicuous property. It is only when the hemispheres are pushed apart that one recognizes that they are interconnected by a massive bundle of nerve fibers, the corpus callosum.

The cerebral hemispheres look like mirror images of each other at first sight,² but they are not: there are systematic anatomical and functional differences. Thus, the left hemisphere plays a greater role in language processing and accordingly has a larger planum temporale.³ The right hemisphere, on the other hand, is specialized for the perception of global spatial relationships.⁴ The functional asymmetry of the brain should not be confused with the principle of contralateral innervation, the fact that each hemisphere is primarily connected with the opposite

1. Hippocrates (ca. 460–375 B.C.) (?), *De morbo sacro* 3, Littré VI 366. Cf. Aristotle (384–322 B.C.), *Historia animalium* I 16, Bekker 494 b 31: “The brain is bipartite in all animals.” Here and in the following, “Littré” refers to E. Littré, ed., *Œuvres complètes d’Hippocrate*, 10 vols. (Paris, 1839–61). “Bekker” refers to I. Bekker, ed., *Aristotelis opera*, 5 vols. (Berlin, 1831–70).

2. This is how Galen (129–ca. 210), for example, saw them: see his *De placitis Hippocratis et Platonis* VIII, Kühn V 789. Here and in the following, “Kühn” refers to C. G. Kühn, ed., *Claudii Galeni opera omnia*, 20 vols. (Leipzig, 1821–33).

3. This anatomical fact was not discovered until 1968. See N. Geschwind and W. Levitsky, “Human brain: left-right asymmetries in temporal speech region,” *Science*, 1968, 161, 186–87.

4. A survey of modern views about hemispheric specialization is to be found in S. P. Springer and G. Deutsch, *Left Brain, Right Brain*, 4th ed. (New York, 1993).

side of the body. This principle (which may already have been surmised in the time of Hippocrates)⁵ counterbalances the principle of hemispheric specialization: it implies that the hemispheres are to some extent mirror images of each other after all.⁶

The functional asymmetry of the brain was discovered in the nineteenth century.⁷ The first publications date from 1863. In this year, Gustave Dax (1815–74) drew attention to an article which his father, Marc Dax (1770–1837), had allegedly written in 1836 but which he had never published.⁸ According to Gustave, his father had pointed out that all of the more than forty cases of aphasia which he had observed in his life were correlated with lesions of the left cerebral hemisphere. Gustave unfortunately did not publish his father's article until 1865.⁹ In the same year that Dax *fils* began publishing his claims about Dax *père*, 1863, the famous Paris doctor Paul Broca (1824–80) realized that the speech center which he had discovered in 1861¹⁰ was located in the left hemisphere in all eight cases of aphasia which he had seen.¹¹ He did not yet dare draw a conclusion from this, but in 1865 confidently asserted that "we speak with the left hemisphere."¹²

5. We will return to this point in section 7.

6. Benton has rightly noted that the concept of contralateral innervation may have "operated to inhibit recognition of the possibility that the two hemispheres might not be equipotential with respect to other functions." A. L. Benton, "Historical development of the concept of hemispheric cerebral dominance," in S. F. Spicker and H. T. Engelhardt, Jr., eds., *Philosophical Dimensions of the Neuro-Medical Sciences* (Dordrecht, 1976), pp. 33–57, citation on p. 42.

7. A survey of nineteenth-century views about hemispheric specialization is to be found in A. Harrington, *Medicine, Mind, and the Double Brain: A Study in Nineteenth-Century Thought* (Princeton, N.J., 1987).

8. See, for example, *Comptes rendus hebdomadaires des séances de l'Académie des Sciences*, 1863, 56, 536: "M. Dax soumet au jugement de l'Académie un Mémoire intitulé: 'Observations tendant à prouver la coïncidence constante des dérangements de la parole avec une lésion de l'hémisphère gauche du cerveau'" The case of Marc Dax is recounted in M. Critchley, "La controverse de Dax et Broca," *Revue neurologique*, 1964, 110, 553–57 [English translation in Critchley, *The Divine Banquet of the Brain and Other Essays* (New York, 1979), pp. 72–82]; in R. J. Joynt and A. L. Benton, "The memoir of Marc Dax on aphasia," *Neurology*, 1964, 14, 851–54; in Harrington, (n. 7) *Double Brain*, pp. 45–47; and in S. Finger, *Origins of Neuroscience* (New York and Oxford, 1994), pp. 391–92.

9. M. Dax, "Lésions de la moitié gauche de l'encéphale coïncident avec l'oubli des signes de la pensée (lu à Montpellier en 1836)," *Bulletin hebdomadaire de médecine et de chirurgie, 2me série*, 1865, 2, 259–62.

10. P. Broca, "Perte de la parole, ramollissement chronique et destruction partielle du lobe antérieur gauche du cerveau," *Bulletins de la Société d'Anthropologie de Paris*, 1861, 2, 235–38.

11. P. Broca, "Localisation des fonctions cérébrales.—Siège du langage articulé," *Bulletins de la Société d'Anthropologie de Paris*, 1863, 4, 200–04.

12. P. Broca, "Sur le siège de la faculté du langage articulé," *Bulletins de la Société d'Anthropologie de Paris*, 1865, 6, 377–93, citation ("nous parlons avec l'hémisphère gauche") on p. 384. A similar conclusion had already been drawn by A. Duval, "Siège de la faculté du langage articulé. Deux cas d'aphémie traumatique produite par des lésions de la troisième circonvolution frontale gauche," *Bulletins de la Société d'Anthropologie de Paris*, 1864, 5, 213–17.

The discovery of the functional asymmetry of the brain came as a complete surprise. In the first half of the nineteenth century everyone was convinced that the brain is functionally symmetric. A disturbance of the "harmony of the hemispheres" was thought to lead to mental illness.¹³ In the eighteenth century the possibility of cerebral asymmetry was likewise ruled out. Meinard Simon Du Pui's (1754–1834) doctoral dissertation *De homine dextro et sinistro* (1780) is a good illustration of this fact.¹⁴ Although the second part of this work (pp. 107–91) is solely concerned with unilateral neurological defects and although the cerebral hemispheres are frequently mentioned in it, neither Du Pui himself nor the many authors whose opinions he discussed referred to the possibility of hemispheric specialization.

Until recently, histories of hemispheric specialization invariably asserted that there are no publications in this field from before 1800.¹⁵ However, in 1981 I happened to notice a much older theory. It is preserved in a codex from about 1100 and it probably dates from classical antiquity. Some classical philologists already knew about this theory, but they had largely kept this knowledge to themselves.¹⁶ I published some articles about the theory¹⁷ and it has by now reached the standard literature about the history of hemispheric specialization.¹⁸ The reason that I want to discuss it again is that I have come to drastically different conclusions regarding the authorship, the dating, and the interpretation of the theory than I have put forward before. I relied too heavily on the

13. M.F.X. Bichat (1771–1802), *Recherches physiologiques sur la vie et la mort* (Paris, 1800), art. 1.3. See also H. Holland (1788–1873), *Medical Notes and Reflections* (London, 1839), ch. 12: "On the brain as a double organ."

14. M. S. Du Pui, *Dissertatio medica inauguralis de homine dextro et sinistro* (Leiden, 1780). Reprinted in J.C.T. Schlegel, ed., *Thesaurus pathologico-therapeuticus*, 2 vols. (Leipzig, 1789), I, 1–182. Broca knew this work, but he thought that it went too far: "Loin de moi la pensée de partager l'homme en deux êtres distincts, comme le fit, à un autre point de vue, Meinard Simon du Pui, dans sa dissertation intitulée: de *Homine dextro et sinistro*." Broca, (n. 12), citation on p. 393. On Du Pui, see D. Woudstra, "Meinard Simon Du Pui (1754–1834), stadsmedicus te Kampen," *Kamper almanak 1969–70*, 233–87.

15. See, for example, J. M. Oppenheimer, "Studies of brain asymmetry: historical perspective," *Ann. N.Y. Acad. Sci.*, 1977, 299, 4–17, p. 4: "It was in fact only in the nineteenth century that questions as to the possible asymmetry of function of the two cerebral hemispheres of *Homo sapiens* began to be raised."

16. There is only one non-philological reference to the theory that I know of: B. Révész, *Geschichte des Seelenbegriffes und der Seelenlokalisation* (Stuttgart, 1917), p. 20. Révész did not indicate his source.

17. G.J.C. Lokhorst, "An ancient Greek theory of hemispheric specialization," *Clio Med.*, 1982, 17, 33–38; idem, "The oldest printed text on hemispheric specialization," *Neurology*, 1982, 32, 762; idem, "Hemisphere differences before 1800," *Behav. Brain Sci.*, 1985, 8, 642.

18. See, for example, A. Harrington, "Nineteenth-century ideas on hemisphere differences and duality of mind," *Behav. Brain Sci.*, 1985, 8, 617–59 (esp. 648); idem, (n. 7) *Double Brain*, pb. ed. (Princeton, N.J., 1989), appendix; Finger, (n. 8) *Origins*, 386.

authority of Max Wellmann (1863–1933), the first modern editor of the text, and others have unfortunately followed me in this.

The text which I will discuss is still the only pre-1800 text about hemispheric specialization which has come to light. The only other passage which comes anywhere close is to be found on a drawing from about 1410. It reads as follows:

The forthyr parte of the brayn is hoot ande drye, the medyl parte hoot ande moyste, the hyndyr parte colde ande moyste, the rygth syde hoot ande dry, the leyfte syde colde ande dry.¹⁹

This theory is undoubtedly based on the doctrine of the four humors, according to which the right side of the body is dominated by the hot and dry “yellow bile” produced by the liver and the left side of the body by the cold and dry “black bile” produced by the spleen.²⁰ The theory is curious, but it is not a theory about the *functional* asymmetry of the brain. It cannot be compared to any other modern theory about cerebral asymmetry either. It is therefore likely that the theory which we will discuss is really the only one which anticipates the nineteenth-century discovery of hemispheric specialization.

The rest of this article is organized as follows. We will start by gradually zooming in on the theory about hemispheric specialization contained in the medieval codex. (It goes without saying that the theory cannot be understood if we pay no attention to the context in which it was put forward.) We will first discuss the codex and its editions (section 2), then the treatise which contains the theory in question (sections 3 and 4), then the relevant passages of this treatise (section 5), and then, finally, the theory about hemispheric specialization itself (section 6). This having been done, we will zoom out and make some general remarks about the background of the theory and its relationship to the developments which have occurred since the time it was proposed (section 7).

2. THE CODEX AND ITS EDITIONS

The theory in question is to be found in an anonymous medical treatise

19. Cambridge, Trinity College, ms. o.2.40, fol. 57v. Reproduced in E. Clarke and K. Dewhurst, *An Illustrated History of Brain Function* (Berkeley and Los Angeles, 1972), p. 21, fig. 24. See also W. Sudhoff, “Die Lehre von den Hirnventrikeln in textlicher und graphischer Tradition des Altertums und Mittelalters,” *Archiv für Geschichte der Medizin*, 1913, 7, 149–205, esp. 196–98.

20. The doctrine of the four humors is about as old as the Corpus Hippocraticum and dominated physiological thinking until the eighteenth century, so the fact that the remark on the drawing is based on this doctrine gives us no clue as to its provenance. The doctrine is well described in E. Schöner, *Das Viererschema in der antiken Humoralpathologie* (Sudhoffs Archiv, Beihefte, Heft 4) (Wiesbaden, 1964).

which nowadays bears the title *De semine* (On sperm). This treatise has only been preserved in manuscript no. 1342–50 of the Royal Library at Brussels (folio 48r–52v).²¹ This codex probably dates from the end of the eleventh century or the beginning of the twelfth century.²² A fifteenth-century inscription on the first page reveals that it originally belonged to the monastery of Saint Pantaleon in Cologne.²³ In the beginning of the sixteenth century, Count Hermann von Neuenar (1492–1530), the humanist friend of Erasmus (ca. 1466–1536), who lived and worked in the vicinity of Cologne, took the initiative to publish a part of the codex, but he died before he could complete this project.²⁴ His nephew Hermann the Younger, Count of Neuenar and Mörs (1514–78), published the part which his uncle had finished editing—including the *De semine*—in 1532.²⁵ He praised his uncle's emendations,²⁶ but more than three centuries later Valentin Rose (1829–1916) could still not hide his irritation.²⁷

21. Descriptions of the codex are to be found in C. Daremberg, "Aurelius de Acutis passionibus," *Janus: Zeitschrift für Geschichte und Literatur der Medicin*, 1847, 2, 468–99, 690–731; in V. Rose, *Theodori Prisciani Euporiston Libri III* (Leipzig, 1894), pp. iv–v; and in A. Beccana, *I codici di medicina del periodo pre-salernitano (secoli IX, X e XI)* (Rome, 1956), pp. 109–12.

22. I follow Beccana's dating. Daremberg (see n. 21) and many others in his wake dated the codex in the twelfth century.

23. Cf. K. Löffler, *Kölnische Bibliotheksgeschichte im Umriß* (Cologne, 1923), pp. 18, 80 (p. 80 erroneously refers to p. 14 instead of p. 18); see also S. Krämer, *Handschriftenerbe des deutschen Mittelalters*, 2 vols. (München, 1989), II, 450. The monastery of St. Pantaleon was founded between 955 and 964. Its early history is described in H. J. Kracht, *Geschichte der Benediktinerabtei St. Pantaleon in Köln 965–1250* (Siegburg, 1975). It is not known when the codex was removed from the monasterial library. Many manuscripts had already been sold by 1718 (Löffler, op. cit., 6); many others were taken away during the French occupation of 1794–1802 (ibid., 39–42). Sir Thomas Phillipps (1792–1872) seems to have possessed the codex in the 1830s (see the *Catalogus librorum manuscriptorum in bibliotheca D. Thomae Phillipps, Bt., impressum typis Medio-Montanis 1837* as reproduced in A.N.L. Munby, ed., *The Phillipps Manuscripts* (London, 1968), no. 3701). The Brussels library owned it by 1839 (F.J.F. Marchal, ed., *Inventaire des manuscrits de l'ancienne Bibliothèque Royale des Ducs de Bourgogne* (Brussels, 1839), nos. 1342–50).

24. On Count von Neuenar, see: *Allgemeine Deutsche Biographie*, 56 vols. (Leipzig, 1875–1912), XXIII, 485–86; P. G. Bietenholz and T. B. Deutscher, eds., *Contemporaries of Erasmus*, 3 vols. (Toronto, 1985–87), III, 14–15; and C. G. Nauert, Jr., "Graf Hermann von Neuenahr and the limits of humanism in Cologne," *Historical Reflections*, 1988, 15, 65–79. The Count is often mentioned in Erasmus's letters. See P. S. Allen, H. M. Allen, and H. W. Garrod, eds., *Opus epistolarum Desiderii Erasmi Roterodami*, 12 vols. (Oxford, 1906–58).

25. Count Hermann von Neuenar, ed., "Octavii Horatiani Rerum medicarum libri quatuor," in *Octavii Horatiani Rerum medicarum libri quatuor* [etc.] (Strasbourg, 1532), pp. 1–114. Bound together with many other works in *Experimentarius medicinae, continens Trotulae Curandarum aegritudinum muliebrium, ante, in et post partum lib. unicum; Oct. Horatiani De curationibus omnium ferme morborum homini accidentium* [etc.] (Strasbourg, 1544). Reprinted in *Medici antiqui omnes, qui latinis literis diversorum morborum genera et remedia persecuti sunt, undique conquistii, et uno volumine comprehensi* [etc.] (Venice, 1547), fols. 291r–317r.

26. He did so in his dedication of the book to Count Hermann von Wied (1477–1552), the archbishop of Cologne, who was a relative of the Neuenars.

27. He said that "Hermann's monstrous work [*labor monstruosus*], which was the result of double perfdy because he superimposed his own emendations on top of the licenses and idle interpretations of the

The most recent edition of the *De semine* dates from 1901.²⁸ It was prepared by Max Wellmann, "the greatest authority on classical medicine of his time."²⁹ Wellmann's edition is more reliable than Count von Neuenar's, but it is far from perfect, as will appear below. Moreover, its long introduction is definitely outdated. At this moment, Armelle Debru is preparing a new edition.³⁰

3. THE CONTENTS OF THE *DE SEMINE*

The contents of the *De semine* are rather heterogeneous. The treatise may be divided into the following parts. The numbers between brackets refer to Wellmann's rather arbitrary section numbers.

- I. A doxographical treatise on spermatogenesis (1-8).
- II. Isolated remarks about kidney stones (9), mother's milk (10), puberty (11), embryology and birth (12-16).
- III. Respiration (17) and perception: the senses in general (18), vision (19), taste (20), smell and hearing (21), the voice (22), touch (23).
- IV. Isolated remarks about menstruation (24), sperm (25), and multiple births (26).
- V. The etiologies of icterus (27), sleep (28), hunger (29), dysentery (30), obstipation (31), digestion and respiration (32), epilepsy (33), sneezing and tinnitus (34), tetanus (35), pneumonia (36), pleuritis (37), hiccough (38), and dropsy (39).
- VI. Isolated remark about the four subdivisions of medicine and the thirteen parts of the body (40).
- VII. The soul, the blood, and the *pneuma*, the veins and the arteries, the heart and the brain, *phrenitis*, the faculty of perception, and the intellect (41-44).

'learned' twelfth century, undeservedly achieved eternal fame by being included in the Aldine collection of medical writers which everybody knew and could easily consult." Rose, (n 21) *Theodorus Priscianus*, iv.

28. M. Wellmann, *Die Fragmente der sikelischen Ärzte Akron, Philistion und des Diokles von Karystos* (Berlin, 1901). Philip van der Eijk is currently preparing a new edition of the fragments of Diocles of Carystus. It will not include the *De semine*.

29. F. Kudlien, "Probleme um Diokles von Karystos," *Sudhoffs Archiv*, 1963, 47, 456-64; citation on p. 456.

30. She has already carried out some preliminary work. See A. Debru, "La doxographie dans le *De semine* de Vindicianus" (unpublished paper read at the Quatrième colloque international sur les textes médiévaux latins antiques, Santiago de Compostela, September 1992) and A. Debru, "Le *De alimento* et l'anonyme de Bruxelles" (unpublished paper read at the Huitième colloque international hippocratique, Staffelstein, September 1993).

Part I is fairly coherent. The text has a clear structure, because it continually compares the claims of a mixed company of authors (Diogenes of Apollonia, Erasistratus, Herophilus, the Stoics, Aristotle, Hippocrates, Herodotus, Asclepiades) with those of Diocles of Carystus (fourth century B.C.). The latter's views are apparently preferred. The author mentioned one of his sources: Alexander Philalethes (first half of the first century A.D.), *De semine*, book I.

From part II onwards the text is hardly more than a series of isolated remarks. Hippocrates is mentioned in §9, §13 and §14, but after this there is no mention of any authority. Most sections state that "he" says (*inquit, dicit*) such-and-such, but they leave us in the dark about the identity of this person. Debru thinks the author was still referring to Hippocrates,³¹ but the abrupt caesura between parts II and III makes this unlikely. Moreover, the author would not have used the phrase "as we have mentioned in one of the six books of the *Epidemics*"³² if he were writing about the views of the author of the *Epidemics*.

4. THE AUTHOR AND HIS SOURCES

The author of the *De semine* is not known. Misled by a line on fol. 1^v of the codex, Von Neuenar attributed it to Octavius Horatianus, a physician from the fourth century A.D. Later scholars attributed it to Theodorus Priscianus (beginning of the fifth century A.D.).³³ Rose was the first one to call this in question. He also pointed out that §§14–16 of the *De semine* resemble §§19–20 of the *Gynaecia* of Priscianus's teacher, Avianus Vindicianus (end of the fourth century A.D.).³⁴ This inspired Wellmann to attribute the whole treatise to Vindicianus.³⁵ This ascription has been widely accepted ever since. There is little evidence against it, except that the treatise does not have the epistolary form which is characteristic for Vindicianus.

31. Debru, (n. 30) "La doxographie."

32. *De semine*, last sentence, my italics. See n. 46 and n. 52 below.

33. When Theodorus Priscianus's *Euporista* was published (just after Neuenar's death) it became clear that the first three books of Neuenar's so-called Octavius Horatianus were identical with that work. Neuenar's fourth book (which included the *De semine*) was from then on also attributed to Theodorus Priscianus. See Sigismundus Gelenius (1497–1554), ed., *Theodori Prisciani archiatri ad Timotheum fratrem Phaenomenon Euporiston liber I, Logicus liber II, Gynaecia ad Salvinam liber III* (Basel, 1532). Modern German translation in Th. Meyer, *Theodorus Priscianus und die römische Medizin* (Jena, 1909).

34. Rose, (n. 21) *Theodorus Priscianus*, pp. 448–55.

35. Wellmann, (n. 28) *Fragmente*, 3–4. See also K. Deichgräber, "Vindicianus," in G. Wissowa et al., eds., *Paulys Realencyclopädie der classischen Altertumswissenschaft, Zweite Reihe, 17. Halbband* (Stuttgart, 1961), cols. 29–36.

The author's sources are unknown. Alexander Philalethes, who is explicitly mentioned in part I, is of course a likely source for this part. Wellmann thought the rest of the treatise was based on the lost writings of Soranus of Ephesus (first half of the second century A.D.), but this is hardly more than speculation.³⁶ The Greek citations in the text only allow us to conclude that the author had some Greek medical writings in front of him.

Finally, it is unclear whose views parts II–VII are setting forth—if they are indeed concerned with the opinions of one and the same person. Wellman thought they expressed the doctrine of Diocles of Carystus, but almost all later scholars have disputed this.³⁷ Nobody has, however, proposed another candidate.

5. THE RELEVANT PASSAGES

Parts III and VII are the most interesting ones from our point of view. Part III starts with a discussion of respiration, which is continued in §32. The theory is rather standard. The air enters and leaves the body through the lungs and the pores in the skin.³⁸ The heart is the motor of the respiratory process. The air flows from the heart to all organs and tempers their heat.³⁹

Sections 18–23 contain a theory of perception which is strongly reminiscent of the Stoic doctrine.⁴⁰ The soul is primarily located in the heart. It is endowed with a “perceptive faculty”⁴¹ which moves back and forth between the heart and the surface of the body.⁴² The perceptive faculty is in contact with the outer world through the pores in the sensory or-

36. Wellmann, (n. 28) *Fragmente*, pp. 6–8. Werner Jäger (1888–1961) thought the entire treatise could be traced back to Soranus of Ephesus. See W. Jäger, *Diokles von Karystos. Die griechische Medizin und die Schule des Aristoteles* (Berlin, 1938).

37. See, for example, Jäger, (n. 36) *Diokles von Karystos*, pp. 190–91; C.R.S. Harris, *The Heart and the Vascular System in Ancient Greek Medicine: From Alcmaeon to Galen* (Oxford, 1973), pp. 103–06; Debru, (n. 30) “La doxographie.”

38. The notion of poral respiration is due to Empedocles (495–435 B.C.). See Harris, (n. 37) *Heart and Vascular System*, pp. 15–18.

39. Wellmann, (n. 28) *Fragmente*, pp. 44–45, 105, and Debru, (n. 30) “La doxographie,” suggest that the last sentence of §17 is related to Hippocrates (?), *De corde* 11, Littré IX 88–90 (a work which probably dates from the Hellenistic period), but I think there is no connection.

40. The connection with the Stoic doctrine has also been pointed out by Wellmann, (n. 28) *Fragmente*, pp. 44–51, and Debru, (n. 30) “La doxographie.” S. Sambursky, *Physics of the Stoics* (London, 1959), chs. 1 and 2, gives an interesting exposition of the Stoic account of perception.

41. Latin: *virtus sensifians* (§18), *virtus sensifica* (§§18–20), *virtus rationabilis* (§19), *virtus sensualis* (§21).

42. §19 states that the perceptive faculty travels from the soul in the heart to the sense organs, whereas §18 states that the perceptive faculty is transmitted to the soul (“ad animam transmittatur”). See Sambursky, (n. 40) *Physics of the Stoics*, ch. 2, for similar views.

gans. These pores vary with the senses, which accounts for the differences between the senses. If the pores of the skin had the same diameter as those of the eyes, we would see with our whole body. The finest channels are the best conveyors of the perceptive faculty because they allow the least admixture of air; this explains why the eye is the most acute sensory organ.⁴³ Sensation arises not only in the heart (§§18–19) but also in the brain (§21).⁴⁴

The passage about hemispheric specialization is to be found in part VII. This passage is, unfortunately, neither concerned with the air within the body nor with the perceptive faculty, but with something else, namely the so-called *pneuma* (Latin: *spiritus*). The relationships between these three concepts are not made clear in the text, but the author seems to have adopted the general Stoic view that the *pneuma* is a subtle, airlike substance or material which serves as the medium, substrate, or vehicle of the perceptive faculty.⁴⁵

Part VII reads, in translation, as follows:⁴⁶

43. This theory is due to Diogenes of Apollonia (ca. 430 B.C.). See Theophrastus, *De sensu* 40–42, cited in H. Diels and W. Kranz, *Die Fragmente der Vorsokratiker*, 6th ed., 3 vols. (Berlin, 1951–52), II, 55, lines 13 ff.

44. “Item cerebrum sine odore esse constituit atque sine sono, siquidem in ipso sit apprehensio odorandi atque tangendi seu audiendi.” That is: “He has also established that the brain has no odor and makes no sound, because the conscious perception of smelling and touching or hearing takes place in that organ” (*De semine* §21). This sentence is embedded in a series of remarks about the senses (§§20–23) which are strongly reminiscent of the Hippocratic *De caribus* 15–18, Littré VIII 602–08.

45. Cf. Sambursky, (n. 40) *Physics of the Stoics*, chs. 1 and 2.

46. The Latin text reads as follows. I have made some emendations; the places where my text differs from the Brussels codex (fol. 52v) or Wellmann, (n. 28) *Fragmente*, pp. 233–34, are respectively indicated by a “B” and a “W.” The numbering is due to Wellmann. “§41. Animae regimen in corde consistit, quae per subtilitatem spiritus seminata est per omnem corporis regionem [retentionem B], quod graecae [grece B] dicimus τί ἐστὶ ψυχῆ; πνεῦμα λεπτομερές παρεσπαρμένον ὄλω τῷ σώματι καὶ ἐξ οὗ κίνησις, αἴσθησις [tīestis sicypneum, aleptomenes partes parmēno alo to somati atque eis vicinis atteris B]. §42. Degestionem inquit fervore fieri et separatas esse corporis maternas sanguinem in venis continen, spiritum in arteriis. §43. Sed pulmonem esse veluti [velut W] cellarium spiritus ad artenas mittendi seu replendi [replens B] omnem [omnis B] corporis regionem, ex quo spiritu omnes nostri artus [arcus B] commoventur [commovebuntur B]. §44. Freneticam passionem inquit fieri tumore, in corde [in corde B pace W pp. 19–20, 234] effecto [suffecto B] et suffocato [offocato B] sanguine, seu calore consuetudinario, ex quo cerebrum sensum et intellectum praebet. Aliud est enim quo [quod B] intellegitur, aliud quo [quod B] sentitur. Sic itaque duo cerebra sunt in capite constituta, unum quod intellectum dat, aliud quod sensum praebet, id est [idque W] quod in dextra parte iacet, ab eo sentitur, a sinistro vero intellegitur, ob hoc sub ea parte subsidente corde et semper vigilante, audiente et intellegente [intelligente W], quia et aures habet ad audiendum. Quod et pericardia [praecordia B] habet ventres [ventris BW], id est receptacula sanguinis et spiritus singulis in partibus secundum aures, nunc ex venis promere sanguinem, nunc ex artenis [arteria W] spiritum, ut graecae [grece B] dicimus ἀρτηρία μικρὸν μὲν <τὸ> αἷμα, πολὺ δὲ τὸ πνεῦμα, αἰ δὲ φλέβες πολὺ ἔχουσι <τὸ> αἷμα, μικρὸν δὲ τὸ πνεῦμα [arteriam microne hema pollude, topneuma de flebis pollude, ethusinhema micron de topneuma B], id est arteria multum habet spiritum et modicum sanguinem, venae [Bene B] autem multum habent sanguinem et modicum spiritum, sicuti memoravimus in libro undecimo, quem epidemion [eridimion B] appellavimus, qui sunt libri sex.” Cf. *Octavius Horatianus* (n. 25), pp. 113–14, and *Medica antiqui* (n. 25),

- §41. The leading part of the soul, which is disseminated throughout the whole body as a result of the subtlety of the *pneuma*, is located in the heart. Or as we say in Greek: "What is the soul? A subtle *pneuma* which is distributed throughout the whole body and which gives rise to movement and sensation."
- §42. He says that the digestive process takes place through heating and that the blood and the *pneuma*, which are respectively contained in the veins and in the arteries, are separate constituents of the body.
- §43. He says that the lungs are a kind of reservoirs from which the *pneuma* is sent to the arteries and the whole body is replenished, as a result of which all our limbs are moved by *pneuma*.
- §44. He says that *phrenitis* is caused by an inflammation⁴⁷ of the heart and a suffocation of the innate heat, on the basis of which the brain provides sensation and intellect. That with which we understand is namely different from that with which we perceive. There are accordingly two brains in the head. The one gives us our intellect, the other provides the faculty of perception. That is to say: the brain on the right side is the one that perceives, whereas the left brain is the one which understands. As a result of this, this is also being done by the heart,⁴⁸ which lies under the latter organ, and which is also continually vigilant,⁴⁹ hearing and understanding, because it too has ears to hear. And because, as he says, the pericardium⁵⁰ has ventricles, i.e., receptacles of blood and *pneuma* on different sides be-

fol. 317r. Fol. 52v of the Brussels codex is partially reproduced in Lokhorst, (n. 17) "An Ancient Greek theory" Page 114 of *Octavius Horatianus* (n. 25) is partially reproduced in Lokhorst, (n. 17) "The oldest printed text."

47. Latin: *tumor*. According to the classic definition of Celsus (ca. 25 B.C.—ca. A.D. 50), an inflammation is characterized by *tumor* (swelling), *rubor* (redness), *calor* (heat), and *dolor* (pain).

48. Längin gives a different translation: "So liegen also zwei Gehirne im Kopf: das eine, das den Verstand, das andere, das die sinnliche Wahrnehmung ermöglicht; und mit dem, was auf der rechten Seite liegt, nimmt man wahr, mit dem linken aber versteht man; und zwar deshalb, weil an dieser Seite das Herz darunterliegt und stets wacht, hört und versteht; es hat ja auch Ohren zum hören" (H. Längin, "Duo Cerebra—Die Asymmetrie der beiden Gehirnhälften: Zur antiken Medizin im Lateinunterricht," *Die alten Sprachen im Unterricht*, 1987, 33:2, 17–21; citation on p. 19, my italics). This translation, in which the causal sequence is reversed, has to be rejected because: (1) the German "und zwar deshalb, weil" corresponds, in the language of the *De semine*, to "ob hoc, quia" (*De semine* §11); (2) apart from the just-mentioned use of "ob hoc" in §11, the *De semine* constantly uses "ob hoc" to refer to something that was said before; and (3) the remarks about perception in §§18–19 make it clear that the heart, not the brain, is both the starting point and the terminal point in the process of perception. The heart is the receiver of that which the brain provides ("praebet"). Harris, (n. 37) *Heart and Vascular System*, p. 105, neutrally translated "ob hoc" as "and," but he had the same view of the relationship between the heart and the brain, as will become clear below (text to n. 67).

49. The image of the heart as a watchman may also be found in Plato (429–347 B.C.), *Timaeus*, 70 A, and in Hippocrates (?), *De corde* 1, Littré IX 80.

50. The Brussels codex uses the term *praecordia*. This word has several meanings, but none of them is appropriate here. Cf. *Thesaurus Linguae Latinae*, Vol. X, Part 2, Fasc. IV (Leipzig, 1985), cols. 509–12.

hind the ears,⁵¹ it alternately draws blood from the veins and *pneuma* from the arteries, or as we say in Greek: “The artery has little blood and much *pneuma*, whereas the veins contain much blood and little *pneuma*.” That is: the artery has much *pneuma* and little blood, whereas the veins contain much blood and little *pneuma*. We have already mentioned this in the eleventh book, which we have called *Epidemics*, and which consists of six books.⁵²

The just-quoted passage in fact contains five different theories: (1) a theory about the nature of the soul; (2) a theory about the contents of the blood vessels; (3) a theory about the causes of *phrenitis*; (4) the theory about hemispheric specialization which we are primarily interested in; and (5) a theory about the function of the pericardium, the ventricles, and the “ears” of the heart. Let us discuss (1)–(3) and (5) first.

(1) The pneumatic conception of the soul which is to be found in §41 and §43 is clearly related to the doctrine of the Stoics. They regarded the soul as a subtle entity which is present in all parts of the body and which has a leading part (the *hêgemonikon*) in the heart. The pseudo-Galenic *Definitiones medicae*, which was presumably written in the first century A.D., contains a description of the Stoic conception of the soul which is almost literally identical with the Greek citation in §41.⁵³ Despite the Stoic terminology, §41 and §43 do not conflict with what we know about the opinions of Diocles of Carystus. Although he was a cardiocentrist, he said that the *pneuma* spreads from the heart to all parts of the body, including the brain.⁵⁴

51. Cf. Hippocrates (?), *De corde* 4, Littré IX 82: “The heart has two bellies [Greek: *gasteras*], which are separated from each other, but enclosed in one envelope, one on the one side, the other on the other.” The “envelope” is the pericardium and the “bellies” are the ventricles (literally: “little bellies”) of the heart. Quoting *De corde* 10, Littré IX 86–88, Wellmann, (n. 28) *Fragmente*, p. 234, note to line 8, suggested that *ventres* [ventris BW] refers to the *valvulae cordis*, but the just-given citation from *De corde* 4 is clearly more to the point.

52. The Hippocratic *Epidemics* consists of seven books, but the ancient commentators regarded the seventh book as spurious (see Daremberg, (n. 21), p. 475, n. 9, and Wellmann, (n. 28) *Fragmente*, p. 4, n. 3). The claim about the contents of the veins and the arteries which is referred to in the text cannot be found in the *Epidemics* as we know it.

53. Galen (?), *Definitiones medicae*, definition 29, Kühn XIX 355. This work was probably written in the first century because it mentions the Eclectic school (definition 14, Kühn XIX 353), which was founded in the first century B.C., but does not mention Galen (second half of the second century A.D.). It is usually regarded as a product of the Pneumatic school, which was founded in the first century B.C. by Athenaeus of Attalia, a pupil of the Stoic philosopher Poseidonius (ca. 135–51 B.C.). See M. Wellmann, *Die pneumatische Schule* (Berlin, 1895). There is one important difference between the *Definitiones medicae* on the one hand and both the Stoic doctrine and the *De semine* on the other: the former work locates the *hêgemonikon* of the soul not in the heart but in the brain (definition 113, Kühn XIX 378; the text talks about “the heart [Greek: *kardia*] of the brain,” but this may be a scribal substitution for “the ventricle [Greek: *koilia*] of the brain”). Cf. Harris, (n. 37) *Heart and Vascular System*, pp. 235–38.

54. Galen, *An in arteriis natura sanguis contineatur* 8, Kühn IV 731, asserts that Diocles and many others maintained that all parts of the body draw *pneuma* from the heart. According to the *Anonymus*

(2) The theory that the arteries contain little blood and much *pneuma* (§42, §44) was widespread in classical antiquity. This theory was based on the correct observation that the arteries are relatively bloodless after death.⁵⁵ The misconception that the same state of affairs obtains in the living body has been suggested as one of the main reasons that the ancients never discovered the circulation of the blood.⁵⁶ This theory is usually attributed to Praxagoras of Cos (a younger contemporary of Diocles) and his father Nicarchus, but may well be older.⁵⁷ There are no indications that Diocles held it.⁵⁸ Nor did he make a systematic distinction between arteries and veins.⁵⁹ It is therefore unlikely that §42 and §44 reflect his views. The Greek citation is again reminiscent of the *Definitiones medicae*.⁶⁰

(3) *Phrenitis* is a mysterious illness which has no obvious equivalent in modern psychiatry. Caelius Aurelianus (fifth century A.D.) described it as “an acute mental derangement accompanied by acute fever, a futile groping of the hands, seemingly in the effort to grasp something with the fingers, and a small, ‘thick’ [i.e., rapid] pulse.”⁶¹ It was explained in many different ways. Depending on the view one held about the location of soul, its cause was variously sought in the blood, the brain, the heart, or the diaphragm (Greek: *phrên*).⁶²

The theory about the etiology of *phrenitis* proposed in §44 does not fit in with what we know about Diocles’ doctrines.⁶³ He did not regard

Parisinus Fuchsii, Diocles located the “psychic *pneuma*” not only in the region of the heart but also in the brain. See R. Fuchs, “Anecdota medica graeca,” *Rheinisches Museum, Neue Folge*, 1894, 49, 532–58; fragment 2, p. 541, and fragment 5, p. 543 (= Wellmann, (n. 28) *Fragmente*, fragment 44, p. 137, and fragment 59, p. 142).

55. Harris, (n. 37) *Heart and Vascular System*, pp. 92–93.

56. *Ibid.*, leitmotiv.

57. *Ibid.*, pp. 8, 108–09.

58. Wellmann, (n. 28) *Fragmente*, pp. 79 n. 3, 90 n. 7.

59. Harris, (n. 37) *Heart and Vascular System*, p. 105. Wellmann (n. 28) *Fragmente*, p. 16, makes the opposite claim, but he presents no evidence for it. Euryphon of Cnidos, an earlier contemporary of Hippocrates, may have been the first physician who made a distinction between arteries and veins. Herophilus of Calchedon (ca. 335–280 B.C.), a pupil of Praxagoras and the founder of the school of Alexandria, was the first one to give a clear description of the anatomical differences between these two types of blood vessels. See Harris, (n. 37) *Heart and Vascular System*, pp. 24, 84, 108, 179, 281.

60. “A vein is a vessel for blood and the natural *pneuma* which is mixed with it, sinew-like, containing perception and the wet and hot substance. It has more blood [than the artery] and less of the vital *pneuma*. An artery is a vessel containing less but purer blood and more of the natural *pneuma* mixed with it and in a more refined form. It is hotter and drier and more perceiving [Greek: *aisthêtikôtera*] than the vein.” Galen (?), *Definitiones medicae*, definitions 73 and 74, Kühn XIX 365; English translation in Harris, (n. 37) *Heart and Vascular System*, p. 240.

61. Caelius Aurelianus, *Treatise on Acute Diseases* I 21; English translation in I. E. Drabkin, ed., *Caelius Aurelianus: On Acute Diseases and On Chronic Diseases* (Chicago, 1950), p. 15.

62. *Ibid.*, *Acute Diseases* I 8.

63. This was correctly pointed out by Harris, (n. 37) *Heart and Vascular System*, pp. 105–06. I want to thank Teun Tieleman for stressing the importance of this point.

phrenitis as an inflammation of the heart but as an inflammation of the diaphragm which hinders the proper functioning of the heart and the intellect (Greek: *phronêsis*) which is seated in the region of the heart.⁶⁴ The remarks about hemispheric specialization in §44 should therefore not be attributed to him without further evidence.

The explanation of *phrenitis* implies that the proper functioning of the brain is a prerequisite for perception and understanding. The brain requires a continual supply of blood and *pneuma* from the heart in order to function properly. If this supply is cut off, delirium and madness set in.⁶⁵

The emphasis on the essential role of the brain in perception and understanding which we encounter here is odd in view of the emphasis on the role of the heart which is to be found in §18 and §19 (but not in §21). (Vindicianus's *Epitome altera* shows a similar ambivalence, which lends support to Wellmann's ascription of the *De semine* to Vindicianus.⁶⁶)

What exactly did the author think about the relationship between the contribution of the heart to the processes of perception and understanding, on the one hand, and that of the brain, on the other? Harris suggested that the author meant that "the brain supplies the contents both of sensation and of intelligence, but it is the heart at the centre which hears and understands."⁶⁷ This interpretation is, however, at odds with §21, which clearly states that the brain perceives too (it says that there is an "apprehensio in cerebro").⁶⁸

As far as perception is concerned, we may reason as follows. First, the brain is an organ that cannot be by-passed on the pneumatic route between the sense organs and the heart. This explains why its proper functioning is a necessary condition for perception. Secondly, the author

64. Fuchs, (n. 54) "Anecdota medica graeca," fragment 1, p. 540 (= Wellmann, (n. 28) *Fragmente*, fragment 38, p. 134). This fragment also tells us that Praxagoras did regard *phrenitis* as an inflammation of the heart.

65. An obstruction of the flow of *pneuma* from the heart is not only one of the causes of *phrenitis*, it also causes epilepsy (*De semine* §33). In contrast with the theory about the causation of *phrenitis*, this explanation of epilepsy does not disagree with the theory which the *Anonymus Parisinus Fuchsii* ascribes to Diocles (and Praxagoras). See Fuchs, (n. 54) "Anecdota medica graeca," fragment 3, pp. 541-42 (= Wellmann, (n. 28) *Fragmente*, fragment 51, p. 140). See also Wellmann, (n. 28) *Fragmente*, pp. 26-29.

66. Vindicianus's *Epitome altera* states, on the one hand, that the mind and the soul reside in the heart (*Epitome altera* XVIII, in Rose, (n. 21) *Theodorus Priscianus*, p. 474; this passage will be quoted in n. 75) and, on the other hand, that man owes his intellect, sight, hearing, smell, and taste to the vessels in his brain: "Cerebrum est medulla capitis copiosis teneribus tenuisque implicatum venolis. Quod multum copiosius habemus quam reliqua animalia, ideoque omnibus illis sapientiores sumus, fistulas plus habendo unde intellectus nobis advenit, visus auditus odoratus et gustus" (*Epitome altera* III, in Rose, (n. 21) *Theodorus Priscianus*, pp. 467-68).

67. Harris, (n. 37) *Heart and Vascular System*, p. 105.

68. See n. 44 above.

probably thought that the *pneuma* in the brain is involved in perception because all *pneuma* in the blood vessels between the heart and the sensory organs partakes of perception. The Stoics did not confine the faculty of perception to the heart. It is coextensive with the *pneuma* and its perceptive capacity. Some Stoics even went so far as to say that the air outside the body which is in contact with the sensory organs “perceives together with us.”⁶⁹ The *Definitiones medicae* similarly states that both the arteries and the veins perceive; the arteries are “more perceptive” because they contain more *pneuma*.⁷⁰

The contribution of the brain to perception is therefore not entirely incomprehensible. It is, however, less clear how the author viewed the contribution of the brain to the intellect. The second part of the just-given explanation applies to the intellect as well: it is intimately connected with the *pneuma* which is present in all regions of the body, including the brain. The first part of the just-given explanation cannot, however, be applied to the intellect. We can therefore only speculate why the author thought that the brain makes an essential contribution to the intellect. He may have been influenced by Erasistratus’s (ca. 310–250 B.C.) theory according to which the brain “distils” a superior “psychic *pneuma*” from the grosser “vital *pneuma*” supplied by the heart (by means of a process called *anathumiasis*); Erasistratus maintained that this psychic *pneuma* is the basis of the higher cognitive functions.⁷¹

(5) The remark in §44 about the physiological roles of the pericardium, the ventricles, and the auricles⁷² is not very clear. There is some similarity with the Hellenistic *De corde*, but the *De corde* denies that the auricles have an auditive function.⁷³ The latter thesis is also rejected in

69. “Ipseque aer nobiscum videt nobiscum audit nobiscum sonat, nihil enim sine eo fieri potest.” That is: “The air sees and hears and speaks together with us because none of these things is possible without it.” Cicero (106–43 B.C.), *De natura deorum* II 83. Galen tells us that the Stoic philosopher Poseidonius, whom we have already mentioned before (n. 53) and who was one of Cicero’s teachers, held the same view. See Sambursky, (n. 40) *Physics of the Stoics*, p. 28.

70. Galen (?), *Definitiones medicae*, definitions 73 and 74, Kühn XIX 365. The relevant passage was quoted in n. 60. Harris made the obviously inappropriate remark that this doctrine “derives ultimately from Empedocles, who located consciousness in the blood surrounding the heart.” See Harris, (n. 37) *Heart and Vascular System*, p. 241.

71. This theory is discussed in *ibid.*, pp. 225–33, 348–63. Because Galen adopted it, it dominated physiological thinking until the eighteenth century.

72. We use the term “auricles” to refer to the ear-shaped appendages of the atria. (The term is ambiguous because it may, in clinical usage, also refer to the atria themselves.)

73. “And near the place where the veins grow out there are cavernous soft bodies bestriding the ventricles, which are called the ears, but they do not have any holes like ears, for they do not hear noises, but they are the instruments by which nature gets hold of the air. And I think they are the creation of a good craftsman. He foresaw that the heart would be a solid body, owing to the thick felty nature of

the Hippocratic *De morbo sacro*.⁷⁴ It is accepted in Vindicianus's *Epitome altera*, which again lends support to Wellmann's hypothesis that Vindicianus was the author of the *De semine*.⁷⁵

In my first publication about the theory of hemispheric specialization in §44, I wrote, on the authority of Wellmann, that "the theory is embedded in views which we [. . .] know to have been held by Diocles."⁷⁶ It will be clear from what has just been said that this claim is untenable. We have mainly found analogies with writings from later periods, namely the writings of the Stoics (third century B.C. and later), the *De corde* (third century B.C.?), the *Definitiones medicae* (first century A.D.?) and Vindicianus's *Epitome altera* (end of the fourth century A.D.).

6. THE PASSAGE ABOUT HEMISPHERIC SPECIALIZATION

The passage about the cerebral hemispheres⁷⁷ is the most remarkable part of §44. It does not have any parallel in the medical literature from classical antiquity. It was, to be sure, not uncommon to distinguish between sense and intellect,⁷⁸ to ascribe these faculties to different parts of the body,⁷⁹ or to ascribe them to the brain.⁸⁰ After the fourth century A.D. it even became common to assign them to *different* parts of the brain.⁸¹

its wall, which would not attract matter. So he placed beside it bellows like those the braziers have for their furnaces. It is through these auricles that the heart gets hold of its air. For you can see the two ventricles, that is the whole heart, tossing together, but the auricles blow out and collapse quite separately." Hippocrates (?), *De corde* 8, Littré 84–86; English translation in Harris, (n. 37) *Heart and Vascular System*, p. 87

74. Hippocrates (?), *De morbo sacro* 17, Littré VI 392.

75. Vindicianus, *Epitome Altera* XVIII, in Rose, (n. 21) *Theodorus Priscianus*, p. 474: "Duae aures habet, ubi mens hominum animusque commoratur. Unde quicquid nobis iudicii est, venit per ipsas cordis aures, omnis et cogitatio extollit et omnis erigitur tumulos." That is: "The heart, where the mind and soul of man reside, has two ears. Everything of which we have knowledge reaches us through those ears of the heart, and all our thoughts and emotions [Greek: *thumos*] are aroused in this way."

76. Lokhorst, (n. 17) "An ancient Greek theory," p. 34.

77. The text does not literally speak about the cerebral hemispheres but about the left brain and the right brain. This *totum pro parte* is, however, not uncommon; recall, for example, the title of the book by Springer and Deutsch, (n. 4) *Left Brain, Right Brain*.

78. This distinction was already made by Alcmaeon of Croton (ca. 500 B.C.). See Theophrastus, *De sensu* 25, quoted in Diels-Kranz, (n. 43) *Vorsokratiker*, I, 215, line 1.

79. Thus, the Pythagorean Philolaus of Croton (fifth century B.C.) said that "the brain is the seat of reason, the heart the seat of the soul and of sense perception." Diels-Kranz, (n. 43) *Vorsokratiker*, I, 413, line 5. (According to Diogenes Laertius, *Vitae philosophorum* VIII 30, cited in Diels-Kranz, (n. 43) *Vorsokratiker*, I, 450, line 17, Pythagoras himself (ca. 570–489 B.C.) maintained that "the seat of the soul extends from the heart to the brain.") Also recall Plato's *Timaeus*, according to which reason is located in the brain and the liver plays a role in perception.

80. Think, for example, of the *De morbo sacro*. Alcmaeon of Croton seems to have been the first encephalocentrist.

81. Nemesius, Bishop of Emesa (end of the fourth century A.D.), located perception in the lateral ventricles of the brain, reason in the third ventricle and memory in the fourth ventricle. Poseidonius of

There is, however, not a single document from the classical literature apart from the *De semine* in which the bold suggestion is made that perception and understanding are due to different cerebral hemispheres. The theory is, unfortunately enough, also quite isolated in the *De semine*. We can therefore only speculate about the reasons why its creator proposed it.

I can think of only one plausible explanation. It consists of four steps.

(1) To begin with, the ancient Greeks knew that the left ventricle and the aorta are relatively bloodless after death. It is easy to observe this in slaughtered animals.⁸² When the Alexandrians began to carry out dissections of human bodies in the third century B.C., this fact was quickly verified in the case of humans.⁸³ This observation was erroneously extrapolated to the living body: it was thought that the left ventricle was filled with *pneuma* rather than blood.⁸⁴ In combination with the pneumatic-cardiocentric conception of the soul, this gave rise to the view that soul is located in the left chamber of the heart. There are two passages in the Greek medical literature which illustrate this theory. The first is to be found in the Hellenistic *De corde*:⁸⁵

If a man, knowing the ancient order [rule] or custom,⁸⁶ removes the heart of a dead man and folds the membranes to,⁸⁷ neither can water get into the heart, nor air, if blown against them, particularly in the case of the left, for they were here designed more surely and rightly so, since the mind [*gnômê*] of man is located in the left ventricle and rules over the rest of the soul.

The other passage is to be found in the pseudo-Galenic *Historia philosophica*:⁸⁸

Byzantium (second half of the fourth century A.D.) held a similar theory, but located imagination in the front of the brain. St. Augustine (354–430 A.D.) located perception in the lateral ventricles, memory in the third ventricle, and motion in the fourth ventricle. Variants of these ventricular localization theories were popular until the eighteenth century. See Sudhoff, (n. 19); Clarke and Dewhurst, (n. 19) *Illustrated History*, ch. 2; and Finger, (n. 8) *Origins*, ch. 2

82. This has made Harns say that "the fact of the empty left ventricle [. . .] may very well have been known in the time of Alcmaeon." Harris, (n. 37) *Heart and Vascular System*, p. 91.

83. Cf. Hippocrates (?), *De corde* 6–11, Littré IX 84–90.

84. Hippocrates (?), *De corde* 6–11, Littré IX 84–90. This opinion was widespread. It was, for example, also held by Cicero (*De natura deorum* II 138), Rufus of Ephesus (beginning of the second century A.D.; see Harris, (n. 37) *Heart and Vascular System*, pp. 263–65), and Galen (Harris, *ibid.*, ch. 6 *passim*). It offers a second explanation of the fact that the ancients never thought of the possibility of a circulation of the blood.

85. Hippocrates (?), *De corde* 10, Littré IX 88.

86. It is generally assumed that this phrase refers to the traditional ancient Egyptian practice of embalming and mummification. See Harris, (n. 37) *Heart and Vascular System*, p. 89.

87. The "membranes" are the cusps of the semi-lunar valves of the aorta and the pulmonary trunk.

88. Galen (?), *De historia philosophica* 28, Kühn XIX 315 (= Aetius, *De placitis philosophorum* IV 5, 7, cited in Diels-Kranz, (n. 43) *Vorsokratiker*, II, 57, line 3).

Diogenes [of Babylon]⁸⁹ locates the leading part of the soul in the arterial chamber of the heart, which is the pneumatic one.

In line with this theory, the thick-walled left ventricle was often regarded as the main location of the innate heat.⁹⁰

In sum, the left ventricle was considered to be superior to the right one. Like most other peoples, the Greeks generally viewed the *right* side as superior to the left side: right was associated with masculinity, strength, heat, light, luck and virtue, whereas left was associated with femininity, weakness, coldness, darkness, misfortune and meanness.⁹¹ The theory about the psychophysiological pre-eminence of the left ventricle is, however, a clear exception to this rule.⁹²

(2) One may now imagine that the inventor of the theory described in §44 transferred the just-presented picture of the superiority of the left side of the heart to the brain. He may either have reasoned by analogy or he may have thought that each hemisphere is primarily connected with the ipsilateral ventricle of the heart.⁹³

(3) At the same time, Greeks generally regarded the intellect as superior to the faculty of perception. It is the intellect which distinguishes

89. This identification of "Diogenes" is due to G. P. Weygoldt, "Zum Verständnis einer pseudo-plutarchischen Nachricht über Diogenes," *Jahrbuch für klassische Philologie* (Leipzig, 1881), pp. 508–11. Cf. M.-P. Duminil, *Le sang, les vaisseaux, le cœur dans la collection hippocratique: anatomie et physiologie* (Paris, 1983), p. 57, and Harris, (n. 37) *Heart and Vascular System*, p. 25 n. 2. Diogenes of Babylon was a Stoic philosopher who lived from ca. 250 B.C. to ca. 150 B.C. He was the author of a lost book *On the leading part of the soul* which is mentioned in Galen, *De placitis Hippocratis et Platonis* II, Kühn V 241. Diels and Wellmann made the suggestion to replace "Diogenes" by "Diocles" (of Carystus), but this proposal was based on nothing but wishful thinking. See Diels-Kranz, (n. 43) *Vorsokratiker*, II, 57 n. 3, and Wellmann, (n. 28) *Fragmente*, pp. 79 n. 3, 103–04, 122 n. 2.

90. See, for example, Hippocrates (?), *De corde* 6, Littré IX 84. This opinion was shared by Galen (see Harris, (n. 37) *Heart and Vascular System*, ch. 6 *passim*) and doubtlessly by many others as well.

91. See G.E.R. Lloyd, "Right and left in Greek philosophy," *J. Hellenic Studies*, 1962, 82, reprinted in G.E.R. Lloyd, *Methods and Problems in Greek Science* (Cambridge, 1991), ch. 2.

92. *Ibid.* Lloyd did not notice this fact because he did not discuss any post-Aristotelian account of heart functioning.

93. The latter idea is analogous to the nineteenth-century suggestion that the dominance of the left hemisphere is due to a better supply of blood on the left side. See A. de Fleury, "Mémoire sur la pathogénie du langage articulé," *Gazette hebdomadaire de médecine et de chirurgie*, 2me série, 1865, 2, 228–32, 244–50; *idem*, "Du dynamisme comparé des hémisphères cérébraux dans l'homme," *Association française pour l'avancement des sciences*, 1872, 1, 834–45; W. Ogle, "On dextral pre-eminence," *Medico-Chirurgical Transactions*, 1871, 54, 279–301; P. Broca, "Rapport sur un mémoire de M. Armand de Fleury intitulé: *De l'inégalité dynamique des deux hémisphères cérébraux*," *Bulletins de l'Académie de Médecine*, 1877, 6, 508–39. See also Harrington, (n. 7) *Double Brain*, p. 78; Oppenheimer (n. 15), p. 5; and A. van Straaten, *Proeve ener verklaring van het verschijnsel der linkshandigheid* (Lochem, 1952), pp. 21–33. This nineteenth-century suggestion is still alive today. See, for example, A. Carmon and G. H. Gombos, "A physiological vascular correlate of hand-preference: possible implications with respect to hemispheric cerebral dominance," *Neuropsychologia*, 1970, 8, 119–28.

man from the animals;⁹⁴ it is a more reliable source of knowledge than sense perception;⁹⁵ Plato even regarded it as the immortal part of the soul.⁹⁶

(4) It does not seem too far-fetched to suppose that the intellectual author of §44 combined theses (2) and (3) with each other and that this made him locate the superior intellect on the superior left side of the brain and the inferior faculty of perception on the inferior right side. We do not know why he wanted to associate intellect and perception with different hemispheres, but if the just-given argument is correct, he could, once under the spell of this desire, hardly have made a different choice. "Is it possible that the localization could just as readily have been the other way around?" Harrington has asked.⁹⁷ It will be clear that the answer is negative.⁹⁸

7. CONCLUSIONS

If the just-given speculative rational reconstruction of the origin of the theory about hemispheric specialization in §44 is correct, then the following two conclusions may be drawn.

First, the theory should not be attributed to Diocles of Carystus. The fact that the human left ventricle is relatively bloodless after death—a fact on which step (1) of the argument crucially depends—did not become known until the Alexandrians started to dissect human bodies in the third century B.C. The Stoic theory of perception in the *De semine* and the parallels with the *De corde*, the *Definitiones medicae*, and Vindicianus's *Epitome altera* likewise point to a date of origin after the fourth century B.C.

Secondly, it is clear that the theory is not based on careful observation

94. Alcmaeon according to Theophrastus, *De sensu* 25, cited in Diels-Kranz, (n. 43) *Vorsokratiker*, I, 215, line 1.

95. Heraclitus, Parmenides, Empedocles, Diogenes of Apollonia, Diocles, Plato and his followers, and many others regarded reason as a more reliable source of knowledge than perception. See Wellmann, (n. 28) *Fragmente*, pp. 45–46; see also the index to Diels-Kranz, (n. 43) *Vorsokratiker*, III, under "aisthēsis."

96. See, for example, his *Timaeus*.

97. Harrington, (n. 18) "Nineteenth-century ideas," p. 648.

98. There may be another, more far-fetched explanation. The top part of the heart was sometimes called *hē kefalē tēs kardias* (the head of the heart). For example, Rufus of Ephesus gave the following description of the heart: "Its top part is called the head, its sharp point the bottom, its hollow parts the ventricles. Of these the one on the left, the artery-like one, is thicker, while the one on the right is more vein-like, is thinner, and has a larger cubic capacity than the left ventricle. On each side of the head of the heart are things like wings. They are hollow and soft and pulsate with the rest of the heart and are called its ears." Rufus of Ephesus, *De nominibus humanis corporis partium*, in C. Daremberg and C. E. Ruelle, eds., *Œuvres de Rufus d'Ephèse* (Paris, 1879), pp. 155–56; English translation in Harris (n. 37), *Heart and Vascular System*, p. 265. Someone may have confused *hē kefalē* (the head) with *ho egkefalos* (the brain) and this may somehow have led to the theory in §44.

and knowledge of the relevant facts. What are the relevant facts? Well, in the first place, the Greeks could have known that unilateral head injuries are often associated with neurological defects on the opposite side of the body. This points to the principle of contralateral innervation. In the second place, the Greeks could have observed that aphasia is often correlated with paralytic symptoms on the right side of the body. In combination with the principle of contralateral innervation, this suggests a left-sided location of the speech center. Descriptions of cases of the first category may already be found in the *Corpus Hippocraticum*,⁹⁹ but the general principle was not stated until the second century A.D.¹⁰⁰ Descriptions of cases of the second category may also be found in the *Corpus Hippocraticum*,¹⁰¹ but the connection with the principle of contralateral innervation was not made until the nineteenth century.

The theory of §44 was not so much based on knowledge of the relevant facts as on reasoning in terms of analogies and polarities—forms of reasoning which were rather popular in ancient Greece.¹⁰² These forms of reasoning are generally fruitless. The long-lasting stagnation in Chinese science, for example, has plausibly been attributed to the habit of trying to explain everything in terms of two very broad opposite categories, “Yin” and “Yang.”¹⁰³

The results were not so bad in the present case, however: although the originator of the theory was standing on a rather shaky foundation, he did not only invent the concept of hemispheric specialization, he even made some specific claims about it which still make a modern impression today. Consider, for example, the following summary of nineteenth-century views on hemispheric function:¹⁰⁴

99. C. B. Courville, “The ancestry of neuropathology: Hippocrates and *De vulneribus capitis*,” *Bull. Los Angeles Neurol. Soc.*, 1946, 11, 1–19

100. Aretaeus of Cappadocia (ca. A.D. 120–80), *De causis et notis diuturnorum affectuum* 17. See F. Adams, ed., *The Extant Works of Aretaeus, the Cappadocian* (London, 1856), p. 306. Aretaeus was a member of the Pneumatic school, which also produced the *Definitiones medicae*. The thesis of contralateral innervation was disputed until the nineteenth century. See, for example, the discussion in Du Pui, (n. 14) *De homine*, pp. 107–91.

101. Hippocrates, *Epidemics* VII. See Finger, (n. 8) *Origins*, pp. 371–72, for more references.

102. See G.E.R. Lloyd, *Polanty and Analogy: Two Types of Argumentation in Early Greek Thought* (Cambridge, 1966).

103. J. C. Eccles, discussion remark in H. A. Krebs and J. H. Shelley, eds., *The Creative Process in Science and Medicine* (Amsterdam, 1975), p. 127.

104. The first three entries have been taken from Harrington, (n. 18) “Nineteenth-century ideas,” p. 622. The fourth has been taken from T. D. Dunn, “Double hemiplegia with double hemianopsia and loss of geographical center,” *Transactions of the College of Physicians of Philadelphia, 3rd Series*, 1895, 17, 45–55. The last entry has been taken from J. H. Jackson, “Clinical remarks on cases of defects of expression (by words, writing, signs, etc.) in diseases of the nervous system,” *Lancet*, 1864, 2, 604–05.

<i>Left hemisphere</i>	<i>Right hemisphere</i>
Humanness	Animality
Motor activity	Sensory activity
Intelligence	Emotion, sensibility
Speech center	Geographical center
Expression	Perception

In the twentieth century, tables such as the following have been presented:¹⁰⁵

<i>Left hemisphere</i>	<i>Right hemisphere</i>
Verbal	Visuospatial
Rational	Intuitive
Objective	Subjective
Intellectual	Sensuous

It is clear that the *intellectus-sensus* dichotomy of the Brussels codex would not be out of place in either table.

Much can be said to detract from the value of the theory about hemispheric specialization in the *De semine*: it is false when taken literally, it does not seem to be based on cogent arguments or acute observations, and it did not have any influence as far as we know. All this does not, however, make it any less remarkable. Many centuries were to pass before the concept of functional cerebral asymmetry was again brought up.¹⁰⁶ The theory described in the Brussels codex is therefore still a striking instance of being (more or less) right for the wrong reasons.

105. Extracted from Harrington, (n. 18) "Nineteenth-century ideas," p. 622. Tables such as this one are often found in popular works. See, for example, R. E. Ornstein, *The Psychology of Consciousness* (San Francisco, 1972), ch. 3: "Two sides of the brain." It should, however, be stressed that they give a highly simplified picture of the experimental data. They make it clear that thinking in terms of analogies and polarities is still very much alive today.

106. The reasons why it took so long are briefly discussed in Lokhorst, (n. 17) "An ancient Greek theory," p. 36. See also Finger, (n. 8) *Origins*, pp. 386–87.