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Knowing through the Eye. Leonardo da Vinci's *Imprensiva* and Alhazen's *Intuitio*

Abstract

Leonardo da Vinci's definition of the first brain ventricle as the *imprensiva* was highly unorthodox in light of the late medieval and Renaissance philosophical and medical tradition. The term itself, *imprensiva*, seems to be a neologism forged by Leonardo, and he never clearly defined its functions in his surviving annotations. This study offers a global assessment of Leonardo's ideas on knowledge by exploring the varied ways in which he interpreted the *imprensiva* in the course of his long career. Essential to understanding Leonardo's reliance on the eye not only as a conveyor, but also as a 'processor' of knowledge is Alhazen's concept of *intuitio*: a verification procedure through which the eye validates, corrects, and construes the data channeled through vision almost in no time. Relying on both a detailed scrutiny of Leonardo's anatomical drawings in connection with the brain and a careful analysis of Leonardo's philosophical and medical sources, this essay demonstrates not only the huge extent but also the limits of Leonardo's use of the image as the most accurate source of knowledge, superior to any form of verbal account.

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The *Imprensiva* and the Brain Ventricles

W 12603r has often drawn the attention of Leonardo scholars (fig. 1).[2] Almost at center stage, Leonardo has traced the outlines of a male profile in pen and red chalk. To the left, above the sketch of an onion shown in transverse section, he notes: "If you cut an onion through the middle, you will be able to see and count all the covers or rinds that circularly clothed the center of this onion."[3] Introducing an analogy, Leonardo explains below: "Similarly, if you cut through the head of a man in the middle, you will first cut the hair, then the scalp and the muscular flesh and the pericranium, then the cranium, and, within, the dura mater and the pia mater and the cerebrum, then again the pia mater and the rete mirabile and their foundation, the bone."[4] Perhaps superfluously, these words indicate that the drawing to the right is not just a profile: partially, at least, it is also the cross section of a head whose skull would have been sliced transversally along its longitudinal axis. Dating from circa 1490–1494, the drawing presents itself as a "prospect": a schematic preview of the layers of flesh, tissue, and bone that Leonardo would cut through when and if performing the dissection of a skull.

* In compiling this essay, I worked on the assumption (deeply rooted in my scholarship) that primary sources should be reflected upon and examined in their original form. This led me not only to read, but also transcribe whole sections of Ms. Vat. Lat. 4595, the only surviving copy of the fourteenth-century Italian vernacular translation (*De li aspecti*) of the Latin version of Alhazen's treatise on optics, *De Aspectibus*. In order to be as accurate as possible, I prepared a philological edition of the relevant section and collated it with the Latin original. In the process, I noted that the scribe (as is often the case) dropped words, phrases, and even whole sentences. I also corrected a few corruptions. On this occasion, I cannot afford publishing my transcription, although in the notes I systematically quote the passages that I discuss here whenever present in the vernacular version. I would like to thank Pietro Roccasecca, not only for his assiduous work on Leon Battista Alberti and his sources on optics and perspective, but also for allowing me to rely on his transcription of *De li aspecti* (to be found at http://dlib.biblhertz.it/perspectiva/doc12.II.html). It served as an initial guide while familiarizing myself with the Vatican manuscript. I am also grateful to Janis Bell, with whom I entertained (and continue to entertain) a dialogue on Alhazen and his relevance for Leonardo. My English quotations of Alhazen, Bacon, and Pecham are taken from the critical editions listed in the bibliography. Now and then in exceptional cases, I may have altered a few words in order to make these translations consistent with the terminology used in this essay. Otherwise, all the translations are mine, unless otherwise specified. In transcribing Leonardo's passages from different critical editions, I slightly modified the spelling and the punctuation every now and then, not only for clarity reasons, but also to harmonize the transcriptions among them. Finally, I would like to thank Susanne Kubersky for her intelligent support in finalizing the publication of this essay, as well as Matteo Motolese and Rosa Piro for discussion on the etymology of the *imprensiva*.

1 Alhazen, *De Aspectibus* [2001], vol. 1, p. 225 [4.16] (2:518): "Et visus comprehendit illam formam et illam figuram et comprehendit omnem intentionem in qua equabuntur individua speciei in omnibus individuis que comprehenduntur ex individuis illius speciei." Alhazen, *De li aspecti*, 54r: "E lo viso comprende quella figura e quella forma e comprende tute le intentione in le quale se equarano li individui de la spetia in tuti l'individui, le quale si comprendono de tuti l'individui de quella spetie"

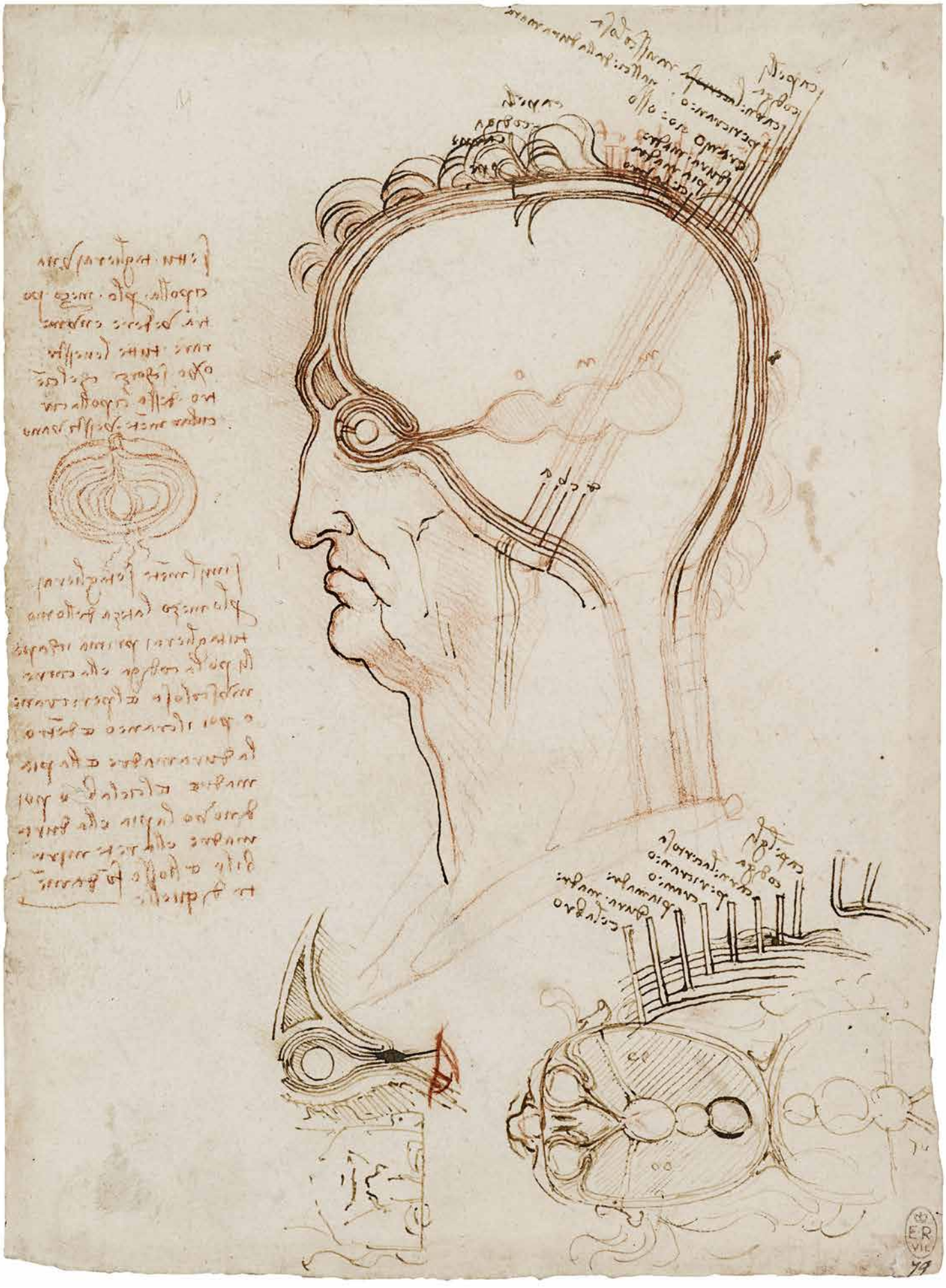
2 See O'Malley/Saunders 1952, p. 330, note 142; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 1, p. 123; Kemp 1971, pp. 121, 127–128; Ackerman 1978, p. 138; Keele 1983, pp. 60–61; *Leonardo: Anatomical Drawings* 1983, p. 51, no. 9A; Todd 1991, pp. 61–64; Pedretti 2007, p. 63, no. 5A; Del Maestro 2011, pp. 174–175; Bambach 2019, vol. 2, pp. 208–211.

3 Leonardo, *Windsor*, vol. 1, 1979, pp. 70–71 (32r) [W 12603r]: "Se tu taglierai una cipolla per lo mezzo, potra' vedere e numerare tutte le veste, ovvero scorze, che 'l centro dessa cipolla circularmente vestivano." For the English translation, see Vangensten/Fonahn/Hopstock 1916, p. 7 [6v].

4 Leonardo, *Windsor*, vol. 1, 1979, pp. 70–71 (32r) [W 12603r]: "Similmente, se taglierai per lo mezzo la testa dell'omo, tu taglierai prima i capelli, po' la codiga e la carne muscolosa e 'l pericraneo, e poi il craneo e, dentro, la dura madre e la pia madre e 'l celabro. Poi di novo la pia madre e la dura madre e la rete mirabile, e l'osso, fondamenta di quelle." For the English translation, see Vangensten/Fonahn/Hopstock 1916, p. 7 [6v].

▶

1 Leonardo da Vinci, W 12603r, The Layers of the Scalp and the Brain Ventricles, ca. 1490–1494, red chalk, pen and ink, 20.3 × 15.3 cm. Windsor, Royal Collection, inv. RCIN 912603r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)



As if in preparation for such a dissection, Leonardo retraced the sinuous contours of these layers in pen and brown ink, labeling each of them with a letter, then enumerating them sequentially at the upper right corner: "Hair, scalp, muscular flesh, pericranium (originating in the dura mater), cranium (that is, the bone), dura mater, pia mater."[5] Right below the diagram of the head, Leonardo schematically redrew a small section of the skull's layers with their respective labels.[6]

In visualizing the tunics that envelop and protect the cranium, Leonardo was almost certainly relying on some anatomical manual. Writing around 1316 in his *Anathomia* (first printed ca. 1475), the late thirteenth-century physician Mondino de' Liuzzi pointed out that "according to Avicenna," the parts of the head are: "The hair, the scalp, the flesh, the exterior membrane, the two interior membranes, the brain, the two lower membranes, the rete mirabile, and the bone at the base of the skull [*basilare*]."[7] Leonardo's reliance on traditional learning derived from Avicenna's eleventh-century *Canon of Medicine* is hardly surprising.[8] His mention of the rete mirable – a web of veins and arteries to be found at the base of the cranium in certain mammals, but not in humans – confirms that, at the time of making W 12603r, his anatomical knowledge of the inside of the human brain was merely literary.[9] In many other respects, however, Leonardo's visualization of the skull layers is unprecedented and utterly original.

In his principal diagram of the head, Leonardo highlights the continuity between the layers of the skull, the tunics around the ocular globe, and, most importantly, the link between the eye, the optic nerve, and the brain ventricles. The study of the eye's physiognomy is not the sole preserve of anatomy. Drawing on Avicenna, Roger Bacon states in his *Perspectiva* (1267) that "the eye has three tunics." Its first tunic, he observes, "derives from the innermost tunic of the optic nerve, which originates in the pia mater." Spreading out from the nerve, this membrane "branches out like a concave net": this is the retina. Stretching toward the front of the eye, the retina's anterior part grows coarser, ending in a central aperture (uvea) by virtue of which "the likenesses of light and color and other visible things can pass through the eye to the optic nerve coming from the brain." Originating in the dura mater, the second tunic also surrounds the ocular globe, creating "a portion of a certain sphere" at the extremity of and aligned with the uvea. Shaped like a "transparent horn," it is called the cornea. The third tunic, which stems from the membrane of the cranium, secures the eye socket within

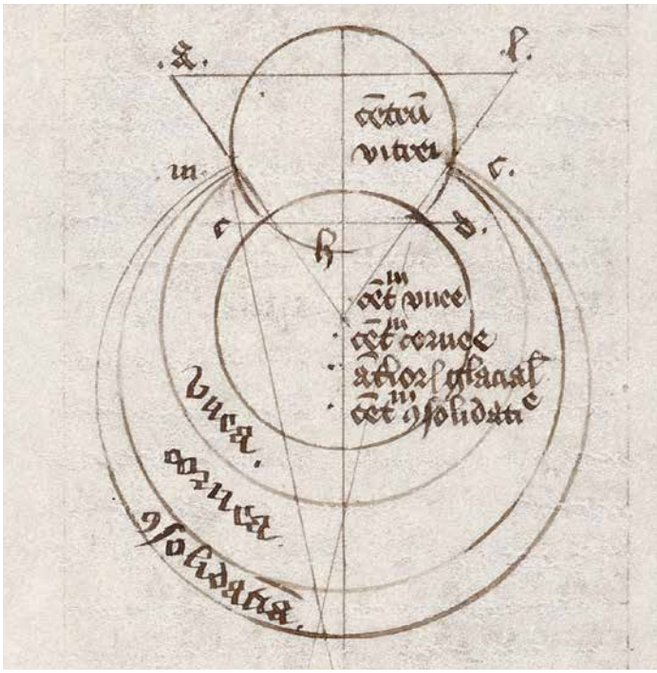
5 Leonardo, *Windsor*, vol. 1, 1979, pp. 70–71 (32r) [W 12603r]: "Capelli; codiga; carne muscolosa; pericraneo: nasce dalla dura madre; cranio, cioè osso; dura madre; pia madre; celabro."

6 As is typical for Leonardo, a similar, albeit more elaborate, sketch reappears on a page of another of his notebooks compiled around the same time. In Leonardo, *Codice Forster*, p. 35 [28r], the layers of the skull are drawn in the form of a rainbow resting on its side, laterally adorned with flaming hair, its innermost arch empty in the absence of the brain. To designate the pericranium, Leonardo here employs the less specialized term *panniculo* (membrane). Besides this, no major differences can be discerned between the two sketches in *Windsor* and *Forster* of the brain coatings and their contents.

7 Mondino [1930], p. 147: "Nell'ultimo luogo ti resta vedere il numero delle parti, le quali, secondo la sentenza di Avicenna nella prima *fen* del terzo canone al primo capitolo, sono in tutto dieci, cioè capelli, cotenna, carne, pannicoli estrinseci, pannicoli intrinseci, cerebro, due pannicoli inferiori, rete mirabile, osso basilare." On Leonardo and Mondino, especially in relation to the anatomy of the skull and brain, see Laurenza 2001, pp. 21–23. See further Solmi 1976, pp. 214–215; and Vecce 2017, pp. 102, 104, 107, and 186.

8 On Avicenna's great impact on medical pedagogy well into the seventeenth century, see Siraisi (1987) 2014. For Leonardo's mention of Avicenna, see Leonardo, *Windsor*, vol. 1, 1979, pp. 78–79 (35r) [W 19097r], and p. 360–363 (113r) [W 19070v].

9 On the rete mirabile, Berengario da Carpi's initial doubts about its existence, and Vesalius's ultimate demonstration that it does not exist in human beings, see Berengario 1521, p. ccclix(r–v); Vesalius 1543, pp. 642–643; and Carlino 1999, pp. 201–202.



2 Diagram of the Interior of the Human Eye, from Roger Bacon, *Opus Maius,* Ms. Digby 235, fol. 234. University of Oxford, Bodleian Libraries, 15th c. (photo Bodleian Libraries, University of Oxford)

the skull and is called the sclera. As Bacon observes, "it falls short of a full sphere" and, for this reason, it appears outside the eye as "fatty white flesh"[10] (fig. 2).

Aware of these physiological implications, Leonardo replicated in a lower section of the sheet the detail of an eye shielded by its three membranes, including a few of the adjacent facial muscles and the frontal sinus (apparently one of his anatomical discoveries). Enclosed within its tunics, abutting but also separated from the brain, Leonardo's eye as depicted in W 12603 r graphically and synthetically translates a notion of sight and of its functioning that was essential to late medieval and early modern optics. In the middle of the eye, Leonardo traced a simple circle corresponding to the glacial humor (the lens), its aperture perforating the enfolding tunics in its search of light from the outside. Cordoned off, as it were, by its membrane walls, the eye's central sphere is granted visual relevance by Leonardo, and with good reason. In his *Perspectiva communis* (1277–1279), John Pecham, a disciple of Bacon, stressed the glacial humor's delicacy, transparency, and sensitivity to light: "[…] if it were not so, it would be unsuited to the subtlety of the visual spirits coming from the brain."[11] To preserve its purity, immateriality, and crystalline nature, the tunics of the eye operate like a system of ballasts, anchoring the glacial humor at the center of the ocular cavity and preventing it from "exuding."

In his diagram of the head, Leonardo does not render the quasi-etherealness of the glacial humor, but clearly evokes a nexus of anatomical and optical functions fulfilled by the eye in conjunction with the brain. It is not immediately apparent at first glance, but the diagrams and sketches of W 12603 r concern not only anatomy and optics, but also epistemology. By looking more closely at these images, it becomes evident that W 12603 r is above all a working hypothesis: a "prospect" of how vision and knowledge interact on physiological grounds. Before retracing in pen the principal contours of his profile, Leonardo had drawn in red chalk, within the space reserved for the brain, a series of interlocking cells, labeled *m*, *n*, and *o*, with the frontal one directly plugged into the optic nerve. Accordingly, Leonardo sketched below, first in red chalk, then in pen, a sagittal view of a skull, its inside punctuated by a system of circles: in the front, the two ocular globes with the optic nerves terminating in the frontal cell of the brain; and, at the back, the two remaining cells of varying size. Perhaps dissatisfied with

10 Bacon [2006], pp. 26–29: "Oculus igitur habet tres tunicas […] et prima tunica eius fit ex tunica nervi interiori que venit a pia matre […] et ramificatur ad modum retis concavi in prima parte sui. Que ideo vocatur rete vel retina […]. Deinde pars eius secunda […] expanditur sperice usque ad anterius oculi, habens foramen in medio sui anterioris partis, ut species lucis et coloris et ceterorum visibilium valeant pertransire per medium oculi usque ad nervum qui venit a cerebro […] et hec pars eius secunda vocatur uvea […] et secunda pars expanditur usque ad anterius oculi, et ibi apparet eius pars manifesta, scilicet portio cuiusdam spere que circulatur super extremitatem uvee, et est sicut cornu clarum, et ideo vocatur cornea […]. Tertia tunica oculi fit ex illa pellicula nervi tertia que venit a membrana cranei; et eius pars prima coniungitur ossi oculi, et ideo est dura et solida […]. Reliqua vero pars extenditur usque ad corneam; nam non completur hec tunica, sed deficit et portio spere. Et est repleta carne pingui et alba, sicut videmus exterius in oculis […]."

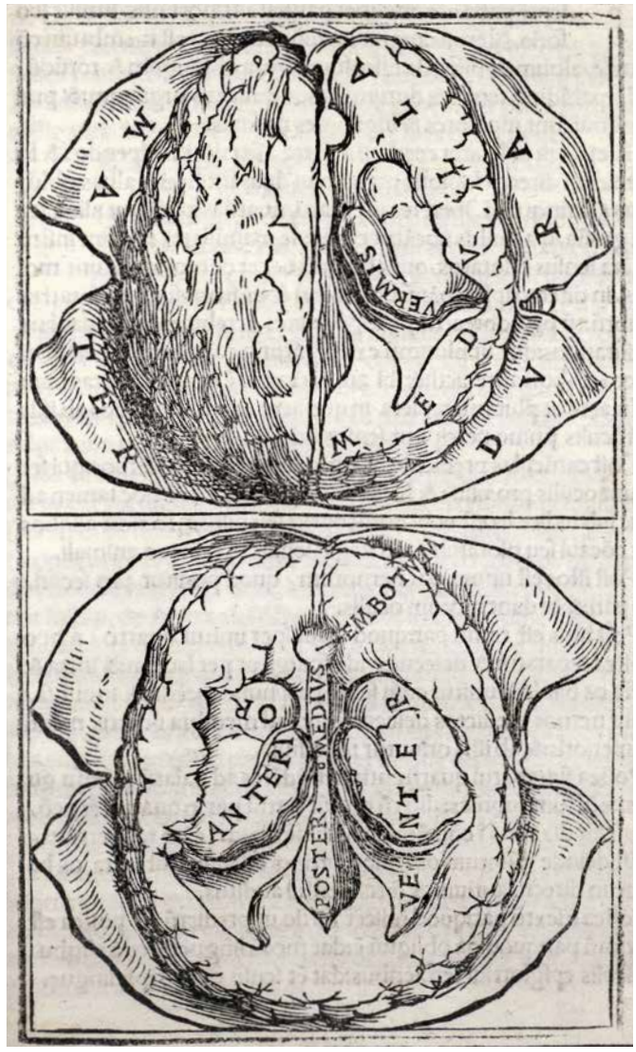
11 Pecham [1970], pp. 112–115: "Hoc patet quoniam pars illa in qua viget vis visive est tenera et passibilis multum, quoniam perspicua et aquea tenerrime compositionis. Aliter enim non congrueret subtilitati spirituum visibilium a cerebro venientium […]. Et est hec tunica [uvea] fortis ne resudet ex ea humor in ea contentus." On Pecham and Leonardo, see, for instance, Kemp 1977a, pp. 131–133.

his diagram, Leonardo quickly redrew to the right a summary contour of an open skull, with its three ventricles, the larger being now the central one, the frontal one clearly connected with the optic and auditory nerves. This detail is even more clearly manifest in the primary sagittal view, where the auditory nerves lead straightaway to two foreshortened ears seen from above. To signal exactly at what level the cranium should be sawn in order to correspond to this sagittal section, Leonardo turned the sheet by ninety degrees and cursorily threw down in pen the frontal features of a male head intersected by a straight line running just above the ears and cutting midway through the ocular globes.

Leonardo's stereometric rendering of the head in sagittal view was not only unprecedented, but also highly unorthodox in light of fifteenth-century anatomical knowledge. In his *Chirurgia magna* (ca. 1363), the French anatomist (and disciple of Mondino) Guy de Chauliac describes the brain ventricles as follows:

> Lengthwise, the brain contains three ventricles, and each has two parts […] the anterior ventricle is the largest, the middle one the smallest, and the central one is medium-sized, and there is a conduit between one another through which the spirits transit, and in the anterior ventricle are mammillary protrusions where the sense of smell is based, and from this ventricle the system of paired nerves that gives rise to the senses moves to the eyes, the ears, the tongue, the stomach, and other organs.[12]

Along the same lines, Mondino invites the anatomist, in dissecting the brain, to proceed to the largest ventricle, the anterior one, warning that it is divided in two parts, right and left, and, among other things, that each of its parts rests on a sort of elongated base.[13] Mondino's procedure in 'excavating' the brain in search of the two symmetrical wings of the anterior ventricle by peeling away the dura mater and cutting through the gray matter is given visual form in Berengario da Carpi's 1523 *Isagogae breves* (fig. 3). In 1508–1510, when Leonardo finally managed to verify that the anterior cell was composed of two lateral parts by producing a wax cast of an ox brain (W 19127r), he found the two parts of this cell and their lower protrusions, but failed to make out its elongated footing (fig. 4).[14]

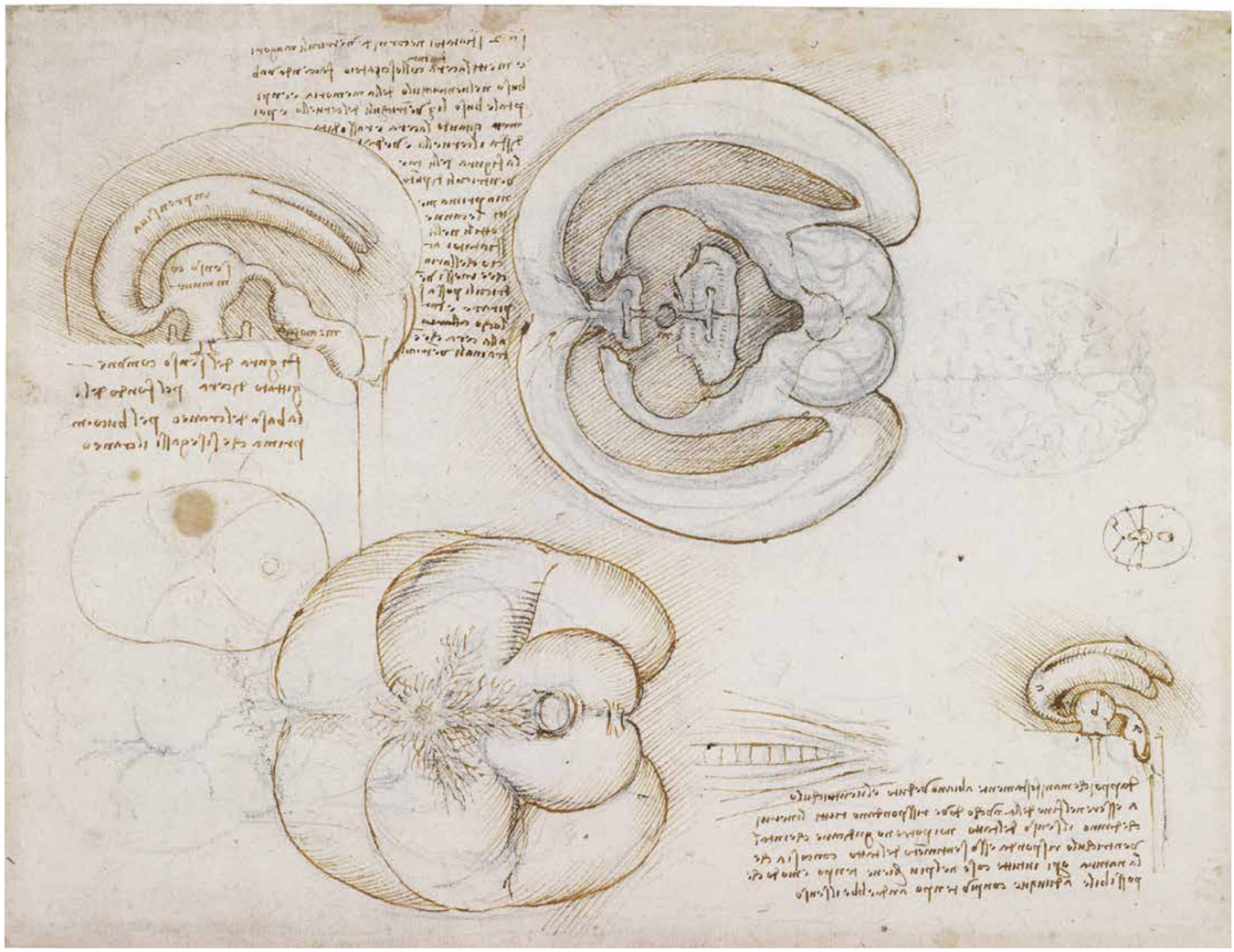


3 View of an Open Brain with the Location of the Right and Left Sections of the Anterior Ventricle, from Jacopo Berengario da Carpi, I*sagogae* breves, Bologna 1523, p. 56 (photo public domain)

12 Chauliac (1580) 1585, p. 29: "Cerebrum secundum longitudinem habet tres ventriculos, et unusquisque venter habet duas partes […]. Horum autem ventriculorum anteriorem esse maiorem, medium minorem, posteriorem mediocrem, et ab uno ad alium esse meatus per quos transeunt spiritus; et in anteriori esse additiones mammillares, in quibus fundamentum habet sensus odoratus, et ab ipso pro maiori parte oriri septem paria nervorum sensitivorum qui producuntur ad oculos, ad aures, ad linguam, ad stomachum, et ad caetera membra […]." On Leonardo and Chauliac, see Solmi 1976, pp. 121–122; and Vecce 2017, pp. 70, 107, 186, and 198.

13 Mondino [1930], pp. 156–157. See also Mondino's text in *Fasciculo di medicina*, s.p.: "[…] nota que questo ventriculo è diviso in dextro et sinistro […] et anchora la parte di là et di qua descendono sino alla basi."

14 See O'Malley/Saunders 1952, p. 340, note 147; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 3, p. 50 [C.V.7]; Ackerman 1978, p. 139; Keele 1983, pp. 65, 241–242; *Leonardo: Anatomical Drawings* 1983, p. 54, note 10; Todd 1991, pp. 94–97; Del Maestro 2011, p. 179; and Fehrenbach 2013, p. 155.

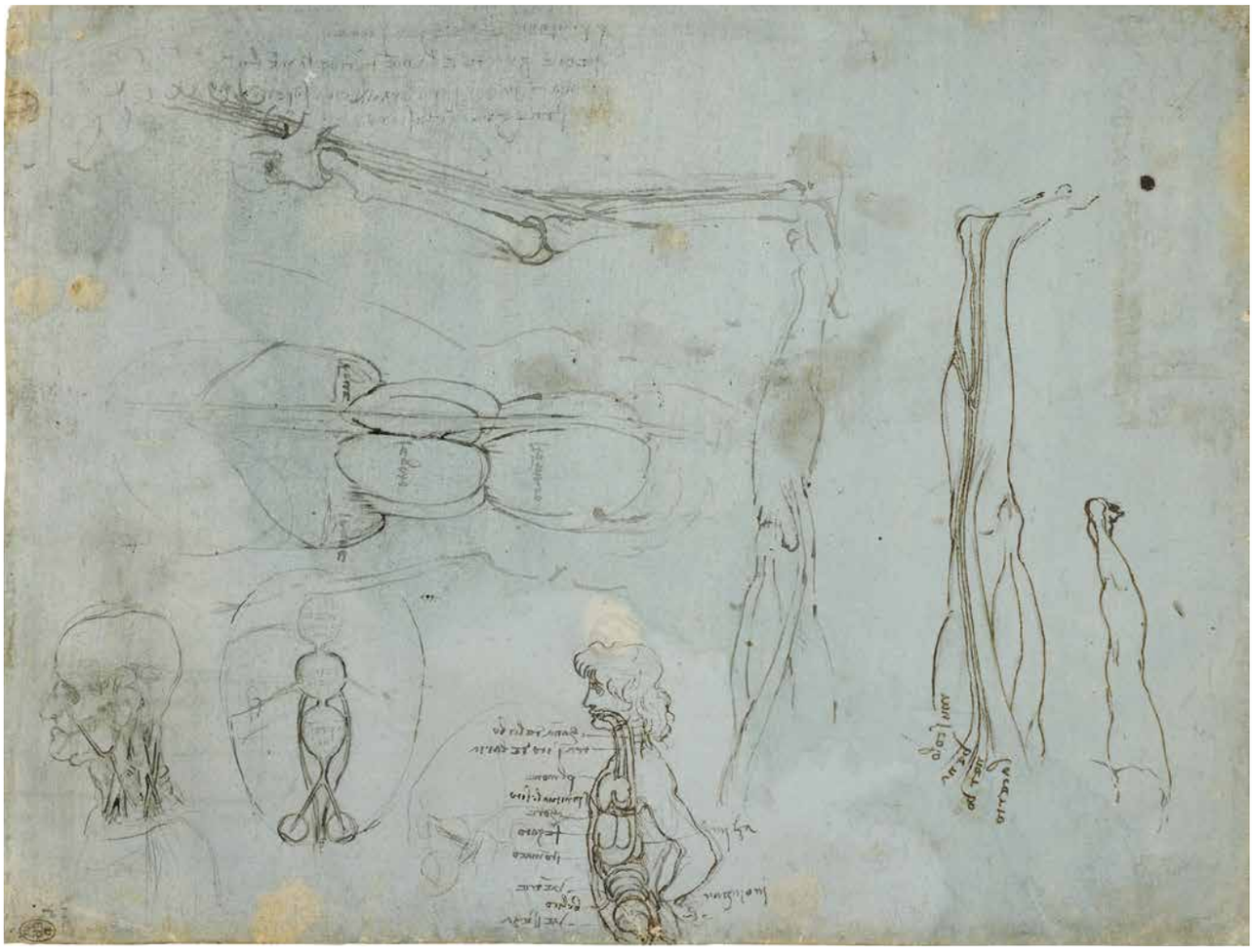


4 Leonardo da Vinci, W 19127r, The Brain of an Ox, ca. 1508–1510, black chalk, pen and ink, 20 × 26.2 cm. Windsor, Royal Collection, inv. RCIN 919127r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

To be sure, in W 12603r Leonardo was unable to imagine the configuration of the brain ventricles with any certainty. It is noteworthy, however, that, while he did seek to precisely grasp the layout of the skull coatings, he did not make any effort to visualize the shape, size, and mutual disposition of the ventricles in accordance not only with anatomical learning, but also with optics. In his *Perspectiva*, for instance, Bacon had also stressed that the anterior cell of the brain has a right and left part "in the form of two ventricles that are to some degree distinct."[15] The separation of this cell into two lateral units was important for Bacon not only on epistemological grounds, but also because the two optic nerves issued "one from the right ventricle and the other from the left." Evidently, Leonardo here disregards this meaningful information, nor does he seem to care (at this point in time at least) about the structure of the optic nerves and their 'interlacing' before reaching the brain (the chiasma): a point largely commented upon by Avicenna and later optical theorists.[16] Instead, Leonardo focuses only on two senses in his representation of the cranial nerves. In the sagittal view of the skull, the optic and auditory nerves converge toward the first ventricle with the

15 Bacon [2006], pp. 22–25: "Et anterius eius, scilicet locus sensus communis, habet dextrum et sinistrum ubi sunt duo ventriculi quomodo distincti […] et nervus qui venit a dextra parte vadit ad sinistrum oculum, et qui a sinistra vadit ad dextrum, ut recta sit extensio nervorum ab origine sua ad oculos."

16 See below, note 26.



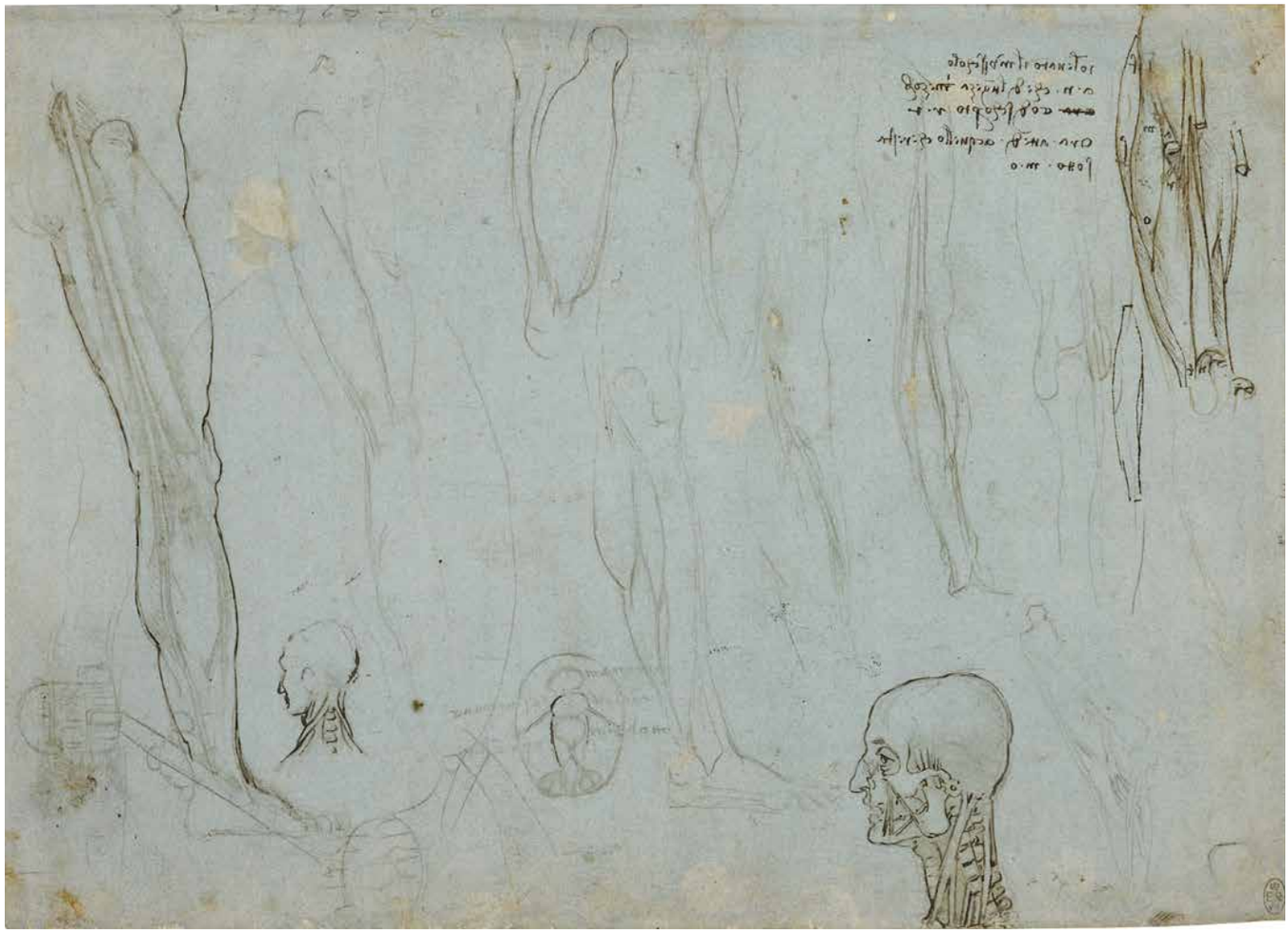
5 Leonardo da Vinci, W 12627r, Miscellaneous Anatomical Studies, ca. 1485–1489, pen and ink over metalpoint on pale blue prepared paper, 22.2 × 29 cm. Windsor, Royal Collection, inv. RCIN 912627r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

symmetry of a sophisticated piece of machinery, whereas the other nerves are simply omitted.

A much more prominent omission regards the names of the ventricles labeled as *m*, *n*, and *o* in the main diagram of the male head, although these can be easily identified by considering two previous anatomical drawings by Leonardo. Executed sometime around 1485–1489, W 12627r contains a variety of anatomical sketches delineated in metalpoint on blue paper, often partially retraced in pen and ink (fig. 5).[17] At the lower left corner, a silhouette of an open skull shows the three brain ventricles, the first defined as "imprensiva," the second as "senso comune," and the third as "memoria."[18] Intriguingly, the two ocular globes and the optic nerves link up with the frontal cell, while the auditory and olfactory nerves skip the *imprensiva* by joining the central cell. In addition to portraying the ligaments of the neck, the profile and bust of an old man at the left of this sketch also comprises a barely legible representation of the three ventricles, the *imprensiva* once again coupled with the ocular cavities. A similar sheet of anatomical drawings by Leonardo, W 12626r, made at the same time in an identical technique, includes a diagram of an open skull with three ventricles, marked by labels that corroborate the identification of the frontal cell as the *imprensiva*

17 See O'Malley/Saunders 1952, p. 366, note 160; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 1, p. 130; Kemp 1971, pp. 119, 123; Keele 1983, p. 6; *Leonardo: Anatomical Drawings* 1983, p. 32, note 3; and Laurenza 2001, p. 17.

18 Leonardo, *Windsor*, vol. 1, 1979, pp. 10–11 (4r) [W 12627r].



6 Leonardo da Vinci, W 12626, The Muscles and Nerves of the Leg and Head, ca. 1485–1489, metalpoint and pen and ink on blue-grey prepared paper, 21.3 × 30 cm. Windsor, Royal Collection, inv. RCIN 912626 (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

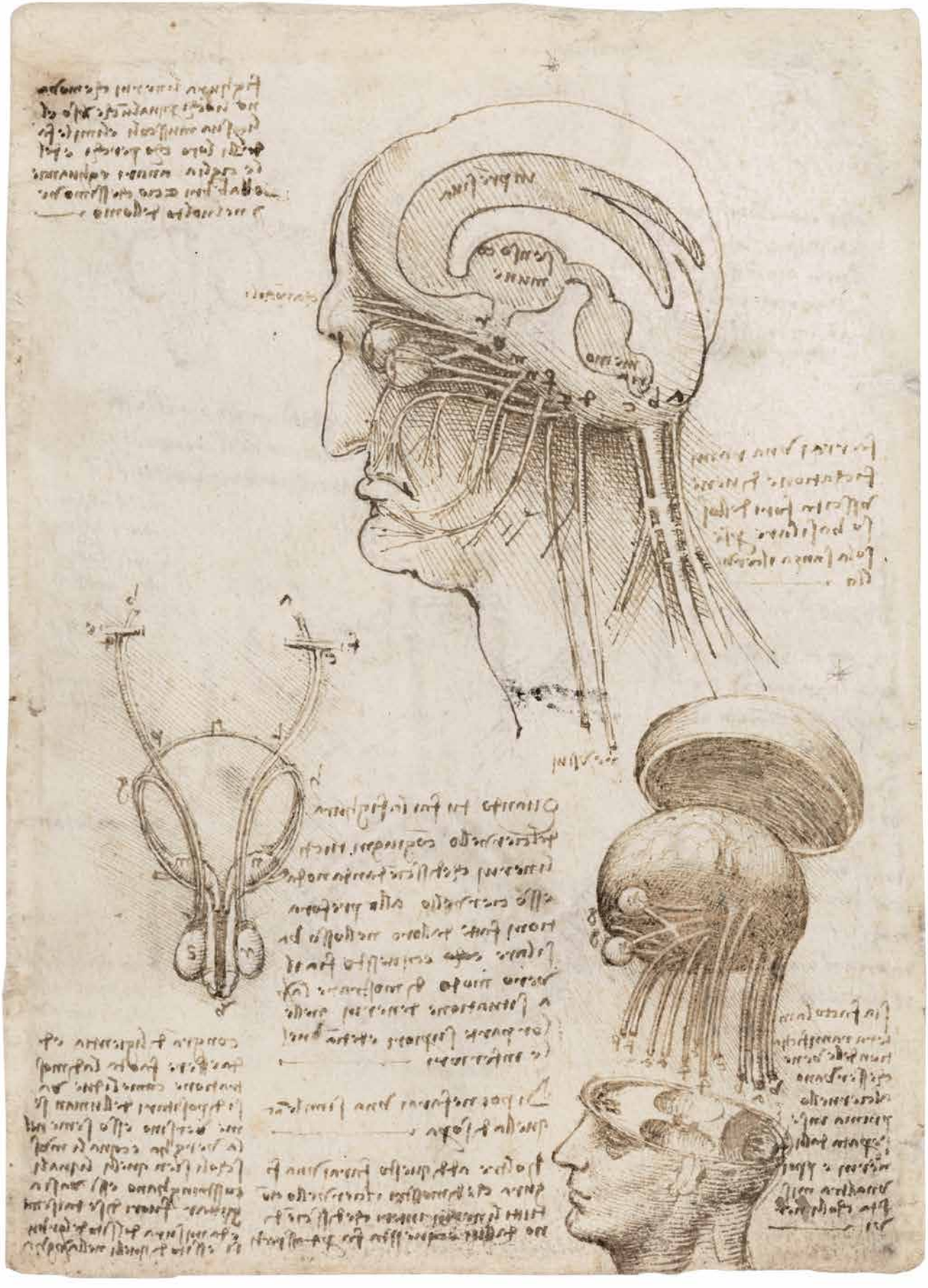
(fig. 6).[19] In this case, however, Leonardo designates the *imprensiva* also as "inteletto" (intellect), and the *senso comune* as "volontà" (will). Notably, the third ventricle qualifies merely as "memoria" (memory).[20] That Leonardo did not change his mind and persisted in his interpretation of the brain's anterior ventricle as the *imprensiva* is confirmed by Weimar's KK 6287r (fig. 7), a sheet of anatomical studies of heads produced around 1508–1510 and originally part of the Windsor anatomical series.[21] Here, even if Leonardo modified the form of the first ventricle by making it correspond to that of the ox brain he had obtained through dissection and wax casting (fig. 4), he kept the label *imprensiva*. In light of this, there is no reason to believe that W 12603r is an exception: the cell designated as *o* should likewise be the *imprensiva*.

If a swift comparison of Leonardo's diagrams of the brain ventricles may suffice to convince us that Leonardo consistently thought of the frontal ventricle as the *imprensiva*, it also reveals some patent contradictions in Leonardo's physiological and epistemological interpretation of the brain. While W 12603r (fig. 8)

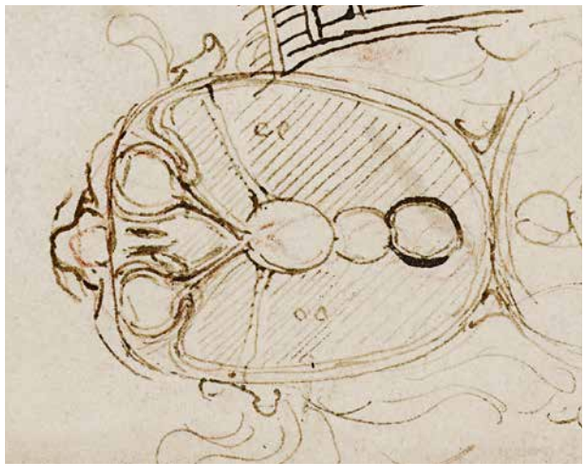
19 See O'Malley/Saunders 1952, p. 264, note 159; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 1, p. 130; Kemp 1971, p. 119; Keele 1983, pp. 61–62; *Leonardo: Anatomical Drawings* 1983, pp. 44–45, note 7; Fehrenbach 1997, p. 183; Laurenza 2001, p. 16; and Pardo 2008, pp. 75–77.

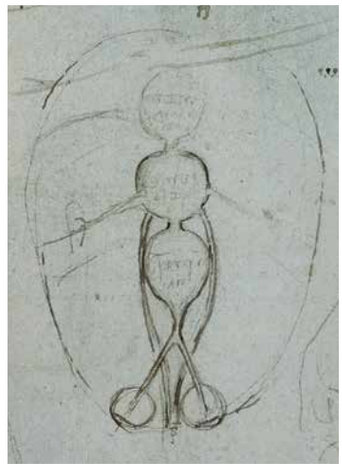
20 Leonardo, *Windsor*, vol. 1, 1979, pp. 16–17 (6r) [W 12626r].

21 See Pedretti 2007, p. 165; Keele 1983, pp. 66, 242; Todd 1991, pp. 102–108; Fehrenbach 1997, p. 183; Pardo 2008, pp. 80–82; Del Maestro 2011, pp. 179–180; Klemm 2013, pp. 194–195; and Bambach 2019, vol. 2, pp. 56–59.



7 Leonardo da Vinci, Anatomical Studies of Heads, ca. 1508–1510, pen with two different shades of brown ink, 19.2 × 13.5 cm. Weimar, Klassik Stiftung, inv. KK 6287 (photo bpk Bildagentur/Klassik Stiftung Weimar)





8 Detail of fig. 1
9 Detail of fig. 5
10 Detail of fig. 6

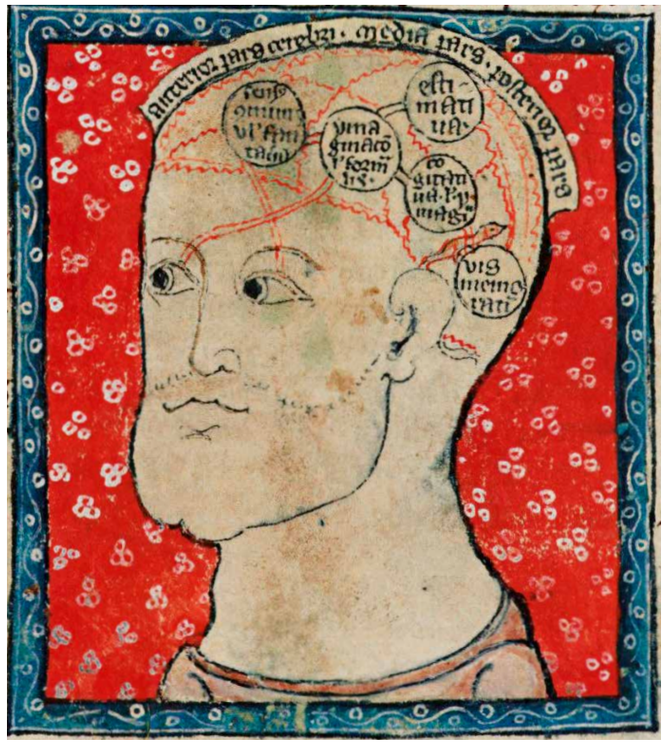
presents the *imprensiva* as linked both to the eyes and the ears, the two earlier sheets W 12627r (fig. 9) and W 12626r (fig. 10) indicate that hearing and smelling pertain to the *senso comune*, whereas sight is instead the privilege of the *imprensiva*. As I will argue later, this discrepancy is far from insignificant. Even more disconcerting is Leonardo's identification of the *imprensiva* as the frontal ventricle: traditionally, this cell was deemed the seat of the *senso comune* (the common organ of the senses, or common receptor), which Leonardo thus relocates to the central ventricle.[22] Furthermore, there is literally no precedent for the term *imprensiva*, which scholars have therefore understood as a neologism coined by Leonardo himself. Despite the novelty of the designation, nowhere does Leonardo expound on what he means by it, and in his notes and drawings the term is used in ways that elude definitive comprehension. To fully understand how problematic Leonardo's invention of the *imprensiva* is, it may be useful to turn to the late medieval and early modern tradition of illustrations exemplifying the process of knowledge in both philosophical and medical manuscripts. In my opinion, the remarkable diagrams contained in W 12603r are subtle elaborations of this tradition.[23]

A fine illumination illustrating an early fourteenth-century British manuscript of natural philosophy (Cambridge Library, Gg.1.1) will serve as a useful starting point (fig. 11).[24] At the bottom of folio 490v, a depiction of a man's face in three-quarter view, endowed with a now almost illegible beard, is framed within an ornamental square, his silhouette standing out from a bright red background. Comparable in certain respects to Leonardo's W 12603r, the upper section of the head morphs into the outer surface of a flayed cranium incised with sutures. Five circles, closely interconnected, form the discreet units symbolizing the faculties of the soul as distributed along the brain ventricles. Departing from the eyes, two sets of parallel lines course upward, crisscrossing each other, one leading to the circle of the "sensus communis" or "sensatio," the other to that of "ymaginatio" or "formalis." These are the two faculties lodged in the frontal ventricle (that is, Leonardo's *imprensiva*), both obviously relating to sight. One atop the other, the two subsequent circles correspond to the faculties of the central ventricle; the captions read respectively "estimativa" and "cogitativa" (or "ymaginativa"). The last faculty, defined as "virtus memorativa," occupies the lowest part

22 For an informed survey of Leonardo's appreciation of the *senso comune* within the context of ancient and early modern epistemology, see Summers 1987, esp. pp. 71–75 and 97–99.
23 In this regard, see Clarke/Dewhurst 1972, esp. pp. 10–48.
24 See Sudhoff 1913, pp. 184–189, with the transcription of the relevant Latin text and brief commentary on the illumination.

of the brain, as indicated by its corresponding circle. As if to reiterate the point, a sort of cartouche-like halo around the top of the man's head is meant to subdivide the cranial zone into three parts: "anterior pars cerebri," "media pars," and "posterior pars." This illumination is particularly noteworthy insofar as it visually translates the mechanisms of vision and knowledge as construed by Avicenna and his late medieval followers.

Following in Avicenna's footsteps, Bacon upheld that "two faculties have their seats in the first cell." Residing in the anterior part of the first ventricle, the common receptor (*sensus communis*) acted "as the source for the particular senses," making judgments about their operations and functioning as a principle of self-awareness. Vision in fact "does not perceive that it sees," nor does hearing perceive that "it hears": it is thus the common receptor that registers and centralizes all these perceptions. Because the common receptor is materially incapable of both receiving and retaining the sensations, the posterior part of the ventricle, called imagination (*ymaginatio*), assumes this function. In Bacon's view, the common receptor and the imaginative faculty work in tandem under the aegis of the fantasy, or "virtus fantastica." Therefore, "when the common receptor receives a likeness and imagination retains it, a complete judgment of the object follows, made by the fantasy."[25] In the illumination, the crisscrossing of the parallel lines leading to the ventricles hints at the specific nature of the optic nerves and their intersection (the chiasma). For Avicenna, the



11 Unidentified illuminator, Human Head with Diagram of the Brain Ventricles, early 1300s, from Trilingual compendium of texts. Cambridge, University Library, Ms. Gg.1.1, fol. 490v (photo Cambridge University Library)

25 Bacon [2006], pp. 6–8: "In prima cellula sunt due virtutes. Et est una sensus communis in anteriori eius parte consistens [...] qui est sicut fons respectu sensuum particularium, et sicut centrum respectu linearum exeuntium ab eo ad circumferentiam [...] qui iudicat de singulis sensibilibus particularibus. Nam non completur iudicium de visibili antequam species veniat ad sensum communem [...]. Et iudicat de operibus sensuum particularium: nam visus non sentit se videre, nec auditus percipit se audire, sed alia virtus que est sensus communis [...]. Cuius autem operatio ultima est recipere species venientes a sensibus particularibus [...]. Sed non retinet eas propter nimiam lubricitatem instrumenti sui [...]. Et ideo oportet quod sit alia virtus anime in ultima parte prime cellule, cuius officium est retinere species venientes a sensibus particularibus [...] que vocatur ymaginatio. [...] Sed tamen tota virtus composita ex hiis duabus, scilicet que occupant totam cellulam primam, vocatur fantasia seu virtus fantastica. [...] Quapropter fantasia comprehendit utramque virtutem et differt ab eis solum sicut totum a parte. Et ideo cum sensus communis recipiat speciem et ymaginatio retineat eam, sequitur iudicium completum de re, quod exercet fantasia."

26 Avicenna [1968–1972], vol. 1, pp. 268–269 (III, 8): "Primum autem cui imprimitur simulacrum visi est humor crystalleidos, penes quem non consistit certe videre; alioquin unum videretur duo: duo enim simulacra sunt in crystalleidis, sicut cum tangitur aliquid utraque manu sunt duo tactus. Sed hoc simulacrum redditur a duobus nervis concavis ubi coniunguntur in modum crucis, qui sunt duo nervi, quorum dispositionem assignabimus cum loquemur de chirurgia. Quasi enim ex forma exteriore venit in aestimatione pyramis rotunda, ita ut iactet angulum suum ultra superficiem crystalleidos, similiter simulacrum quod est in crystalleide, mediante spiritu reddente qui est in nervis contingentibus se, reddetur affectioni pyramidis, et offendunt se duae pyramides et cancellantur ibi, et unitur ex eis forma similitudinaria una penes partem spiritus qui gestat virtutem videndi." See also Bacon [2006], pp. 62–65: "Et quia virtus tunc fontalis est una, ad quam continuantur virtutes oculorum per medium nervorum opticorum, ideo potest una res apparere una quantum est ex hac causa." For binocular vision in Alhazen and, following his example, Bacon and Peckham, see Raynaud 2016, esp. pp. 71–79, 95–101.

27 In this regard, see Sudhoff 1913, esp. pp. 179–180; Steneck 1974; Smith 1992; Kemp/Fletcher 1993; and Verboon 2014.

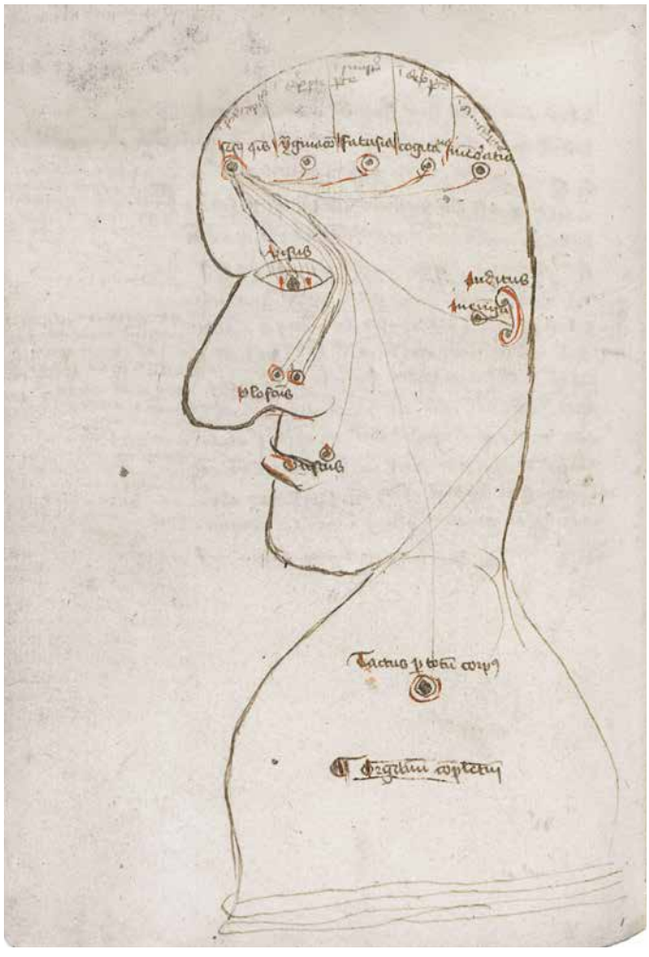
28 See Verboon 2014, esp. pp. 216–217, 222–225 (comment on the Erfurt drawing).

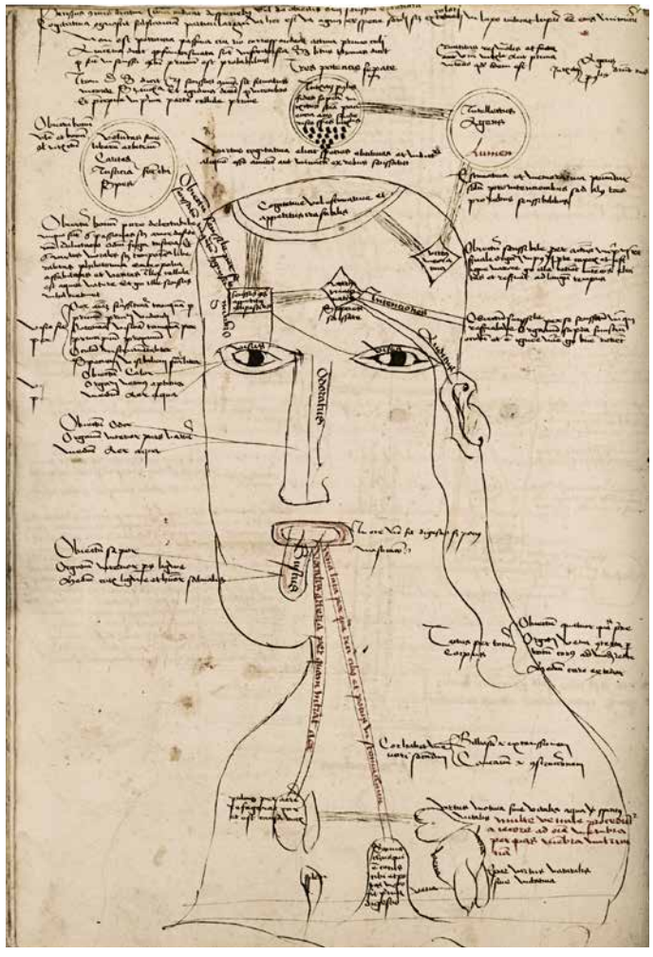
convergence of the nerves was necessary if a single image were to emerge from the physiological process of binocular vision.[26] For the illuminator who produced this image, the subsequent separation of the optic nerves and their location in two different areas of the frontal ventricle was likely intended to signify the two ways in which the image, transformed into "spiritus," can either be perceived as a transitory sensation in the common receptor or remain impressed as a "spiritual form" in the imagination.

Needless to say, different authors interpreted in different ways the process of human knowledge achieved by the faculties of the soul dwelling in the ventricles.[27] What matters here is that, over time, brain ventricle diagrams became one of the customary means of visualizing the nature and functions of the spiritual faculties. There is evidence that scholars in the fifteenth century increasingly -resorted to them for both clarification and memorization. An interesting (if clumsy) example of this is offered by a diagram contained in a fifteenth-century manuscript (now at the Universitäts- und Forschungsbibliothek, Erfurt) of Peter of Dresden's *Parvulus philosophie naturalis*, a compendium of the *Philosophia pauperum* or *Philosophia naturalium* erroneously ascribed to Albert the Great, but in reality a summary of Albert's work on natural philosophy by Albrecht von Orlamünde (fig. 12).[28] In the Erfurt manuscript, the profile and bust of a man is used not only to pinpoint the five senses through their specific organs and respective captions, but also to intimate that all these organs terminate in and are governed by the common receptor, now a point drawn in the upper part of the head. Four more points designate the other faculties: "ymaginativa," "fantasia," "cogitativa," and "memorativa." In this case, the anonymous scholar who executed the diagram did not distinguish between *cogitativa* and *estimativa*.

12 Brain Ventricle Diagram, from Peter of Dresden, *Parvulus philosophiae naturalis*. Erfurt, Universitäts- und Forschungsbibliothek, Amploniana collection, Ms. quart. 240, fol. 139v (photo Universitäts- und Forschungsbibliothek, Erfurt)

13 Brain Ventricle Diagram, ca. 1480–1488, from Peter of Dresden, *Parvulus philosophaie naturalis*. Norrköping, Stadsbiblioteket, 426 fols., unfoliated (photo Norrköpings Stadsbiblioteket)

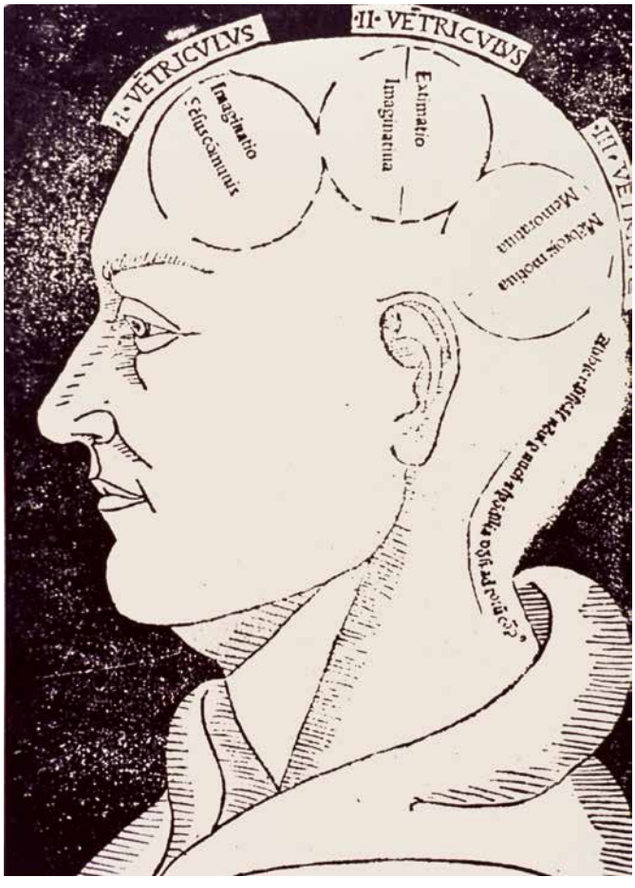


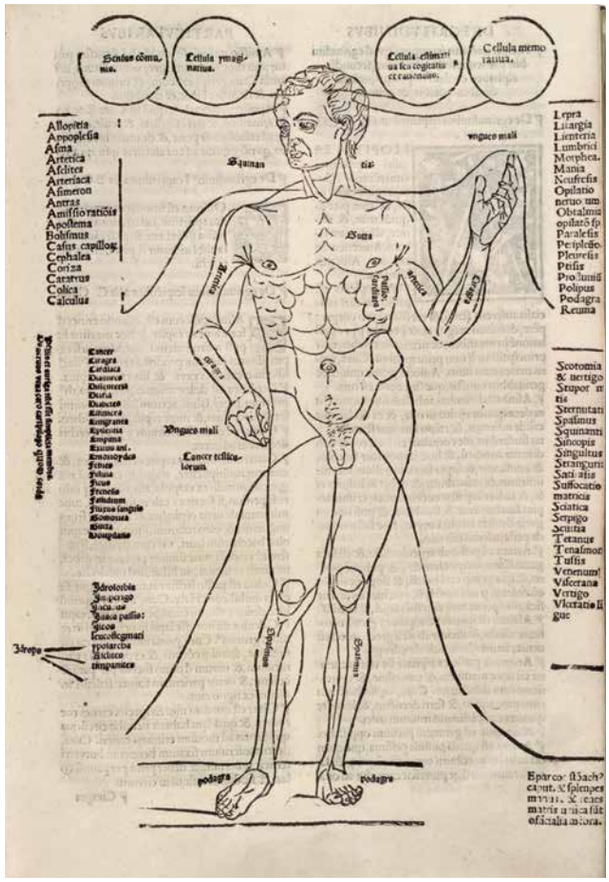


In another brain ventricle diagram (fig. 13), now in the Norrköpping Stadsbiblioteket and also produced in connection with the *Parvulus philosophie* around 1480–1488, the anonymous scholar availed himself of a complex system of glosses in order to elucidate the mechanisms of knowledge.[29] I will linger only upon a few relevant details of this sheet. The rectangle above the male figure's right eye corresponds to the "sensus communis" and is linked exclusively with "visus" (that is, sight). From this rectangle two sets of loose streaks leap, beamlike, to other parts of the brain, one leading to a lozenge closer to the man's left eye, the other to a reversed section of a circle crowning the top of the head. Associated with "auditus" (hearing) and probably "tactus" (touch), the lozenge represents the "virtus ymaginativa." Consequently, the section of a circle at the top of the head accommodates the "cogitativa" or "estimativa." A second lozenge to the far left of the man's head pertains instead to the "virtus memorativa." According to the diagram, communication is established only between the *cogitativa* and the *memorativa*, the latter being the only spiritual function channeling information to a concentric circle above, qualified as "intellectus agens" and "lumen" (that is, the active intellect or "light"). At the upper left of the diagram, hovering above the entire figure, a second concentric circle corresponds to "intellectus possibilis" (the passive intellect). Now is not the time for a detailed interpretation of the entire diagram. It is interesting that its author created an articulated hierarchy of vectors of cognition ascending from the external senses, to the faculties of the soul, to the intellect, which, not coincidentally, was conceived of as the most divine of human capacities: a bridge between man and God. I underscore this point because, in a baffling reversal, Leonardo in W 12626r likens the *imprensiva* (that is, the ventricle closest to the senses, or, to be more exact, vision) to the *inteletto*, the highest faculty of the soul, without clarifying whether he was referring to the active or passive intellect.

14 Brain Ventricle Diagram, from Albrecht von Orlamünde, *Philosophia pauperum sive philosophia naturalis* (Baptista Farfengus, Brescia 1490), unpaginated (photo US National Library of Medicine, Bethesda)

15 Detail of fig. 1





16 Diagram of the Human Body, from *Il Dignissimo Fasciculo de medicina* (Giovanni and Gregorio De Gregori, Venice 1494), unpaginated (photo University of Toronto Library)

Almost all the brain ventricle diagrams executed in fifteenth-century manuscripts originated in northern Europe and it can be assumed that Leonardo did not see any of the numerous examples that have come down to us. Nevertheless, the circulation of such diagrams in Italy at least in the 1490s is solidly documented by two printed texts: Albrecht von Orlamünde's *Philosophia pauperum* (published in Brescia in 1490) and Joannes de Ketham's *Fasciculus medicine* (published in 1491, then in Italian vernacular in 1494 as the *Fasciculo di Medicina*). Leonardo seems to have owned both works.[30] In the *Philosophia pauperum*, the fine woodcut of a male face in profile summarizes the number and functions of the brain ventricles (fig. 14).[31] The circle in the frontal part of the cranial zone reads: "imaginatio" and "sensus communis"; the middle circle contains "estimatio" and "imaginativa"; the third "membrorum motiva" and "memorativa." The association of memory with corporeal motion is not rare, and Leonardo himself maintained that the third ventricle played a key role in coordinating the motor nerves and touch.[32] Nevertheless, Leonardo (as already mentioned) also ascribed to the common receptor the willpower (*volontà*) traditionally believed to cause motion in the body, and which therefore was primarily germane to *cogitativa* and *estimativa*.[33]

In any case, the affinity of W 12603r with the woodcut in the *Philosophia pauperum* is unquestionable, especially if we imagine the initial version of Leonardo's diagram in red chalk, with its demarcation of the three ventricles as interconnected circles and the letters labeling each of them (*m*, *n*, and *o*) as didactic markers (figs. 14, 15). Admittedly, the *Philosophia pauperum* woodcut does not display an anatomical interest, as Leonardo's diagram does. However, the identification of the brain ventricles and their functions was part and parcel of late fifteenth-century anatomical practices, as demonstrated by one of the woodcuts illustrating the *Fasciculus medicine* (a miscellany of medical texts including Mondino de' Luzzi's *Anathomia*). In this plate (fig. 16), four circles appear in relation to the head of a human figure represented in its entirety. The

29 Verboon 2014, pp. 226–228.

30 It can be assumed that the "filosofia d'alberto magno" (Vecce 2017, p. 198) mentioned in Leonardo, *Madrid II* [1974], 2v–3v (1503), could be either the *Pauperum philosophia* (printed in Brescia, 1490 and 1493) or the *Summa naturalium seu opus philosophiae naturalis* (printed in Venice, 1496). For Ketham's *Fasciculus medicine* and Leonardo, see Vecce 2017, pp. 104, 198.

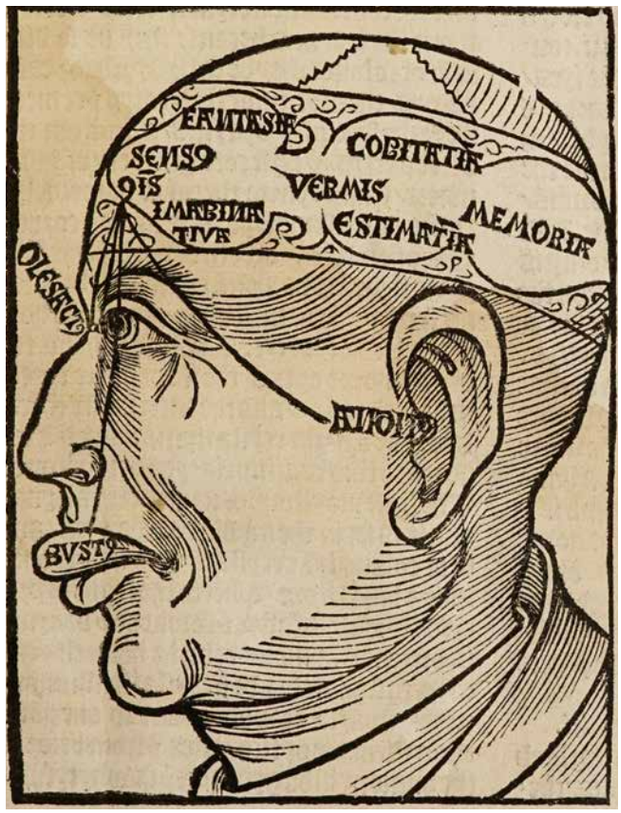
31 See Sudhoff 1913, p. 149; and Verboon 2014, pp. 216–217.

32 Leonardo, *Windsor*, vol. 1, 1979, pp. 332–333 (104r) [W 19127r]: "Dappoi che manifestamente abbiano veduto el ventriculo *a* [Leonardo's *memoria*] essere nel fine della nuca, dove rispondano tutti il nervi che danno il senso del tatto, noi potreno giudicare che in tal ventriculo risponda esso sentimento del tatto. Con ciò sia che la natura operi in tutte cose nel più brieve tempo e modo ch'è possibile. Adunque con più tempo andrebbe il senso." See further Kemp 1971, p. 124; Keele 1983, p. 230, 241–243; and Fehrenbach 1997, p. 187.

33 See, for instance, Leonardo, *Codice Atlantico* [2000], vol. 1, p. 564 (327v): "La natura ha ordinati nell'omo i muscoli ufiziali, tiratori de' nervi, e quali possino movere le membra secondo la volontà e desiderio del comun senso, a similitudine delli ufiziali strebuiti da uno signore per varie provincie e città, i quali in essi loghi rappresentano e obbediscano alla volontà d'esso signore"; and Leonardo, *Codice Atlantico* [2000], vol. 3, p. 1423 (729v): "Ancora nel senso del tatto, il quale diriva da esso senso comune, non si ved'elli istendersi colla sua potenzia insino alle punte delle dita, le quali dita, subito che hanno tocco l'obbietto, immediate il senso ha giudicato se è caldo o freddo, se è duro o molle, se è acuto o piano?" For a succinct explanation of the relationship between will and self-motion as common to animals and humankind in Thomas Aquinas's work, see Pasnau 2002, pp. 201, 209–214. On voluntary animal motion in Galen, see Frampton 2008, pp. 116–205.

circles are identified as the "senso comune," the "cellula della imaginatione," the "cellula estimativa overo cogitativa della rasone," and the "cellula de la memoria." The importance of brain ventricle diagrams in early sixteenth-century anatomical studies is also confirmed by one of the woodcut illustrations (fig. 17) in the English edition of Hieronymus Brunschwig's volume on surgery (first printed in 1497 as *Das Buch der Cirurgia*, then in English in 1525 as *The Noble Experyence of the Vertuous Handy Warke of Surgeri*). While the general scheme of the figure with its indication of the spiritual faculties carried out in the brain is analogous to those discussed previously, the indication of the "vermis" (choroid plexus) between the anterior and middle ventricles reflects a broader engagement with anatomy and dissection.[34] In W 19116r, a sheet filled with anatomical remarks and a few sketches in the margin, Leonardo noted that "the muscle called worm [*verme*] […] situated in one of the ventricles of the brain" would lengthen and shorten itself "to open and shut the passage of the *imprensiva*, or the common receptor, to memory."[35]

Leonardo's independence in illustrating the brain ventricles becomes evident if we consider that he was already drawing brain diagrams in the late 1480s. Equally obvious, however, is Leonardo's debt to the philosophical and anatomical iconographic tradition, which suggests that such diagrams were widely circulated in the late fifteenth century, with Leonardo and his interlocutors commenting upon them within a context of intense spoken debate. From this point of view, W 12603r is not only the product of a mostly untraceable oral culture of scientific divulgation, but also constitutes the intermediary step in an anatomical, epistemological, and optical program specifically undertaken by Leonardo. No doubt Leonardo conceived, or rather visualized his program in W 12603r in anticipation of anatomical dissections that never took place, or took place only partially. Be that as it may, by the end of the 1480s, Leo-nardo had already managed to study the human skull, measuring it with care and identifying some of its key spots in connection with the optic nerves and brain ventricles. In W 19058r, dating from circa 1489, Leonardo presents us with an exploded view of a skull seen laterally from above at a moderate height, with two straight lines intersecting almost at its center (fig. 18).[36] In the sheet, Leonardo indicates that all the senses converge at the intersection point of these



17 Brain Ventricle Diagram, from [Hieronymus Brunschwig], *The Noble Experyence of the Vertuous Handy warke of Surgeri* (Petrus Treveris), London 1525, p. 16 (photo University of Toronto Library)

34 Brunschwig (1497) 1525, p. 16. Sudhoff 1913, p. 203, mentions a similar woodcut published in Magnus Hundt's *Antropologium* (1501).

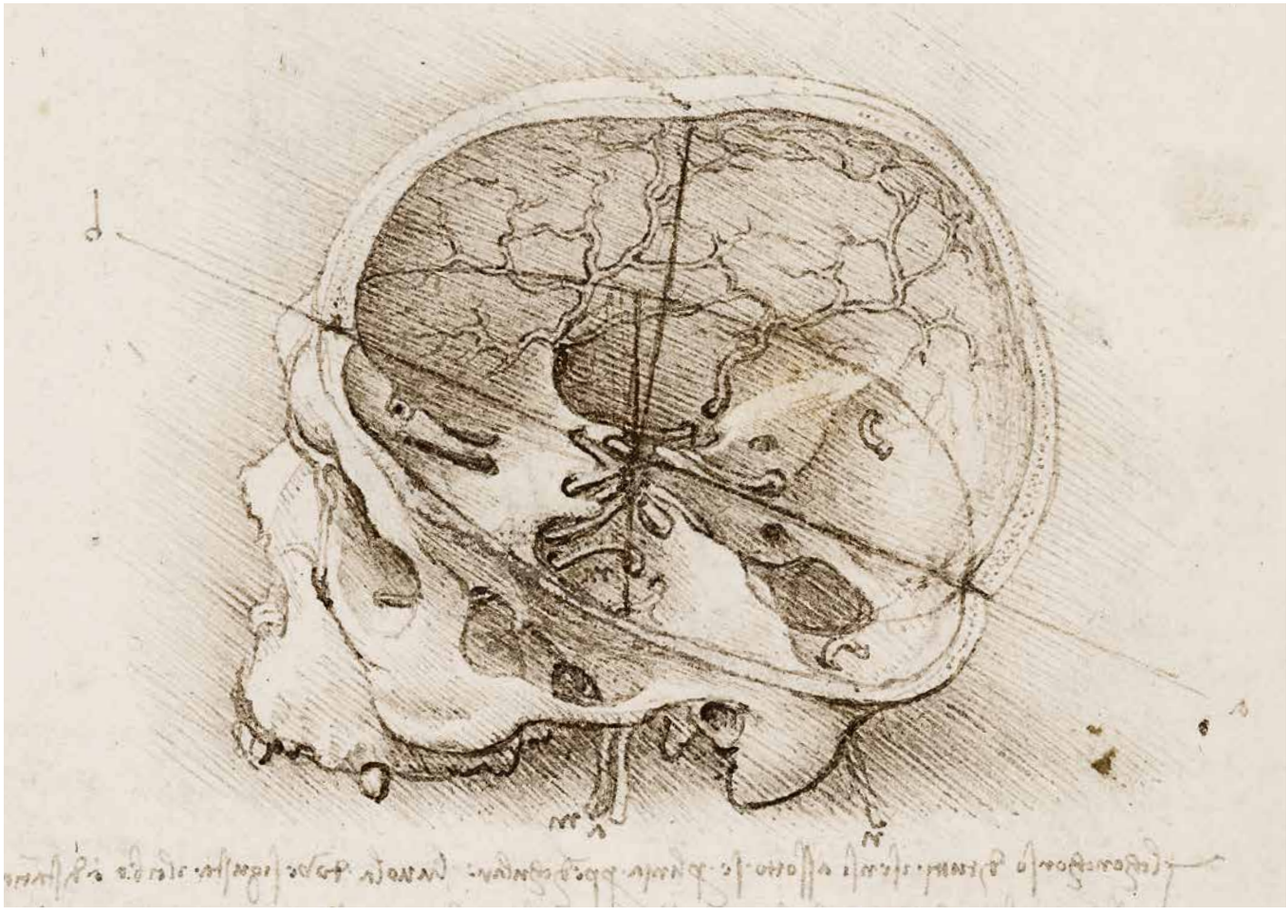
35 Leonardo, *Windsor*, vol. 1, 1979, pp. 374–381 (115r) [W 19116–19117r]: "del muscolo detto verme, che sta nell'un de' ventriculi del cervello, il quale s'allunga e raccorta per entrare il transito della imprensiva, ovver senso comune, alla memoria." Avicenna [1968–1972], vol. 1, pp. 270–271 (III, 8), explains the role of the "worm" in a similar, but not identical manner: "Deinde forma quae est in imaginatione penetrat posteriorem ventriculum, cum voluerit virtus aestimativa et elevaverit vermem, et de duobus membris quae terminantur penes vermem fecerit unum, et coniungetur forma cum spiritu qui gerit virtutem aestimativam, mediante spiritu qui gerit virtutem imaginativam, quae vocatur in hominibus virtus cogitationis, et forma quae erat in imaginativa imprimetur in spiritu virtutis aestimationis, et virtus imaginationis deservit virtuti aestimationis, reddens ei quod est in imaginativa."

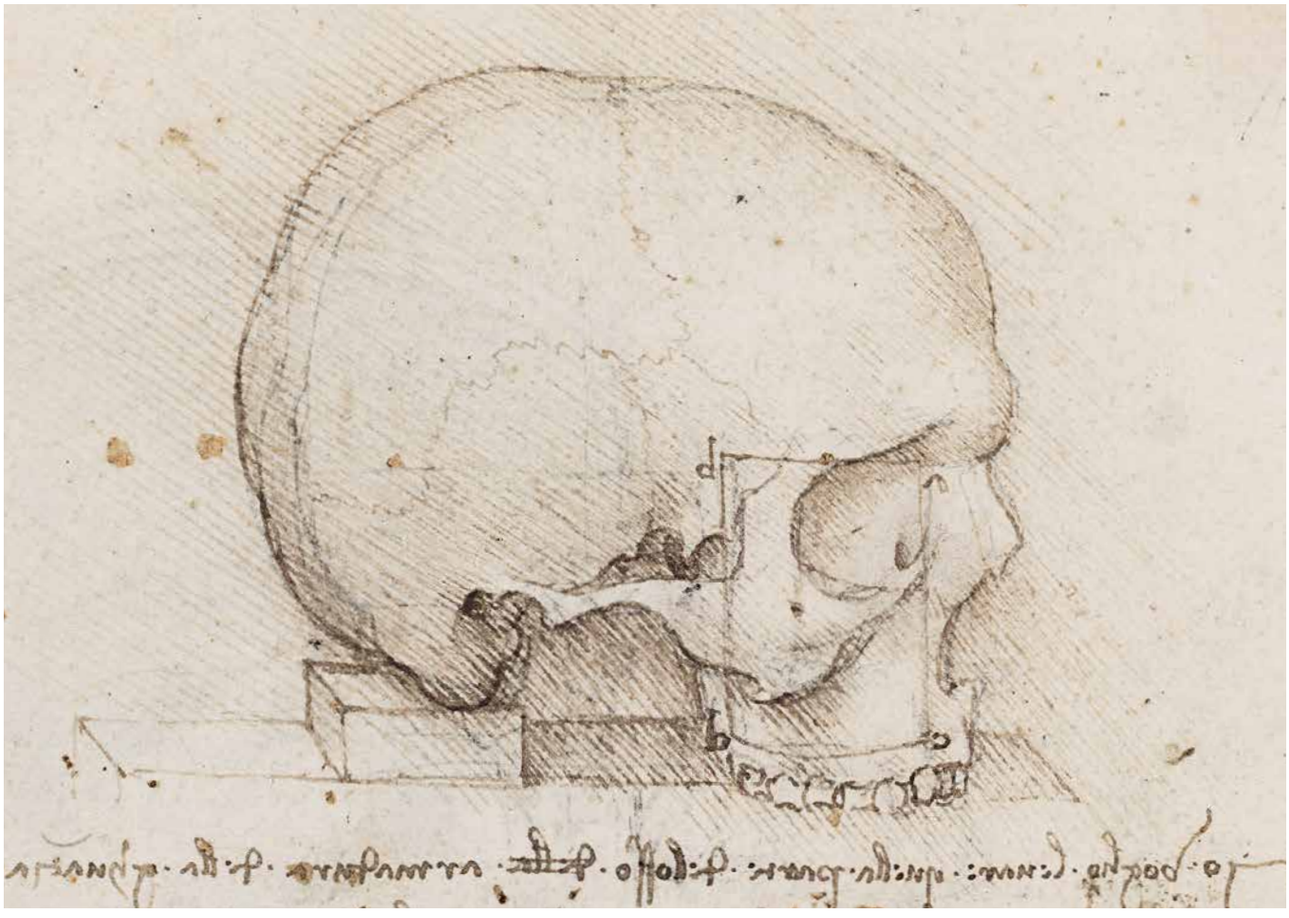
36 See O'Malley/Saunders 1952, p. 50, note 6; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 3, p. 24 [B 41]; Keele 1983, pp. 64–65; Zwijnenberg 1999, pp. 155–157; Laurenza 2001, pp. 19–20; Pedretti 2007, pp. 42–52, note 2 B; Pardo 2008, p. 77; and Del Maestro 2011, p. 177.

▶

18 Leonardo da Vinci, W 19058r, The Cranium Sectioned, ca. 1489, pen and ink, 19 × 13.7 cm. Windsor, Royal Collection, inv. RCIN 919058r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

19 Leonardo da Vinci, W 19057v, The Cranium, ca. 1489, traces of black chalk, pen and ink, 18.8 × 13.4 cm. Windsor, Royal Collection, inv. RCIN 919057v (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)





two straight lines ("il concorso di tutti i sensi").[37] It has thus been assumed that this would correspond to the seat of the common receptor, that is, Leonardo's middle ventricle, although this is by no means self-evident. In the drawing – a prodigy of visual accuracy with its depiction of the imprints left by the meningeal vessels on the inner surface of the cranium – the intersection point also marks the location where the optic chiasma emerges from the orbital cavities.

Leonardo's keen interest in this anatomical detail is evinced by another sheet from the Windsor series, W 19057v, with lateral views of the skull (fig. 19).[38] In the drawing at the bottom, Leonardo removed a section of the cheek bone by exposing the maxillary sinus as if within the elevation of a two-story building. In Leonardo's words, the "hole" labeled *b* in the exploded micro-view is where "the visual power passes to the sense [*la virtù visiva passa al senso*]."[39] It stands to reason that the "senso" singled out here by Leonardo is the common receptor, although the term remains ambiguous: the *imprensiva* also classifies as an internal "senso" and, in any case, is described by Leonardo as a gateway to the *senso comune*. Even so, the risk of self-contradiction persists. If we posit that W 12603r was executed after Leonardo had performed his anatomical scrutiny of the cranium, it must be concluded that either he was still convinced that the senses (or at least the optic and auditory nerves represented in the sagittal view of the open skull) terminated in the *imprensiva* (that is, the frontal ventricle), and not the common receptor, or that he disregarded his identification of the common receptor as the primary destination of the sensory nerves. I will argue that in W 12603r Leonardo's attempt to adapt his freshly acquired knowledge of the skull's interior to his theory of the *imprensiva* as the receptacle of the optic nerves, as previously formulated in W 12626v (fig. 10) and W 12627r (fig. 9), resulted in self-contradiction. On the one hand, the position of the frontal ventricle in the sagittal view of W 12603r seems to correspond to the intersection point established by Leonardo in W 19057r (fig. 20), the recto of W 19057v touched upon earlier, as the "concorso di tutti i sensi," with the optic nerves reuniting within the frontal ventricle at approximately one-third of the cranium's length.[40] On the other hand, Leonardo clearly locates the common receptor (*senso comune*) in proximity to the ocular cavity.[41]

The real novelty of W 12603r consists in Leonardo's suggestion that the auditory nerves refer equally to the *imprensiva*. Leonardo may have reached this conclusion by reflecting on how visual input seems to be inextricably 'encoded'

37 Leonardo, *Windsor*, vol. 1, 1979, pp. 102–103 (42r) [W 19058r]: "Il concorso di tutti i sensi ha sotto sé per linia perpendiculare l'uvola dove si gusta il cibo a distanzia di due dita […] e ha sopra sé la giuntura dell'osso del craneo una mezza testa, e ha dinanzi a sé per linia orizzontale i' lagrimatoio delli occhi a una terza testa; e dirieto a sé ha la nuca e due terzi d'una testa e ha, dai lati, i due polsi delle tempie per equale distanzia e altezza." See further Bambach 2019, vol. 2, pp. 194, 202.

38 See O'Malley/Saunders 1952, p. 46, note 4; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 3, p. 24 [B 40]; Keele 1983, p. 63; *Leonardo: Anatomical Drawings* 1983, p. 48, no. 8B; and Bambach 2019, vol. 2, p. 194.

39 Leonardo, *Windsor*, vol. 1, 1979, pp. 108–109 (43v) [W 19057v]: "Il buso *b* è dove la virtù visiva passa al senso."

40 Leonardo, *Windsor*, vol. 1, 1979, pp. 106–107 (43r) [W 19057r]: "Dove la linia *am* s'intersega colla linia *cb*, lì fia il concorso di tutti i sensi, e dove la linia *rn* s'intersega colla linia *hf*, lì fia il polo del craneo, innel terzo della bassezza della testa, e così *cb* fia nel mezzo." See also O'Malley/Saunders 1952, p. 52, note 7; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 3, p. 24 [B 40]; Kemp 1971, p. 118; Keele 1983, p. 65; *Leonardo: Anatomical Drawings* 1983, p. 48, no. 8A; Summers 1987, pp. 71–73; Todd 1991, p. 94; Fehrenbach 1997, p. 183; Laurenza 2001, pp. 19–20, 23–25; and Bambach 2019, vol. 2, p. 194.

41 Leonardo, *Windsor*, vol. 1, 1979, pp. 104–105 (42v) [W 19058v]: "Il vacuo della cassa dell'occhio e 'l vacuo dell'osso sostenitore della guancia e quello del naso e della bocca sono d'equale profondità, e terminano sotto il senso comune per linia perpendiculare."

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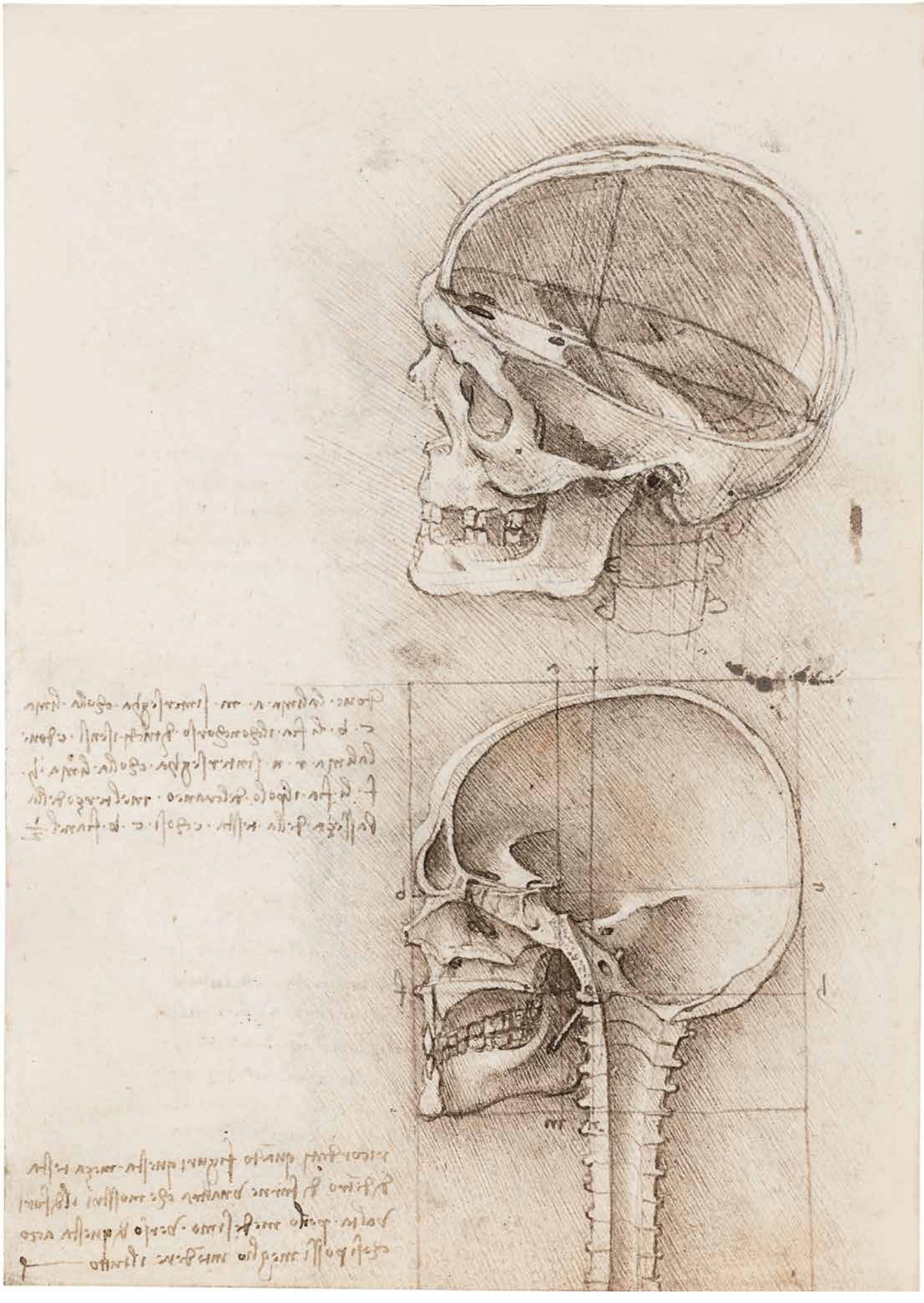
20 Leonardo da Vinci, W 19057r, The Skull Sectioned, ca. 1489, traces of black chalk, pen and ink, 18.8 × 13.4 cm. Windsor, Royal Collection, inv. RCIN 919057r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021).



within words. As we will see later, for Leonardo words come to the brain as hybrid "figurations": some sort of sound-image compounds. Similarly, an interest in the synesthetic processes of human perception may have resulted in the rather puzzling idea (formulated around 1492 in CA, 245 r) that the *imprensiva* acts as a sort of general 'dispatcher':

> The ancient thinkers have concluded that the element of judgment conferred to mankind is caused by an instrument, to which the other five senses refer through the *imprensiva*, and such an instrument they called common receptor, and they say it is placed at the center. And they call it common receptor only because it is the common judge of the other five senses, that is, seeing, hearing, touching, tasting, and smelling. The common receptor operates [*si move*] through the *imprensiva*, which is situated between it and the senses. The *imprensiva* operates [*si move*] through the likenesses of the things conveyed to it by the external instruments, that is, the senses, which stay between the exterior things and the *imprensiva*; by the same token, the senses operate [*si movano*] through the objects. The likenesses of the surrounding things send their likenesses to the senses, and the senses transfer them to the *imprensiva*, and the *imprensiva* dispatches them to the common receptor, which fixes them in the memory, and they are kept there in conformity with the importance or force [*potenzia*] of the thing conveyed.[42]

In this passage, Leonardo declares for the first and arguably only time that the *imprensiva* – and not the common receptor as upheld by "the ancient thinkers" – coordinates the information channeled by all five senses. We cannot say for sure whether Leonardo's new emphasis on the *imprensiva* as a perceptual "terminal" derived from his reflection on the senses' interactions and their function in knowledge or from his recently conducted anatomical studies of the skull. What is particularly striking, however, is that, even in light of new evidence, Leonardo did not give up his conviction that the *imprensiva* dwelled in the brain's frontal ventricle: a conviction utterly at odds with the doctrines of the "ancient thinkers" invoked as the very guarantors of his unconventional views.

At this point, it must be admitted that attempting to solve Leonardo's ambiguities with regard to the *imprensiva* may be a hopeless endeavor. The reason for this is not only the fragmentary nature of Leonardo's surviving drawings and especially his notes, with almost none of them preceding his first long sojourn in Milan (1482–1499). More to the point though, Leonardo's uncertainties are both an integral component and an inevitable outcome of his methodology. If we compare W 12603 r to W 19057 r, we find at work two thoroughly opposite, yet complementary approaches to the question of the brain ventricles and their interaction with the senses and the soul (figs. 1, 20). In W 19057 r, Leonardo is able

42 Leonardo, *Codice Atlantico* [2000], vol. 1, p. 390 (245 r): "Li antichi speculatori hanno concluso che quella parte del giudizio che è data all'omo sia causata da uno strumento, al quale referiscano li altri 5 mediante la imprensiva, e a detto strumento hanno posto nome senso comune, e dicano questo senso essere situato in mezzo il capo […]. E questo nome di senso comune dicano solamente perché è comune iudice de li altri 5 sensi: cioè vedere, udire, toccare, gustare e odorare. Il senso comune si move mediante la imprensiva, che è posta in mezzo infra lui e i sensi. La imprensiva si move mediante la similitudine delle cose a lei date da li strumenti superfiziali, cioè i sensi, i quali sono posti in mezzo infra le cose isteriori e la imprensiva; e similemente i sensi si movano mediante li obbietti. La similitudine delle circustanti cose mandano le loro similitudine a' sensi, e sensi la trasferiscano alla imprensiva, la imprensiva le manda al senso comune e da quello sono stabilite nella memoria e lì sono più o meno retenute secondo la importanzia o potenzia della cosa data." For the dating of this passage to ca. 1492, see Pedretti 1957, pp. 264–289.

to see, measure, and scrutinize the skull: he can ground his conclusions securely in the *sperienza*. In W 12603 r, Leonardo is forced to speculate: he *assumes* that there is a point of attachment between the sensory nerves and one of the brain ventricles and he tries to visualize this hypothesis as persuasively as possible, even at the risk of destabilizing previous convictions about the exclusive relationship between sight and the frontal ventricle (the *imprensiva*).

As a result, the new visualization in W 12603 r of the *imprensiva* as the common receptacle of at least two senses (sight and hearing) truly represents a "prospect": a possibility that, in order to be verified, necessitated a kind of autopsy (in the Greek sense of the term, that is, a self-conducted ocular inspection) that Leonardo simply could not undertake, given the technical limitations of his dissecting skills. And yet, however reluctant he was to deal with unseen things, to draw out conclusions about the invisible, Leonardo could not renounce the principles of speculative gnoseology if he wanted to explain the mechanisms of vision as intrinsic to knowledge. What is truly remarkable is that, in adopting a long-established theory of the spiritual faculties as enacted by the brain ventricles, he radically shook up its premises by granting the otherwise unknown *imprensiva* pride of place in his anatomy, optics, and epistemology.

The Protean Nature of the *Imprensiva*

But what exactly is the *imprensiva*? In the first place, *imprensiva* is an adjective, and as such requires a noun, implicit in this case. As a spiritual faculty, *imprensiva* refers to "virtù" or, if we think of its Latin equivalents like *cogitativa* or *memorativa*, to a "vis," "virtus," or "potestas."[43] Following Giovan Francesco Melzi's transliteration of this term as "impressiva," scholars have construed the *imprensiva* exclusively as the eye's capacity to be impressed.[44] Valid in many respects, this interpretation is however reductive, besides being questionable on linguistic grounds. Indeed, *imprensiva* does not derive from *imprim-* (to impress), but from *imprend-*, sometimes a variant of *apprend-*.[45] Leonardo clearly distinguishes *impressione* (im-

43 For a definition of faculty in medieval philosophy, see Perler 2015.

44 For an interpretation of Leonardo's *imprensiva* and its relation to the other faculties lodged in the ventricles, see Kemp 1977b, p. 379 ("receptor of impressions"); Keele/Pedretti 1979, p. 90; Keele 1983, pp. 61–68, 76, 229–230, 237–239, and 364; Farago 1992, pp. 301–302; Fehrenbach 1997, pp. 182–184; Fehrenbach 2002, pp. 537–538; Kemp 2006, p. 108; Pardo 2008, p. 77; Del Maestro 2011, p. 173; Klemm 2013, p. 152 ("[Das Auge] nimmt diese [Proportionen und Harmonien von Einzelteilen] als *eine* Gestalt wahr und gibt sie als solche an die *impressiva* weiter, also an die Kammer, wo der Sinnesphysiologie Leonardos zufolge alle Sinnesformen zusammenlaufen. *Bevor* in der Kammer des *senso comune* die Beurteilung der gesehenen Formen stattfindet, erfolgt ein solches *iudicium* also bereits in den Augen"); Fehrenbach 2015a, pp. 213–216; Fehrenbach 2015b, pp. 72–74 [abridged version of Fehrenbach 2015a]; Di Napoli 2019, esp. pp. 26–28 (where it is unconvincingly suggested that Leonardo's late localization of the *imprensiva* within the eye indicates that he had intuited the role played by the retina in seeing as understood in contemporary neurology) and p. 36; Fehrenbach 2019, pp. 41–44 ("Wir können uns Leonardos *imprensiva* als hypersensiblen Resonanzraum vorstellen, in dem die ungemein schwach gewordenen, durch das dunkle Augeninnere gegangenen Abbilder der Wirklichkeit nachhallen […]. Durch ihr Eindrucksvermögen hält die *imprensiva* aber auch implizit die einzelnen vorübergehenden Sinneswahrungen wie in Nachhall präsent"); and Fehrenbach 2020, pp. 18–21 (basically the same text as in Fehrenbach 2019). In particular, Fehrenbach 2020, p. 20, points briefly in the direction of my argument in this essay: "In tal modo l'*imprensiva* rende anche implicitamente possible l'unificazione delle singole impressioni della percezione spontanea (l'*aspectus simplex*, nella terminologia di Alhazen) in una visione d'insieme (l'*intuitio* di Alhazen)."

45 Quaglino 2013, pp. 85–86, points out that the nexus *ns* in *imprensiva* has a "truly phonetic value," thus suggesting that the term does not derive from *imprimere*. See further Piro 2019, pp. 196–197.

pression) from *imprensione* (the act of lighting through fire).[46] In CA 48r (ca. 1515), Leonardo, dealing with ballistics, states that "the time of the ignition provoked by fire on gunpowder [*imprensione fatta dal foco nella polvere*] will be exactly proportionate to the quantity of gunpowder."[47] In other passages, Leonardo employs *apprendere* (and notably not the variant *imprendere*) exclusively in relation to fire.[48] It bears noting that Leonardo does not employ either variant in the much more usual sense of "learning" or "grasping." If Leonardo meant *imprensiva* as the equivalent of *apprensiva* (the vernacular form of the scholastic *apprehensiva*), his writings do not confirm this possibility, indeed they even discount it.[49] Steeped in Leonardo's later theories on vision, Melzi intuitively replaced the

46 *Grande dizionario della lingua italiana*, vol. 7, p. 513, records the expression "fare imprensione" in the sense of "to believe" (Lionardo Salviati, 1539–1589). TLIO (*Tesoro della Lingua Italiana delle Origini*) lists three passages by Jacopo Alighieri (Dante's son, 1289–1348) where the meaning of *imprensione* is given as "astral influence" or a "distinctive trait," URL: www.tlio.ovi.cnr.it (accessed 01.03.2021). I doubt the reliability of this interpretation: in two passages the TLIO quotes, *imprensione* seems related to fire (in one case in relation to Mars, which Dante considers to be made of fire). More research is thus necessary. The *Vocabolario degli Accademici della Crusca* (1612) 1691, vol. 2, p. 845, also seems to simplify the question by making the meaning of *imprensione* identical with *impressione*. The first example recorded by the *Vocabolario* (taken from the vernacular translation of Livy's Third Decade, erroneously attributed to Giovanni Boccaccio) cannot be verified, as the manuscript consulted for it has not been identified. In the printed version of this manuscript (Livio [1875–1876], vol. 1, p. 121), the passage was emended as "la 'mpressione del piede." "Di prima imprensione" for "stubborn" may not mean "di prima impressione" as suggested by the *Vocabolario*, but "di prima apprensione": that is, somebody who abides by his or her first understanding of things.

47 Leonardo, *Codice Atlantico* [2000], vol. 1, p. 55 (48r): "Dico [...] che il tempo della imprensione fatta dal foco nella polvere sarà nella medesima proporzione della quantità della polvere, cioè tripla."

48 See Leonardo, *Manoscritto I* [1987], p. 106 (100v): "La bombarda solo accresce la forza, perché in più lungo moto che fa la ballotta nel suo corpo, più polvere s'accende; perché bisogna confessare che tale apprendimento di foco si facia con tempo divisibile, e quanto più parti di tempo dura, tanto più polvere s'accende e più il foco si prieme in tale strumento e con più impeto e furore scaccia da sé la ballotta"; Leonardo, *Codice Atlantico* [2000], vol. 1, p. 359 (227r): "Quanto maggior somma di foco s'apprende in pari tempo 'n una medesima bombarda, con tanta maggiore potenzia si move la sua pallotta"; Leonardo, *Codice Atlantico* [2000], vol. 3, p. 1772 (973v): "Se batterai uno filo grosso di ferro con ispessi colpi tra l'ancudine e 'l martello sopra uno medesimo loco, potrai in nel loco battuto apprendere il solfanello"; Leonardo, *Codice Arundel* [1998], vol. 1, Testi, p. 139 (57r) [in relation to water]: "Quando apprende il foco, quando lo spegnie, calda, freda [...]." I was able to find one example of *imprendere* in relation to fire outside Leonardo: a passage in Guglielmo Capello's commentary on Fazio degli Uberti's *Dittamano*, compiled ca. 1435–1437. See Gallerani 2011, p. 78: "In questo tempo in Roma s'imprese fuoco e brussossi de la città le più alte parte e nel tempio di Iupiter si discollò la sinistra mano de la sua statua d'oro finio."

49 *Apprensiva* appears only once in Leonardo's writings: *Codice Atlantico* [2000], vol. 3, pp. 1421 (729r): "[...] il circolo della luce che appare in mezzo al bianco dell'occhio è di natura apprensiva delli obbietti." In this same passage, Leonardo uses the term *imprensiva* twice, and it refers specifically to the faculty connected to the common receptor. A passage in the vernacular translation (attributed to Bono Giamboni) of Brunetto Latini's *Li Livres dou Trésor* shows an interesting example of *imprendere* in the sense of *apprendere* in connection with the brain ventricles: "Per ciò dicono li savi che 'l capo, ch'è magione dell'anima, ha tre celle, una dinanzi per imprendere, l'altra nel mezzo per conoscere, e la terza drieto per memoria" (Brunetto (1533) 1839, vol. 1, p. 23). Reading this, one can understand how *imprensiva* could have been an equivalent of *apprensiva* from a linguistic point of view. Nevertheless, terminologically, *apprehensiva* refers to all sorts of activities carried out by the external senses and other spiritual faculties (not only the *senso comune*). In his *De natura et origine animae*, Albertus Magnus explains the point succinctly: "Adhuc quaecumque est virtus operans in corpore, non est apprehensiva nisi corporalium formarum, figuras scilicet et intentiones qualitatum sensibilium. Intellectus autem [...] apprehensivus est simplicium infigurabilium et insensibilium sive hic et nunc existentium" (Albertus Magnus [1890–1899], vol. 12, p. 401).

idiosyncratic *imprensiva* (with its derivation from a rather antiquated and Tuscan-flavored *imprendere*) with a more transparent neologism: *impressiva*.[50]

Bearing in mind the particular use of *apprend-*/*imprend-* documented in Leonardo's manuscripts, it is legitimate to speculate about the origins of the term. Initially, the *imprensiva* may have referred to the eye's ability to "shed light" or "spark light." Leonardo's unconventional association of the *imprensiva* with the *inteletto* (especially if, by this, he meant the active intellect) could explain the meaning of the neologism. Like the intellect, the *imprensiva* would be able to "light" (that is, form and evoke) images in the absence of their referents. For Avicenna and his followers, this capability was the privilege of the *imaginatio* in conjunction with the common receptor. As will be shown later, Leonardo seems to have assigned this ability to the *imprensiva* (and undoubtedly not the imagination). By the same token, Leonardo's early attraction to the extramission theory of vision would have led him to envision the eye as a source of light and the process of seeing as the faculty of "setting alight."[51] Whether or not inspired by any of these theories, the hermeneutical analogy behind Leonardo's invention of the term *imprensiva* is inexorably lost to us unless new documentation is one day unearthed. Enshrined as it is in Leonardo's hermeneutics, the notion of the *imprensiva* must hark back to his formative period in Florence, for which there is scant documentation.

While the original meaning of the *imprensiva* cannot be recovered with certainty, its functions and finality can be reconstructed from Leonardo's writings. On a preliminary basis, it can be argued that Leonardo oscillated between an active, epistemological understanding of the *imprensiva*, and a more empirical appreciation of its physical and physiological effects, mostly described as

50 Carlo Vecce, in Leonardo, *Libro di pittura* [1995], vol. 1, pp. 104–105, discusses Melzi's transliteration of Leonardo's writings with regard to Melzi's Lombard origins and the evolution of the Italian vernacular around 1540. The *Grande dizionario della lingua italiana*, vol. 7, p. 520, records that the adjective *impressivo*, albeit rare, is already used in fifteenth-century Tuscany (Bernardino da Siena), while the noun *impressiva* appears only in Melzi's transcription of Leonardo's notes. Melzi's interpretation of the *imprensiva* as *impressiva* is justified by Leonardo's theory on image reception. In fact, Leonardo tends to avail himself of the verb *imprimere* in describing how the images transmitted by the visible objects impress themselves onto the surface of the cornea or the glacial humor. For instance, in Leonardo, *Manoscritto D* [1989], p. 3 (1r), dated to ca. 1508, Leonardo observes: "Nature made the surface of the cornea situated in the eye in a convex form so that the surrounding things can impress [*impremere*] their likenesses according to wider angles, which would not occur if the eye was flat." For Leonardo, the imprint of a luminous body could get caught in the rims of the eyelids: the likenesses of those objects "impress themselves [*s'impremano*] upon the thickness of the eyelids": Leonardo, *Manoscritto D* [1989], p. 7 (2r).

51 See, in this regard, Frosini 2003, p. 83: "È un fatto, in ogni modo, che in quel foglio [*Codice Atlantico* [2000], vol. 3, pp. 1419–1424 (729r–v)], è questo l'unico passaggio contrario alla tesi estromissiva, e che è ancora a quest'ultima che va la preferenza di Leonardo." Even philosophers who refuted the extramission theory believed that some sort of light resided in the eye, based on the luminescence typical of certain animals' pupils. See, for instance, Avicenna [1968–1972], vol. 1, p. 257 (III, 7): "Iam etiam patebit tibi quod ipsa pupilla potest esse de his quae in nocte lucent et illuminant et iactat radios suos super id quod est oppositum illis. Oculi etenim multorum animalium sunt huiusmodi, sicut oculus leonis et serpentis; et quandoquidem sic est, potest illuminare tenebrosum; unde multa ex animalibus vident in tenebris, quoniam illuminant rem luce procedente ex oculis et virtute suorum oculorum." Similarly, Leonardo notes in *Codice Atlantico* [2000], vol. 3, p. 1423 (729v): "Il pescio detto linno alcuni lo dicano di Santo Ermo, il quale nasce ne' liti di Sardigna, non è elli visto da li pescatori, la notta, allumare co' li occhi a modo di 2 candele gran quantità d'acqua, e tutti quelli pesci che si trovano in detto splendore, subito vengon sopra l'acqua rovesci e morti?" For Leonardo's initial inclination toward an extramission theory of vision, see Kemp 1977a, pp. 133–134; Ackerman 1978, pp. 126–127; Strong 1979, pp. xx–xxi, 302–311; Keele 1983, pp. 69–71; and Frosini 2003, pp. 78–84.

passive.[52] The active connotations of the *imprensiva* may be considered vestigial, as they are documented in early drawings (1485–1492) and in key passages of the so-called *paragone* (all of these key passages, with one exception, were compiled by 1492).[53] Even in Ms. A (ca. 1492), there is already evidence that Leonardo was thinking of this faculty in more passive terms, likening it with the eye's mechanical susceptibility to visual impression.[54] However, some of Leonardo's initial reflections on the *imprensiva* as a passive faculty of the eye do not necessarily reflect his own convictions or are formulated in such a tentative manner that they betray undecidedness.[55] As a general rule, Leonardo's interest in the *imprensiva* as a spiritual faculty seems to ebb away as he becomes increasingly entangled in unraveling the complex mechanisms of image inversion and optical aberrations.[56]

In investigating the physiology of vision, Leonardo tends to be inconsistent in defining the location of the *imprensiva*. In CA 599r (ca. 1492), Leonardo tackles the delicate question of image inversion, an important aspect of his theory of vision contingent upon his experimentation with the camera obscura. Because, as he rightly contends, light is refracted in passing through the cornea (*luce*), it follows that the image reaching the glacial humor is reversed, that is, turned upside down. In order to remedy this, Leonardo posits that a first refraction occurs before the image is re-refracted in its transit through the glacial humor. Leonardo's explanation of this phenomenon implies that the *imprensiva* receives the re-reversed image as if this faculty was situated in the glacial humor.[57] This is also suggested by yet another of his observations in Ms. A 81r (ca. 1492). If we fix our gaze on an object in close proximity to us and, with one finger, push upward the lower eyelid of only one of two open eyes, we will see the object doubling in two different positions, above and below. The image, in effect, results from the

52 In general, Leonardo uses adjectives with the suffix *-ivo/a* to designate an action. For him, anatomical organs possess the capacity for expelling and impeding (*virtù espulsiva*, *virtù impeditiva*), while muscles have the ability to dilate and stretch (*moto dilatativo*, *moto astensivo*). See Leonardo, *Windsor*, vol. 2, 1980, pp. 632–635 (159r) [W 19066r]: "Ma e' pò ben trovarsi 'n un medesimo membro una virtù espulsiva e una virtù impeditiva 'n un medesimo 'stante, ché gran differenzia è da ritenere a impedire"; and *Windsor*, vol. 2, 1980, pp. 640–641 (161r) [W 19068r]: "perché tutti li muscoli hanno moto dilatativo e astensivo nota, nel fare della natomia, quali sono li nervi che entrano infra il meri e la spina nel collo inne' muscoli posti nel detto loco."

53 The dating of Leonardo's so-called *paragone* remains an open question. In his *Trattato dell'arte della pittura* (1584), Giovan Paolo Lomazzo declares that he had read an autograph book by Leonardo written at the behest of Duke Ludovico Sforza, where Leonardo discussed whether "painting or sculpture is more noble": Lomazzo 1584, p. 158. For different reasons, it is thus generally assumed that Leonardo compiled a *paragone* book at the beginning of the 1490s. The question is complicated by the fact that Leonardo reprised some of these remarks in subsequent compilations. As a result, it is impossible to date the *paragone* observations with certainty. See in this regard Pedretti 1964, pp. 121–128; Farago 1992, p. 15; and (with regard to the passages relevant to this discussion) the dating proposed by Vecce in Leonardo, *Libro di pittura* [1995], vol. 1, pp. 140 (15), 142 (18), 144 (19), 146 (22), 148 (23). All these passages seem to hark back to the early 1490s. The only other important annotation for this essay that seems to have been written later (ca. 1500–1505) is Leonardo, *Libro di pittura* [1995], vol. 1, p. 132 (2).

54 See below, note 58.

55 I refer in particular to Leonardo, *Codice Atlantico* [2000], vol. 3, pp. 1419–1424 (729r–v), as established by Frosini 2003, p. 83.

56 Frosini 2003, p. 85, pithily observes: "Il crinale tra spirito e virtù spirituali, tra magia e prospettiva, sul quale Leonardo si muove circa il 1490, rappresenta un momento di svolta molto importante nel suo itinerario intellettuale, dato che è in questo momento che egli sceglie consapevolmente di diventare un 'filosofo' e 'matematico'." As intimated by Frosini, Leonardo's interest in "spirito" and "virtù spirituali" were rooted in the culture of the Florence of his early years. It is no coincidence, then, that Leonardo's emphasis on the *imprensiva* as an epistemological tool begins to subside "circa il 1490."

57 Leonardo, *Codice Atlantico* [2000], vol. 2, p. 1175 (599r): "Adunque, dando la superfizie dell'occhio a la imprensiva le spezie mandatole dai contra posti obbietti per mezzo d'uno corpo sperico il quale è situato in mezzo l'occhio, è necessario che le spezie faccino intersegazione e rivoltinsi sottosopra nel contatto de la imprensiva." On Leonardo's theory of image

combined impressions engendered by the divergent focus of each eye. In Leonardo's words, "If you lift the lower eyelid upward, it will push the eye backward and raise the cornea upward, and the part of the eye at the center toward the back will make an opposite movement, as will the likenesses of the objects impressed in that part at the back of the eye where the power [*virtù*] of the *imprensiva* is based."[58] In these examples, there is practically no difference between the receptivity of the cornea and that of the *imprensiva*: both endure the action of the visual likenesses by becoming impressed. In CA 729r, Leonardo goes as far as to describe the pupil as "a perforated nerve that penetrates the internal faculties, which is filled with the power of the *imprensiva* and of judgment [*virtù imprensiva e giudiziale*] that befalls the common receptor." Similarly, the glacial humor, "which shares the quality of the *imprensiva* [*virtù imprensiva*] and sees many things, does not grasp them, but turns the pupil at the center toward them, and this proceeds in a straight line to the common receptor [again merely denoted as *senso*], which seizes the likenesses [*spezie*], and keeps those it pleases in the prison of memory."[59] Once again, the *imprensiva* is downgraded to a limited "power" in the service of the common receptor and is hence deprived of autonomy.

On the contrary, Leonardo elsewhere distinguishes the activity of the *imprensiva* by placing it outside the purview of the ocular nerve. In Ms. A 100v, Leonardo argues that a face perceived in the distance appears to the eye to be blurry and "incomprehensible" because its already colorless likeness, passing from the surface of the eye to the *imprensiva* "through a dark medium, that is, the hollow nerve that seems to be dark […] becomes tinged with the darkness it encounters on its way, and, reaching the *imprensiva*, it appears dark."[60] It is impor-

re-invertion, see Ackerman 1978, pp. 129–130, 138–141. See further, Leonardo, *Codice Atlantico* [12000, vol. , p. 1175 (599v) ["la *imprensiva*, posta direto allo sperico omore graciale, ridirizza le spezie"] and Ackerman 1978, p. 141, where this observation is assessed. It is unlikely that Leonardo thought that the *imprensiva* actively re-inverted the image, unless he was generally referring to the role of the chiasma in "redressing" the likenesses of the objects, as postulated by Avicenna, among others. On the question in general, see Strong 1979, pp. 336–338.

58 Leonardo, *Manoscritto A* [1990], pp. 161–162 (81r-Ashb. 1): "Questo tale effetto accade perché l'occhio che col dito è remosso di sotto in su, o di sopra in giù, si move movendo o spingendo i sua coperchi, che dentro al lor nascimento si congiungano colla superfiziale pelle dell'occhio. E se spingerai in alto il coperchio di sotto, lui si tirerà dirieto l'occhio e leverà la luce in alto, e la parte dell'occhio che si trova dal centro in dirieto farà contrario movimento, e di contrario movimento fiano le similitudine de li obietti impressi in quella parte dell'occhio posteriore, dove si fonda la virtù dell'imprensiva. E questo effetto accade tenendo aperti tutti e dua li occhi, perché l'occhio che non è remosso vede la cosa nel suo sito, e quello ch'è remosso move la similitudine dell'obietto impressa nella sua imprensiva e mai la cosa vista dall'occhio remosso fia di quella espedita forma che fia quella ch'è vista dall'occhio che non è remosso, imperò ch'essendo rimosso non vede la similitudine dell'obietto per quella linea centrica, donde meglio si giudica le cose, anzi si vede da quelle parti che sono dintorno a esso centro, e perché le sono d'omore meno trasparente, più confuse fieno viste le cose." It is noteworthy that Bacon [2006], pp. 64–65, resorts to a similar experience to establish the importance of the chiasma of the ocular nerves lest the image be perceived as double.

59 Leonardo, *Codice Atlantico* [2000], vol. 3, p. 1421 (729r): "E questo circulo [of the pupil] medesimo ha in sé uno punto che apparisce nero, il quale è uno nervo forato che va dentro alle intrinsiche virtù, il quale è pieno della virtù imprensiva e giudiziale che capita al comun senso […]. Così questa, perché è uno omore che tiene della virtù imprensiva e vede molte cose, ma non le piglia, ma subito vi volge la popilla di mezzo, la quale va per linia al senso, e quella piglia le spezie, e quelle che piacciano, le incarcera nella prigione della memoria."

60 Leonardo, *Manoscritto A* [1990], p. 198 (100v): "Noi vediamo chiaro che tutte le similitudine delle cose evidenti che ci sono per obietto, così grande come piccole, entrano al senso per la picciola luce dell'occhio. Se per sì piccola entrata la similitudine de la grandezza del cielo e de la terra, essendo il volto de l'omo, infra sì gran similitudine di cose, quasi niente per la lontanità che lo diminuisce, quasi occupa sì poca d'essa luce che rimane incomprensibile. E avendo a passare dalla superfizie alla imprensiva per uno mezzo oscuro, cioè il nervo voto che pare oscuro, quella spezie non sendo di colore potente, si tigne in quella oscurità della via, e giunta alla imprensiva pare oscura."

tant to underscore that Ms. A 100v dates from around 1492, and therefore after or around the time Leonardo was analyzing the human skull in his quest for the brain ventricles. Not surprisingly, therefore, these observations conform with the information conveyed in the drawings previously discussed. On the other hand, the almost contemporaneous remarks in which Leonardo downplays the role of the *imprensiva* seem to herald a line of inquiry on image inversion and optical aberrations that would continue to preoccupy the artist until late in his life.[61]

A very different approach to the notion and function of the *imprensiva* can be gleaned from Leonardo's famous remarks on the *paragone* gathered by Melzi in the so-called *Libro di pittura*. As touched upon earlier, Leonardo's *imprensiva* is not synonymous with the faculty of imagination traditionally located by Avicenna and his followers in the frontal ventricle along with the common receptor.[62] In Avicenna's *De anima*, the likeness of the form seen impresses itself in the spirit "that carries the power of the common receptor, and the common receptor receives that form, and, with this, vision is achieved." Nevertheless, Avicenna continues, the faculty of seeing is distinct from the common receptor. This is why

61 For Leonardo's predominant interest in these two topics later in his career, see, for instance, Kemp 1977a, esp. pp. 138–146. Other passages in which the *imprensiva* seems to be within the eye or its location remains uncertain are: Leonardo, *Manoscritto C* [1986], p. 32 (16r), dated to 1490–1491 ("L'occhio uso nelle tenebre che subito vede la luce riceve detrimento, onde subito si richiude non potendo essa luce sopportare. E questo accade perché, volendo la popilla alcuna cosa conoscere nelle usate tenebre, s'accresce di grandezza operando ogni sua forza di mandare alla imprensiva la similitudine delle ombrose cose"); Leonardo, *Manoscritto D* [1989], p. 8 (2v), dated to ca. 1508 ("La popilla dell'occhio che per minimo spiraculo retondo riceve le spezie de' corpi posti dopo esso spiraculo, sempre le riceve sotto sopra e sempre la virtù visiva le vede diritte come sono. E questo nasce che le dette spezie passano per il centro della spera cristallina, posta nel mezzo dell'occhio, e in esso centro s'uniscano in punto, e poi si dilatano nella opposita superfizie di tale spera non si sviando dalle lor rettitudine, e in tal superfizie le spezie si dirizzan secondo l'obbietto donde son causate, e di lì son prese dalla imprensiva e mandate al senso comune dove son giudicate"); Leonardo, *Madrid II* [1974], p, 37 (25v) dated to ca. 1503–1504 ("l' lume veduto con un ochio è la metà di minor potentia e magnitudine che'l lume veduto con due ochi. Provasi: sia a la imprensiva dove l'ochio conferisce li obbietti luminosi. Dico che [c] allumina per un sol grado di lume essa imprensiva. Agiuntovi b essa imprensiva riceve 2 gradi di lume. E perché 2 gradi di lume sono in dupla proportione a uno grado, noi troviamo essa imprensiva essere doppiamente alluminata da due lumi, e da cento, cento volte più. Quello loco sarà più alluminato che da maggior somma di luce sarà percosso. E così sarà manco alluminato che fia veduto da minor lumi"); Leonardo, *Madrid II* [1974], p. 33 (24r) ("Vede il doppio più potente splendore li due ochi che porgano a una sola inprensiva che non fa uno solo ochio"); Leonardo, *Madrid II* [1974], p. 35 (24v) ("Ancora per lo esemplo del lume che dà più due ochi che uno alla nostra inprensiva"). Leonardo also compares the dimension of the brain ventricle with the *imprensiva* in man and animals: Leonardo, *Manoscritto D* [1989], p. 17 (5r), dated to ca. 1508 ("Del gran variare che fan li animali notturni dalla loro maggiore popilla de l'occhio nella notte alla minore popilla del dì. Proporzione del ventricolo della imprensiva posto nel cervello delli animali colla loro popilla"); Leonardo, *Manoscritto D* [1989], p, 18 (5r), dated to ca. 1508 ("Perché se la popilla dell'omo raddoppia la notte il diamitro alla sua popilla, che vol dire quattro tanti quella del dì, il diamitro della popilla del duco, ovver gufo, cresce 10 volte. Quel del giorno, che in somma vol dire 100 volte la popilla del dì. Oltre a di questo il ventriculo posto nel cervel dell'omo, detto imprensiva, è più che dieci volte tutto l'occhio dell'omo, del quale la popilla donde si causa il vedere è men che la millesima parte d'esso occhio, e nel gufo la popilla notturna è assai maggiore che'l ventriculo della imprensiva posto nel suo cervello. Onde maggiore proporzione ha l'omo dalla imprensiva sua alla sua luce che non fu quella del duco che è quasi equale. E questa imprensiva dell'omo rispetto a quella del gufo è come una gran sala che ha lume per una piccola busa rispetto a una piccola sala tutta aperta; che nella gran sala v'è notte di mezzogiorno e nella piccola, aperta, v'è giorno di mezzanotte, non essendo il tempo nuvoloso. E con questo si mosterrà più potente causa mediante la notomia delli occhi e imprensiva di questi due animali, cioè dell'omo e del duco").

62 Although Leonardo uses *imaginatione*, *imaginativa*, and *fantasia* interchangeably, he was obviously aware of the distinctions between a sensory and a deliberative imagination: Kemp 1977b, pp. 362–384 (specifically on Leonardo).

"the common receptor returns that form to another part of the spirit that is continuous with the part of the spirit that carries it, and impresses that form in it, and stores it therein in the formative power, that is, the *imaginativa* […] which receives and preserves the form."[63] The ability of the common receptor to make judgments upon the flow of sensations it relentlessly receives from all the senses is secured only by recourse to the imagination. It is only through comparison between the form perceived on the spot and the forms preserved by virtue of and within the imagination that a judgment can be uttered and verification can take place. Indeed, in the faculty of the soul where the imagination resides "the forms remain in existence, even after having been absent for a long time."[64]

Unlike Avicenna's imagination, Leonardo's *imprensiva* not only precedes the common receptor, but also usurps some of its functions, acting as an interface with the senses, in particular sight. Furthermore, Leonardo makes a clear distinction between the *imprensiva* and the *imaginativa* (or imagination). In the *paragone*, Leonardo argues:

> Imagination does not see with the same excellence as the eye, because the eye receives the species or likenesses of the objects and gives them to the *imprensiva*, and from the *imprensiva* to the common receptor, where it is judged. But imagination does not extend outside the common receptor except when it passes to the memory, and it stops there, and there it dies out if the thing imagined is not of great excellence.[65]

In Leonardo's opinion, the supremacy of painting over poetry should be predicated upon the shortcomings of the imagination by comparison to sight: the poet's imagination does not originate in the eye, but in the common receptor, or (as he puts it) in the tenebrous eye (*occhio tenebroso*) of the mind.[66] "Oh what a difference there is," he exclaims, "between imagining this light in the tenebrous eye and seeing it in actuality outside the darkness!"[67] Within the context of the *paragone*, it is thanks to the eye's immediacy and its privileged relationship with

63 Avicenna [1968–1972], vol. 1, pp. 269–270 (III, 8): "Deinde haec virtus quae est sensus communis reddit formam alii parti spiritus, quae est continua cum parte spiritus quae vehit ipsum, et imprimit in illam formam ipsam, et reponit eam ibi apud virtutem formalem, quae est imaginativa, sicut postea scies, quae recipit formam et conservat eam. Sensus etenim communis est recipiens formam, sed non retinens; imaginativa vero retinet quod recipit illa."

64 Avicenna [1968–1972], vol. 1, p. 270 (III, 8): "Sed in spiritu in quo est imaginativa, formae sunt existentes, quamvis a longo tempore absentatae fuerint."

65 Leonardo, *Libro di pittura* [1995], vol. 1, p. 139 (15): "Non vede la immaginazione cotal eccellenzia qual vede l'occhio, perché l'occhio riceve le specie, overo similitudini de li obbietti, e dalli alla impressiva, e da essa impressiva al senso comune, e lì è giudicata. Ma la imaginazione non esce fuori d'esso senso comune, se non in quanto essa va alla memoria, e lì si ferma e lì muore, se la cosa immaginata non è da molta eccellenzia." See further Farago 1992, pp. 199–201.

66 For an interpretation of the *occhio tenebroso*, see Pardo 2008, esp. p. 79; Fehrenbach 2015b, esp. pp. 74–76, who interprets the expression in moral and theological terms; and Fehrenbach 2019, pp. 47–48. See further Büdel 1961, pp. 295–299. In his *Trattato di architettura civile e militare*, Francesco di Giorgio Martini intimates that readers of unillustrated architectural treatises are blinded by their own *immaginativa*, which leads them to create works that are as different from the original as light is from dark: "Inperò che andando drieto alla immaginativa, ciascuno fa varie composizioni che sono talvolta più differenti dal vero e dalla prima intenzione che dalla chiara luce la tenebrosa notte" (Martini [ca. 1477] 1967, vol. 2, p. 489). See further Zwijnenberg 1999, esp. p. 44.

67 Leonardo, *Libro di pittura* [1995], vol. 1, pp. 139–140 (15): "Adonque in tal caso di finzione diremo con verità essere tal proporzione dalla scienzia della pittura alla poesia, qual è dal corpo alla sua ombra derivativa, et ancora maggiore proporzione, con ciò sia che l'ombra di tal corpo almeno entra per l'occhio al senso comune, ma la immaginazione di tale corpo non entra in esso senso, ma lì nasce, in l'occhio tenebroso. O che differenzia è a imaginar tal luce in l'occhio tenebroso al vederla in atto fuori delle tenebre!"

the *imprensiva* that painting overcomes poetry, and the visual defeats the aural. "Painting," Leonardo boasts, "immediately represents itself to you with the evidence [*dimostrazione*] with which its author made it […] and the poet, who delivers the same things to the common receptor through the ear, an inferior sense, does not give the eye any other pleasure than the one experienced in hearing the account of something."[68]

In another of his notes, Leonardo points out that:

> [P]ainting instantly represents its essence in the visual power and by its own means from which the *imprensiva* receives its natural objects […] and poetry delivers the same, but by a means less worthy than the eye, which brings to the *imprensiva* the figurations of the things named more confusedly and with greater delay than the eye, the true intermediary between the object and the *imprensiva*, which immediately reports with the greatest truth the true surfaces and figures of whatever stands before it.[69]

Although Leonardo's phrasing is not easily understood, it is evident that seeing and hearing are not directed to the same faculty. While the eye constantly and quickly communicates with the *imprensiva*, the ear either liaises first with the common receptor or releases its information belatedly to the *imprensiva* in the form of "figurations" (*figurazioni*). Now, it is a paradox that the ear should channel visual impressions to the mind, unless we assume that meaningful sounds (*le cose nominate*) turn into their relative forms (*le figurazioni*) in reaching (or by virtue of) the *imprensiva*. An alternative hypothesis would suggest that these "figurations" originate in the imagination (within the common receptor), and for this reason they are confused and delayed. If this is the case, why should they then be rerouted to the *imprensiva*? The only plausible answer is that, conjured up by sounds, these muddled forms somehow need the *imprensiva* to complete their process of visualization. This is confirmed by another observation in the *paragone* where Leonardo points out that the pleasure of hearing words is ultimately experienced through the eye, albeit "through a long delay."[70] From whatever standpoint we may look at the question, Leonardo's *imprensiva* appears to operate not only as a receptor of images, but also as a provider of forms. By delivering names – that is, acoustic signs or signifiers – to the *imprensiva*, the common receptor would be able to visualize what otherwise would remain inscrutable, ensconced within the imagination's "tenebrous eye" in an inchoate state of comprehensibility. Leonardo insists on these ideas in another of his *paragone* notes. "The eye," he says, "[…] which is said to be the window of the soul, is the principal means by which the common receptor can consider the infinite works of nature in greater richness and more magnificently, and the ear is the second one, which becomes noble on account of the things recounted that were seen by the eye."[71]

The contemplation of nature by the soul through the eyes is unlikely to be confined to a momentary perception in time. In painting nature, the painter

68 Leonardo, *Libro di pittura* [1995], vol. 1, p. 146 (22): "La pittura immediate ti si rappresenta con quella dimostrazione per la quale il suo fattore l'ha generata […]. e in questo caso il poeta, che manda le medesime cose al comun senso per la via de l'audito, minor senso, non dà a l'occhio altro piacere che s'un sentissi raccontare una cosa." See further Farago 1992, pp. 219–221.

69 Leonardo, *Libro di pittura* [1995], vol. 1, p. 146 (23): "La pittura ti rappresenta in un subito la sua essenzia nella virtù visiva, e per il proprio mezzo, donde la impressiva riceve li obbietti naturali […] e la poesia referisce il medesimo, ma con mezzo meno degno che l'occhio, il quale porta nella impressiva più confusamente, e con più tardità le figurazioni delle cose nominate che non fa l'occhio, vero mezzo infra l'obietto e la impressiva, il quale immediate conferisce con somma verità le vere superfizie e figure di quel che dinanzi se gli apresenta[…]." See further Farago 1992, p. 221.

does not reproduce instantaneously what he sees, but he summons "before" his eyes the likenesses of the things observed and considered previously, thus rearranging them in conformity with his imagination. "I have also ascertained," Leonardo writes in another annotation:

> [T]hat it is of no little advantage, when lying in bed in the dark, to reenact with your imagination [*con la imaginativa*] the outlines of the surfaces of the forms previously studied, or other relevant things understood through subtle speculation, and this is a truly commendable and useful action in preserving things in your memory.[72]

To avoid contradiction, we must suppose that the forms evoked by the imagination in the dark or in the "tenebrous eye" of the common receptor – where, according to Leonardo, the *imaginativa* has its own seat – are processed in tandem with the *imprensiva*. Leonardo likely alludes to this when he advises: "At the beginning, you will set out to supply your eye with the notion and invention first conceived in your imagination by drawing with the evidence of the form [*con dimostrativa forma*]."[73] Put otherwise, the form provided by the imagination remains "hazy" as long as it is deprived of the optical definition granted it by and through the eye. Leonardo nonetheless omits to explain by which means the imagined form acquires enough visual evidence to become suitable for ocular verification. If the imagination is dark, what then "brings to light" the form to be reproduced in the drawing? To be sure, Leonardo nowhere specifies that the *imprensiva*, apt as it is to process "figurations," is responsible for the "lighting" of the forms imagined, lending them optical features in simulation of sensory experience.[74] However, the intervention of a spiritual faculty is required in the transfer of the image from the "tenebrous eye" onto the drawing. If the imagination was in fact able to visualize its own inventions "con dimostrativa forma," the procedure of verification described by Leonardo would be superfluous.

This does not mean that Leonardo disregarded the role of imagination altogether. Its importance in etching the forms of the visible world in the memory cannot be underestimated. Indeed, in another annotation from the *Libro di pittura*, Leonardo remarks:

> When you want to memorize well [*saper … a mente*] a thing you have studied, proceed as follows: after drawing the same thing so many times you believe you carry it in your mind, try to reproduce it without the example [drawn after the thing]. Then, transpose your example through oiled paper onto the flat surface of a thin glass, and put the glass over the thing you drew

70 See below, note 103.

71 Leonardo, *Libro di pittura* [1995], vol. 1, pp. 142–143 (19): "L'occhio, che si dice la finestra dell'anima, è la principal via donde il comune senso pò più copiosa e magnificamente considerare le infinite opere de natura, e l'orecchio è il secondo, il quale si fa nobile per le cose raconte le quali ha veduto l'occhio." See further Farago 1992, p. 209.

72 Leonardo, *Libro di pittura* [1995], vol. 1, p. 178 (67): "Ho in me provato essere di non poca utilità, quando ti ritrovi allo scuro nel letto, andare con la imaginativa repetendo li lineamenti superfiziali delle forme per l'addietro studiate, o altre cose notabili da sottile speculazione comprese, et è questo proprio un atto laudabile et utile a confermarsi le cose nella memoria."

73 Leonardo, *Libro di pittura* [1995], vol. 1, p. 182 (73): "[…] attenderai prima col disegno a dare con dimostrativa forma a l'occhio l'intenzione e la invenzione fatta in prima nella tua imaginativa."

74 In Leonardo, *Codice Arundel* [1998], vol. 1, Testi, p. 270 (278v), Leonardo enigmatically points out: "Perché vede più certa la cosa l'occhio ne' sogni che colla imaginazione stando desto." Besides reiterating that the imagination lacks optical definition, Leonardo here raises a question whose answer, if provided, would have enabled us to better understand his ideas about how, in the absence of sensory experience, the "eye" is able to see with greater clarity.

> without the example, and notice where the impression from the oiled paper differs from your drawing, and where you find an error, take care not to repeat it in the future. Indeed, go back to the example and reproduce the part you failed as many times as necessary in order to fix it in your imagination [*imaginativa*].[75]

What emends, improves, and registers a form within memory is not just imagination, but a validation process based on ocular scrutiny: only the eye can certify the accuracy of the imagination through comparison between the thing seen and its depictions either on paper or in the soul. And only the eye can contribute a new and corrected visual template (an *essemplo*) destined for storage in the imagination and memory as a blind form, or a form in potency, susceptible to being restored in time by the eye and fleshed out with the aid of drawing. Indeed, Leonardo's *essemplo* serves as the artistic 'prototype' of a natural form seen and studied with consummate attention.

The process of validation endorsed by Leonardo as a basic artistic practice accords in numerous respects with his understanding of the *sperientia*. In both cases, repeated visual scrutiny is inescapable in order to confirm or deny an assumption: the drawing generated by the imagination is the equivalent of an idea – a mental "prospect" – that must be tested against nature in order to be verified, with the thin glass surface imprinted by the "example" drawn after nature acting as the point of convergence between the natural, the mental, and the artistic image. Testing is the paramount means for detecting errors, developing informed assumptions, or even arriving at certainties. Not surprisingly, Leonardo's invention of the *imprensiva* reflects his faith in the eye not only as the organ of vision and visualization, but especially as a tool of verification: the infallible touchstone of truth. It is upon these premises that Leonardo strives to outline a global theory of vision in terms of physiology, anatomy, and epistemology. In an interesting annotation of circa 1489 contained in W 19019r (another anatomical sheet from the Windsor series), Leonardo offers a description of how the common receptor commands and regulates both the senses and the whole body. Here, Leonardo sums up his ideas by resorting to a political metaphor:

> Tendons and their muscles serve the nerves as soldiers obey their leaders, and the nerves serve the common receptor as the leaders their captain, and the common receptor serves the soul as the captain his lord. Thus, the joints of the bone obey the ligament, and the ligament the muscle, and the muscle the nerve, and the nerve the common receptor, and the common receptor is the seat of the soul, and memory is its ammunition, and the *imprensiva* its advisor [*referendaria*].[76]

75 Leonardo, *Libro di pittura* [1995], vol. 1, pp. 180–181 (72): "Quando tu vorrai saper una cosa studiata ben a mente, tien questo modo: cioè quando tu hai disegnato una cosa medesima tante volte che te ●lla paia aver a mente, prova a farla sanza lo essemplo; et abbi lucidato sopra un vetro sottile e piano lo essempio tuo, e porrallo sopra la cosa ch'hai fatta sanza lo essempio, e nota bene dove 'l lucido non si scontra col disegno tuo, e dove trovi errato, lì tieni a mente di non errare più, anzi ritorna allo essempio a ritrarre tante volte quella parte errata che tu l'abbi bene nella imaginativa." On this passage in connection with Leonardo's "memory," see Pardo 2008, esp. pp. 67–68.

76 Leonardo, *Windsor*, vol. 1, 1979, pp. 88–89 (39r) [W 19019r]: "I nervi coi loro muscoli servono alle corde come i soldati a' condottieri, e le corde servano al senso comune come i condottieri al capitano, e 'l senso comune serve all'anima come il capitano serve al suo signore. Adunque la giuntura delli ossi obbedisce al nervo e 'l nervo al muscolo, e 'l muscolo alla corda, e la corda al senso comune, e 'l senso comune è sedia dell'anima, e la memoria è sua ammunizione, e la imprensiva è sua referendaria."

Leonardo's identification of the common receptor as the seat of the soul is more unconventional than it might seem. In the late medieval and early modern philosophical and anatomical tradition, the common receptor, as the principle of empirical judgment, does not have latitude to move the body: it primarily issues reliable opinions about the data conveyed to it through the senses. As already mentioned in relation to W 12626v, Leonardo also views the common receptor as the seat of *volontà* (will). But will (that is, the principle of motion) was traditionally directed by the *cogitativa* and the *estimativa*, both lodged in the central cell of the brain. By merging the common receptor with the *cogitativa* and *estimativa*, Leonardo strengthens the link between the activity of the senses, self-perception, and the thought process, thereby overlooking the faculties of the soul responsible for transcendental abstraction and speculation: first and foremost, the intellect as traditionally construed by scholastic philosophers. In a bold and sophisticated shift, Leonardo furthermore defines the *imprensiva* as the *inteletto*, a point I will return to later.[77] Leonardo's oversight of the epistemological functions carried out by the transcendental faculties of the soul and his emphasis on the common receptor as the coordinating principle of mind and body dovetail with his conviction that knowledge can be obtained only through the senses:

> It seems to me that all those sciences are vain and filled with errors that do not rise from experience, the mother of all certainty, and do not end in a knowledgeable experience, that is, when their origins and means do not pass through the five senses. And if we doubt the certainty of everything that passes through the senses, all the more so should we doubt the things that are impervious to the senses, such as the essence of God and the soul, and suchlike, which are always subject to debate and contention.[78]

In connoting the common receptor as the lord of the body machine, Leonardo discards deeply entrenched axioms of late medieval and early modern metaphysics. The "essence," that is, the *quid* of things eludes the senses, and therefore is hardly worth reflecting upon. The empirical abstractions of the *cogitativa* and the *estimativa* do not, and should not, trespass the realm of the senses. The circuitry of knowledge designed by Leonardo entails that abstraction draws on the senses and relentlessly deflects back to them for correction and verification. It is in this light that Leonardo's puzzling definition of the *imprensiva* as the *referendaria* of the

77 In his *De divina proportione*, written when he was in Milan in close proximity with Leonardo, Luca Pacioli notoriously noted: "E deli nostri sensi per li savii el vedere più nobile se conclude. Onde non immeritamente anchor de' vulgari fia detto l'ochio esser la prima porta per la qual lo intellecto intende e gusta" (Pacioli [1509] 2010, p. iiiir). No doubt, Leonardo shared this conviction with Pacioli, but his association of the eye with the intellect through the *imprensiva* goes well beyond the scope of Pacioli's generic statement. On Pacioli's culture and his importance for Leonardo, see more recently Azzolini 2005. Leonardo's localization of the intellect in the frontal brain is also problematic on medical grounds. In his *De natura hominis* (390 AD), Nemesius of Emesa (an author widely known to late medieval and early modern natural philosophers) had already pointed out: "If the front ventricles have suffered any kind of lesion, the senses are impaired, but the faculty of intellect continues as before. It is when the middle of the brain is affected that the mind is deranged, but then the senses are left in possession of their natural functions" (Cyril/Nemesius [1955], p. 342). On Nemesius and his theories on the brain ventricles and animal motion, see Frampton 2008, pp. 251–259.

78 Leonardo, *Libro di pittura* [1995], vol. 1, p. 156 (33): "Ma a me pare quelle scienzie sieno vane e piene d'errori le quali non sono nate dall'esperienzia, madre d'ogni certezza, e che non terminano in nota esperienza, cioè che la loro origine, o mezzo, o fine, non passa per nessun de' cinque sensi. E se noi dubitiamo della certezza di ciascuna cosa che passa per li sensi, quanto maggiormente dobbiamo noi dubitare delle cose ribelle ad essi sensi, come della essenzia de dio e dell'anima e simili, per le quali sempre si disputa e contende." See further Farago 1992, pp. 251–253.

common receptor must be interpreted. In Leonardo's time, the *referendario* was a high-ranking officer well-versed in law, tasked with the validation of judicial practices and, on this count, called upon to counsel the prince or his political analog in legal or administrative matters.[79] In other words, the common receptor "refers" to the *imprensiva*, making judgments and deliberations on the basis of its advice and having them validated through its judicial authority. For Leonardo, in fact, the common receptor is the "judicial part" (*parte iudiziale*) of the soul, although its authority seems to be shared with the *imprensiva* in a sort of indefinite symbiosis.

Alhazen and the Knowledge of the Eye

Leonardo's outlook on the *imprensiva* and the cognitive function of the eye can be fully explained only by assuming that he engaged extensively with crucial ideas formulated by Alhazen in his treatise on optics (ca. 1011–1021), known in the early Renaissance Latin world as *De aspectibus*.[80] Recent studies have rightly suggested that Leonardo's notion of visual knowledge was inspired by Alhazen's concept of *intuitio*.[81] According to Alhazen, in order to acquire proper knowledge, the object ought to be scrutinized point by point along the centric ray passing between it and the eye; by shifting the focus and scanning the object in its entirety, the beholder comes to know the object with the greatest certainty. By the same token, Leonardo states (sometime around 1492): "It is evident that the eye does not comprehend the objects if their likenesses do not go to it in a straight line, and whatever strays from that straight line is understood to a lesser extent."[82] In CA 1101a (ca. 1492), Leonardo further observes: "Even though the likenesses go to the eye in a pyramidal configuration, the eye is unable to know [*non conosce*] unless it triangulates with the object seen according to the [visual] pyramid."[83] In a succinct manner, Leonardo points out elsewhere (sometime earlier, around 1482–1485) that the centric line "knows and judges the bodies and colors," and, even more pointedly, that "the eye is the universal judge of all bodies."[84] No doubt, Leonardo forged an experimental methodology based on Alhazen's theory of the *intuitio*. In W 19601r (ca. 1510–1513),

79 See *Grande dizionario della lingua italiana*, vol. 15, p. 676. It is possible that Leonardo's metaphor of the *referendaria* is indebted to one or more sources yet to be identified. In his *De anima*, William of Auvergne, writing in 1240, compares the soul to a "rex" or "imperator," noting that it is served by a "consiliarius" (the equivalent of a *referendario*), Auvergne [1674], p. 95: "Dico insuper quod virtus intellectiva servitura eius lege et jure naturae subditissima est, et propter hoc ad imperium eius omnia facit quaecum potest: exempli gratia, cum imperat eam cogitare, disputare, inquerere, deliberare, necesse habet unumquodque istorum facere instar consiliariorum qui regi cuicumque vel imperatori assistere habent lege et iure imperi sui sive regni, nec denegare se possunt quin omnia ista exequantur ad regis imperium et mandatum [...] iure igitur et lege naturae virtutis istae servit ipsa mens sive ratio quae subdita est eidem tamquam inferior et ancilla ipsius."

80 On Leonardo and Alhazen, see Ackerman 1978, esp. pp. 116–118; Strong 1979, pp. 319–320; Eastwood 1989; Farago 1992, pp. 77, 105–108; and Bell 1993. Leonardo's keen interest in solving "Alhazen's problem" is well known: see more recently Bambach 2019, vol. 1, p. 52.

81 Particularly important here is Fiorani 2013, esp. pp. 271–274, who has proved inspiring in my research. See further Farago 1992, p. 348. On Alhazen's *intuitio* and the relationship between seeing and comprehending, see Federici Vescovini 1965b, pp. 118–132.

82 Leonardo, *Codice Atlantico* [2000], vol. 2, p. 661 (380v): "Chiaro si complende l'occhio non intendere li obietti se le spezie non vengon a quello per linia retta, e quella cosa fia manco intesa che più si partirà da detta linia."

83 Leonardo, *Codice Atlantico* [2000], vol. 3, p. 1953 (1101a): "E benché piramidalmente le spezie vadino all'occhio, l'occhio non conosce se non fa piramide contraria contro alla cosa veduta."

84 Leonardo, *Windsor*, vol. 1, 1979, pp. 36–39 (22v) [W 19147–19148v]): "Dico che l'occhio portando con seco infinite linie le quali sono appiccate ovvero unite con le sopravegnenti che si partano dalla cosa veduta, e solo la linia di mezzo d'essa sensuale è quella che cognosce e giudica i corpi e colori; tutte l'altre sono false e bugiarde"; Leonardo, *Manoscritto A* [1990], p. 21 (10r): "[...] occhio, universale giudice di tutti i corpi."

Leonardo lays out plans to exhaustively map out the human body. He notes: "If you want to know thoroughly the anatomical parts of man you must either turn him or your eye in order to examine him from different aspects, from below, from above, and from the sides, turning him round and investigating the origin of each part."[85] Leonardo's intention to provide his anatomical notes with drawings of body parts or organs observed from different viewpoints was meant to enable readers of his work to scrutinize "every part and every whole" of the human machine as though they had that "very same part in [their] hand and went on turning it round bit by bit until [they] obtained full knowledge."[86] In a similar vein, Alhazen had declared in his *De aspectibus*: "The scrutiny through which the form of the visible object is determined […] will not be accomplished until the visual axis moves over all the cross sections of the visible object."[87] As a result:

> [B]y moving the eye over the parts of the visible object, the sensitive faculty is affected in two ways. First, it perceives the visible object as a whole at numerous reprises, and second, it perceives with clarity each part of the visible object along the visual axis or along a radial line that is near to the visual axis. Thus, everything about those parts that can be seen is revealed to the sense [of sight].[88]

Leonardo's notion here – that in order to obtain full knowledge, anatomical parts must be visually described from at least three different angles and imaginarily rotated, like objects in our hands, and so made fully accessible to scrutiny – can be construed as a nimble adaptation of Alhazen's *intuitio*.

From these remarks, it is obvious that for Leonardo seeing is not just perceiving: the eye as a sensory organ is capable of knowledge and judgment, both faculties contingent upon visual scrutiny by means of the centric ray or, in Alhazen's terminology, *intuitio*. To be sure, some of these ideas are not exclusive to

85 Leonardo, *Windsor*, vol. 2, 1980, pp. 594–597 (154r) [W 19061r]: "[…] se tu vuoi bene conoscere le parte dell'omo natomizzato tu lo volti, o lui o l'occhio tuo, per diverso aspetto, quello considerando di sotto, di sopra e dalli lati voltandolo e cercando l'origine di ciascun membro."

86 Leonardo, *Windsor*, vol. 2, 1980, pp. 594–597 (154r) [W 19061r]: "Adunque per il mio disegno ti fia noto ogni parte e ogni tutto mediante la dimostrazione di tre diversi aspetti di ciascuna parte. Perché quando tu aria veduto alcun membro dalla parte dinanzi con qualche nervo, corda o vena che nasca dalla opposita parte, e' ti fia dimostro il medesimo membro volto per lato, o dirieto, non altrementi che se tu avessi i 'mano il medesimo membro e andasilo voltando di parte in parte insino a tanto che tu avessi piena notizia di quello che tu desideria sapere."

87 Alhazen, *De Aspectibus* [2001], vol. 1, p. 220 [4.9] (2:515): "Comprehensio ergo forme vere rei vise non erit nisi per intuitionem, et intuitio per quam certificatur forma rei vise non complebitur nisi per motum visus. Et cum corpus rei vise fuerit alicuius quantitatis, non complebitur intuitio eius nisi per motum axis radialis in omnes dyametros rei vise." Alhazen, *De li aspecti*, 51v–52r: "la comprensione adonche de la forma vera de la cosa visa no si compierà sinò per lo sguardamento, e lo sguardamento per lo quale si certifica la forma de la cosa visa non si compierà sinò per lo moto del viso. E quando el corpo de la cosa visa fosse d'alchuna quantità, non si compierà lo sguardamento de esso sinò per lo moto de l'asse radiale in tuti li diametri de la cosa visa."

88 Alhazen, *De Aspectibus* [2001], vol. 1, pp. 221–222 [4.10] (2:515): "Per motum ergo visus super partes rei vise adquirit sentiens duas dispositiones quarum altera est frequentatio comprehensionis totius rei vise; et secunda est que comprehendit quamlibet partium rei vise per axem radialem aut per illud quod est prope axem radialem manifesta comprehensione. Apparet ergo sensui omne quod est possibile apparere ex illis partibus." Alhazen, *De li aspecti*, 52r: "E per lo moto adonche del viso sopra la parte de la cosa visa aquista el sentiente due dispositione de le quale l'una è frequentatione de la comprensione de tuta la cosa visa e la siconda è che comprende ziascheduna de le parte de la cosa visa per l'axe radiale de manifesta, ovoi cum manifesta comprensione. Apare adonche al senso ogne cosa la quale è possibile aparere de quelle parte."

Alhazen, and Leonardo could have borrowed them from a number of other sources, in particular Bacon or Pecham.[89] Nevertheless, Leonardo's insistence on the immediacy of visual perception as a factor of epistemological certainty and his conviction that *sperienza* necessitates a prolonged practice of scrutiny and verification could only have been inspired by Alhazen's text (most likely through one or more knowledgeable mediators within a context of oral exchange). It is perhaps useful to add that, contrary to Avicenna's *De anima* or Bacon's *Perspectiva* – to name only a couple of texts relevant to Leonardo – Alhazen's *De aspectibus* had already been translated into Italian vernacular by the fourteenth century, and manuscript copies of it circulated in fifteenth-century Florence, as demonstrated by the case of Lorenzo Ghiberti, who consulted a copy for his *Commentari*.[90]

In Alhazen's view, the act of seeing is rarely a matter of sheer perception. The notion, for instance, that an object is transparent to the light cannot be inferred by simply looking at it. It is only through visual scrutiny, by "experiencing" the object under given circumstances, that the eye can ascertain not only its transparency to light, but also that transparency and light are two separate things. In this case, perception is achieved "through differentiation and judgment" (*per distintione e ragione*).[91] Albeit distinct from perception, differentiation and judgment blend into perception. "Not everything that is perceived by sight," Alhazen argues, "is perceived through perception alone; instead, many visible characteristics will be perceived through judgment and differentiation in conjunction with the perception of the form that is seen."[92] "Sight," Alhazen goes on, "also perceives many things by means of recognition," that is, through remembering.[93] Even if

89 For the importance of Alhazen on medieval optical science, Bacon and Pecham in particular, see Smith 2015, esp. pp. 260–273.

90 See Federici Vescovini 1965a; Federici Vescovini 1980; Bergdolt 1988, p. XXX; Federici Vescovini 1998; Lorenzo Bartoli's introduction to Ghiberti [1998], pp. 14–15 (list of the passages transcribed from Alhazen's treatise) and pp. 33–41; Raynaud 2001; and Ambrosini 2008, esp. pp. 176–207 (basically, a paraphrase of passages from Ghiberti derived from Alhazen, Bacon, and Pecham). Recently, Raynaud 2019, pp. 96–99, has demonstrated that Ghiberti did not rely on the vernacular translation of Alhazen's *De aspectibus* known to us through Ms. Vat. Lat. 4595. Raynaud however does not rule out the possibility that Ghiberti consulted Alhazen's treatise in a different vernacular translation. It is commonly assumed that Leonardo was able to access Lorenzo Ghiberti's *Commentari* and its related passages from Alhazen's optical treatise through Ghiberti's grandson, Bonaccorso: see more recently Bambach 2019, vol. 1, p. 310. On Bonaccorso, see Scaglia 1976. On Alhazen and Leon Battista Alberti, see Roccasecca 2016, pp. 95–96, 98–101, 103–104, 106–107, 122–124, 127, 130–133, 145–148, and 170.

91 Alhazen, *De Aspectibus* [2001], vol. 1, pp. 99–100 [3.13–14] (2:431–32): "Et etiam sensus visus comprehendit diafonitatem corporum diafonorum et diafonitatem corporum que non sunt in fine diafonitatis, sed non comprehendit diafonitatem talem ratione nisi per comparationem. Quoniam lapides diafoni quorum diafonitas est modica non comprehenduntur a visu esse diafoni nisi postquam fuerint oppositi luci, et comprehendetur lux a posteriori eorum, et comprehendetur quod sunt diafona. Et similiter diafonitas cuiuslibet corporis diafoni non comprehendetur a visu nisi postquam comprehendetur corpus aut lux que est a posteriori eius, et comprehendetur cum hoc per distinctionem quod illud quod apparet a posteriori est diversum a corpore diafono. Comprehensio autem eius quod illud quod est a posteriori corporis diafoni est diversum ab illo corpore non est comprehensio solo sensu, sed est comprehensio per rationem. Et cum diafonitas non comprehendetur nisi per signationem, ergo non comprehendetur nisi distinctione et ratione." Alhazen, *De li aspecti*, 21v–22r: "E ancho el senso del viso comprende la diafonità de li corpi diafoni e la diafonità de li corpi i quali sono in fine de la diafonità, ma non comprende tale diafonità senò per comparatione, perché le pietre diafone de le quali la diafonità è pocha non si comprendeno dal viso essere diafoni se no da poi che gli serano oposite a la luxe, e quando si comprenderà la luxe d'il de dietro de esse, si comprenderà che le sono diafone. E similimente la diafonità di ziascheduno corpo diafono non si comprende dal viso senò da poi che serà compreso el corpo overo la luxe la quale è da la parte de dietro de esso, e comprenderassi cum questo per la distintione che quello corpo che apare de dietro è diverso dal corpo diafono. Ma la comprensione di quello che quello che è da la parte de drieto del corpo diafono è diverso da quello corpo non è comprensione solamente del senso, ma è comprensione per ragione. E perché la diafonità non si comprende senò … per distintione e ragione."

recognition does not equate with perception, "perception through recognition does […] entail perceiving by some means of judgment, for recognition is the perception of similarity between two forms."[94] While recognition is a kind of judgment, it is also "distinct from other [forms] of judging; rather than involving an evaluation of all the characteristics of the form, recognition will occur through defining features."[95] In spite of these dissimilarities, "the faculty of recognition is allied with the faculty of sensation, so the perception of sensible characteristics is fully achieved only through recognition."[96] Because some sort of judgment is always inextricably ingrained in seeing, the act of judging consubstantial with sight is sometimes accomplished "in an extraordinarily short time," so much so that, because of its speed, it is not apparent that the perception of certain visible characteristics involves judgment. Accordingly, Alhazen notes, "as soon as the form reaches [the eye], sight perceives all the characteristics it possesses, and so they will be differentiated by it at the moment of perception."[97]

92 Alhazen, *De Aspectibus* [2001], vol. 1, p. 100 [3.16] (2:431): "Et cum ita est, non ergo omne quod comprehenditur a visu comprehenditur solo sensu; sed multe visibiles intentiones comprehendentur per rationem et distinctionem cum sensu forme vise." Alhazen, *De li aspecti*, 22r: "E perché così è, non adonche ogne cosa che si comprende dal viso si comprende dal solo senso, ma molte visibili intentione si comprendono per ragione e distintione cum lo senso de la cosa visa ovoi dela forma visa." This and the following passages by Alhazen (notes 93–100) are recapitulated by Pecham [1970], p. 136 [56], in a single paragraph: "Dico sensum spoliatum solum sensum quoniam quedam comprehenduntur non solo sensu sed cooperante virtute distinctiva et argumentatione, quasi imperceptibiliter immixta, quedam etiam adminiculo scientie acquisite. Verbi gratia cum apprehunduntur duo individua esse similia, ipsa similitudo neutra est formarum, nec comprehenditur solo sensu sed collatione unius ad alterum. Similiter etiam colorum differentia et aliarum rerum. Amplius scriptura non comprehenditur solo sensu sed per distinctionem partium eius, quam facit vis distinctiva mediante visiva. Similiter res assuete cum videntur, quod statim vise cognoscuntur, non est nisi ex relatione speciei recepte ad habitum memorie, et hoc quasi per ratiocinationem." Ghiberti, (ca. 1447) 1998, p. 186 [xxi. 6], offers a translation of this passage, under the heading: "Non tutte le intentioni esser comprese dal senso spogliato."

93 Alhazen, *De Aspectibus* [2001], vol. 1, p. 101 [3.18] (2:431): "Et etiam visus comprehendit multas res visas per cognitionem […]."

94 Alhazen, *De Aspectibus* [2001], vol. 1, p. 101 [3.20] (2:432): "Comprehensio autem per cognitionem est comprehensio per aliquem modorum rationis, quoniam cognitio est comprehensio consimilitudinis duarum formarum […]."

95 Alhazen, *De Aspectibus* [2001], vol. 1, p. 102 [3.22] (2:432): "Cognitio ergo non est nisi modus rationis; sed ista ratio distinguitur ab omnibus rationibus, quoniam cognitio non erit per inductionem omnium intentionum que sunt in forma, sed erit per signa."

96 Alhazen, *De Aspectibus* [2001], vol. 1, p. 103 [3.24] (2:433): "Et virtus cognitionis est coniuncta virtuti sensus, et non completur comprehensio sensibilium nisi per cognitionem."

97 Alhazen, *De Aspectibus* [2001], vol. 1, pp. 103–104 [3.26] (2:433): "Et etiam plures intentiones visibilium que comprehenduntur per rationem et distinctionem comprehenduntur in tempore valde parvo, et non apparet quod comprehensio earum sit per rationem et distinctionem propter velocitatem rationis per quam comprehenduntur iste intentiones. […] Apud ergo istum eventum istius forme, comprehendit omnes intentiones que sunt in ea, et sic distinguentur ab eo apud comprehensionem." Alhazen, *De li aspecti*, 23r: "E ancho più intentione de le cose visibile si comprendeno in tempo molto picholo e non pare che la comprensione loro sia per ragione e distintione per la velocità de la ragione per la quale si comprendeno queste intentione . . . Apresso adonche lo avignimento di questa forma comprende tute le intentione le quali sono in esse, e così si distinguerano da essa apresso la comprensione." A similar, but much less detailed conclusion, is reached by Pecham [1970], p. 136 [57]: "Nullum enim visibile cognoscitur sine distinctione intentionum visibilium vel sine collatione aut relatione ad universalia cognitorum prius a sensibilibus abstracta, qui fieri non possunt absque ratiocinatione. Sed tempore non indiget perceptibili vis distinctiva in hiis communiter comprehensis, quia arguit per aspectum ad sibi notissima, nec arguit per comparationem et ordinationem propositionum, vis enim distinctiva nata est arguere sine difficultate, que etiam aptitudo naturaliter exeritur." Ghiberti (ca. 1447) 1998, pp. 186–187 [xxi. 7], offers a translation of this passage under the heading: "Nelle distintioni, [del]le ragioni de' visibili impercettibilmente essere argumentato."

Alhazen likens the instantaneity of the process of visual perception to that of certain logical deductions. "When the premises are evident and general," he declares, "the faculty of discrimination does not require much time to reach the conclusions entailed by them but, instead, will understand the conclusion immediately after grasping the premises."[98] Most importantly, the conclusions arrived at in this manner "will not be based on words or on the arrangement of premises." In fact, "the faculty of discrimination grasps the conclusion without needing words and without needing an arrangement of premises or an arrangement of words."[99] This kind of non-verbal, immediate reasoning is typical of a "perceptual conclusion." Therefore, Alhazen contends, "the visible properties that are perceived through judgment are generally perceived very quickly, and for the most part it does not seem as if their perception is arrived at through judgment."[100]

In his *paragone*, Leonardo attacks poets on account of their inability to achieve immediacy through the fiction of words. In a paradoxical challenge, Leonardo exclaims: "And you, poet, who also claim to be an imitator, why don't you represent things with your words so that the letters, which make your words, are equally adored?"[101] Even though, for Leonardo, poetic words also deserve being celebrated, they remain "accidental": the derived product of man's learning as opposed to images – the primary product of nature, which is the object of the painter's work.[102] As codified signs and not likenesses of nature, words do not bring as much pleasure as images. In fact, words do not come with immediate comprehension, which in their case is always only achieved with time.

98 Alhazen, *De Aspectibus* [2001], vol. 1, p. 104 [3.27] (2:433.): "Et similiter argumentatio et omnes rationes quarum propositiones sunt universales et manifeste; non indigent virtus distinctiva aliquanto tempore etiam in comprehendendo suas conclusiones, sed apud intellectum statim propositionis intelligetur conclusio." Alhazen, *De li aspecti*, 23r: "E similemente l'argumentazione e ogne ragioni de le quale le propositione sono universale e manifeste. Non ha di bisogno la virtù distintiva alquanto tempo anchora in comprendere le sue conclusione, ma apresso lo intelecto de la propositione del viso se intenderà la conclusione."

99 Alhazen, *De Aspectibus* [2001], vol. 1, p. 104 [3.28] (2:433): "Et causa in hoc est quod virtus distinctiva non arguit per compositionem et ordinationem propositionum, sicut componitur argumentatio per vocabula, quoniam argumentum quod concludit non erit argumentum secundum verbum nec secundum ordinationem propositionum. Argumentum autem virtutis distinctive non est ita, quoniam virtus distinctiva comprehendit conclusionem sine indigentia in verbis et sine indigentia ordinationis propositionum et ordinationis verborum." Alhazen, *De li aspecti*, 23r: "E la ragione non è che la virtù distintiva arguisca per compositione e ordinatione de la propositione como si compone l'argumentatione per vocabuli, perché l'argumento che la conclude non è argumento sicondo el verbo o sicondo la ordinatione de le propositione. Ma l'argumento de la virtù distintiva non è così perché la virtù distintiva aprende la conclusione sencia indigentia in parole e sencia indigentia de ordinatione de parole."

100 Alhazen, *De Aspectibus* [2001], vol. 1, p. 103 [3.30] (2:434): "Intentiones ergo visibiles que comprehenduntur ratione comprehenduntur pluries valde velociter, et non apparet in maiori parte si comprehensio earum sit in ratione." Alhazen, *De li aspecti*, 23r: "Le intentione adonche visibile le quale si comprendeno […] molto veloce e non apare in la magiore parte perché la comprensione loro sia per ragione."

101 Leonardo, *Libro di pittura* [1995], vol. 1, p. 150 (26): "O tu, poeta, che ti fai tu ancora imitatore, perché non rapresenti tu con le tue parole cose che le lettere tue contenitrici d'esse parole ancora non sieno adorate?" See further Farago 1992, p. 233.

102 Leonardo, *Libro di pittura* [1995], vol. 1, p. 150 (26): "Adonque laudiamo quello che con le parole satisfà a l'audito, e quel che con la pittura satisfà al contento del vedere. Ma tanto meno quel delle parole, quanto elle sono accidentali e create da minor autore che l'opere di natura, di che 'l pittore è imitatore; la qual natura è terminante dentro alle figure delle lor superfizie." In another note (Leonardo, *Libro di pittura* [1995], vol. 1, p. 140 [15]), Leonardo stresses the limitations of words in describing the variety of the natural phenomena: "Ma molto più sanza comparazione sono le varietà in che s'astende la pittura che quelle in che s'astende le parole, perché infinite cose farà il pittore che le parole non le potrà nominare per non avere vocaboli apropriati a quelle." See further Farago 1992, pp. 203, 233–235.

Taunting the poet in a *paragone* note, Leonardo asks: "Now see what difference there is between hearing something that pleases the eye through a long delay [*con lunghezza di tempo*] and seeing it with that swiftness with which we see the natural things."[103] Comprehension is also delayed when the words of the poet are addressed to the ears. The poet who sets about describing a beautiful body, will be forced to evoke it part by part, the evocation of each part compromising in turn the simultaneous perception of the whole. Paradoxically – Leonardo argues with a modicum of sophistry – each part of the body sinks into oblivion as soon as it is described, such that the audience is unable to visually embrace the beauty of the body in its entirety.[104] The reason for this, Leonardo argues, is that the eye alone is endowed with immediate perception and comprehension. Obviously, Alhazen was not interested in this sort of artistic debate, although he addresses the question of beauty and aesthetic pleasure. It is nonetheless significant that Leonardo exploits the argument of the immediacy of visual perception and of perceptual conclusion with a view to extoling painting, his own *scienzia*, to the detriment of poetry.

In Alhazen's optics, the act of seeing leads to immediate conclusions because sight over time assembles a cache of information enshrined in the soul and operating as self-evident premises. Due to their self-evidence, these premises function with imperceptible immediacy. Switching from optics to logic in illustrating the functioning of the eye, Alhazen structures the process of vision in analogy with the process of logical deduction. It may be in this sense, too, that Leonardo asserts that the eye "knows and judges." To be sure, not all logical deductions are implemented directly through vision: for Alhazen, some require the faculty of self-perception that, in the work of subsequent optical theorists, was ascribed to the common receptor.[105] According to Alhazen, "the second deductive process through which the faculty of discrimination perceives how it perceives what it perceives is not a process that occurs terribly quickly." This is why "at the instant of perception, how the visible properties perceived through judgment are [themselves] perceived is usually not evident."[106]

103 Leonardo, *Libro di pittura* [1995], vol. 1, p. 146 (22): "Or vedi che differenzia è da l'udire raccontare una cosa che dia piacere a l'occhio con lunghezza di tempo, o vederla con quella prestezza che si vedeno le cose naturali." See further Farago 1992, p. 219.

104 Leonardo, *Libro di pittura* [1995], vol. 1, p. 145 (21), explains this paradox by extending the comparison to music: "Ma della pittura, perché serve all'occhio, senso più nobile che l'orecchio, obietto della poesia, ne risulta una proporzione armonica […]. Ma molto più farà le proporzionali bellezze d'un angelico viso posto in pittura, della quale proporzionalità ne risulta un armonico concento, il quale serve all'occhio in un medesimo tempo che si faccia della musica all'orecchio. […] Ma della poesia la qual s'abbia a stendere alla figurazione della predetta bellezza, con la figurazione particulare di ciascuna parte della quale si compone in pittura la predetta armonia, non ne risulta altra grazia che se si facessi a far sentire nella musica ciascuna voce per sé sola in vari tempi, delle quali non si componerebbe alcun concento, come se volessimo mostrare un volto a parte a parte, sempre ricoprendo quelle che prima si mostrano, delle quali dimostrazioni l'oblivione non lascia comporre alcuna proporzionalità d'armonia, perché l'occhio non le abbraccia con la sua virtù visiva a un medesimo tempo." See further Farago 1992, pp. 217–219.

105 See above, note 25.

106 Alhazen, *De Aspectibus* [2001], vol. 1, p. 107 [3.37] (2:436): "Et etiam secundum argumentum per quod comprehendit virtus distinctiva qualitatem comprehensionis eius ad illud quod comprehendit non est argumentum in fine velocitatis, sed indiget consideratione. […] Et propter hoc non apparet multotiens qualitas comprehensionis rerum visibilium que comprehenduntur ratione apud comprehensionem." Alhazen, *De li aspecti*, 24v: "[…] E anche el sicondo argumento per lo quale comprende la virtù distintiva la qualità de la comprensione de esso a quello che lui comprende non è argumento in fine di velocità … E per questo non apare molte volte la qualità de la comprensione de le cose visibili le quali si comprendeno per ragione apresso la comprensione."

In spite of their combined action, Alhazen clearly differentiates the act of perception fulfilled by the seeing eye from the faculty of discrimination that enables the eye to reach immediate conclusions through judgment and recognition. Consequently, he posits that the faculty of discrimination resides not in the eye itself, but in what he defines as the "final sensor" (called *ultimo sentiente* in *De li aspecti*):

> When the form reaches from the surface of the sensitive organ to the hollow of the common nerve [the optic nerve], every part of the sensitive body will sense the form. And when the form arrives at the hollow of the common nerve, it will be perceived by the final sensor, and at that time differentiation and deduction will take place.[107]

Alhazen's description of sight's final sensor was found to be misleading. "Since Alhazen says that this final sensor (*ultimo sentiente*) is in the front part of the brain," Bacon notes, "it would seem to some that it is [identical with] the common receptor and the imagination or fantasy, which are in the front part of the brain." Nevertheless, Bacon concludes, this is not possible: rather, "the ultimate sentient power can be defined otherwise in relation to one particular sense, such as sight, hearing, the sense of smell, or the like. And in these terms, the ultimate sentient power in binocular vision is the common nerve." Aware that his interpretation did not solve the ambivalence of Alhazen's statement, Bacon specifies: "We should not take 'front part of the brain' to denote the first cell of the brain, but a place near it, namely the aperture in the skull where the nerves intersect." As a result, "the eyes are not alone in rendering judgment concerning visible things, but judgment begins in the eyes and is completed by the ultimate sentient power, the source of the visual faculty, [located] in the common nerve."[108]

It may or may not be a coincidence that in his scrutiny of the skull, Leonardo was concerned with the chiasma of the ocular nerves in connection with the brain ventricles, that is, with what Bacon deemed to be the source of the "ultimate sentient power" of sight. More relevantly perhaps, Leonardo also embraced the notion that the "perforated" optic nerve was "filled with the power of the *imprensiva*," as mentioned earlier in relation to CA 729r. In any case, it is noteworthy that both Alhazen and Bacon, to a different extent, had been compelled to postulate the existence and intervention of an intermediate and more advanced kind of visual power: one apt not only to receive the impression of the visible objects, but also to deliver unmediated judgment upon them. Whether or not Alhazen's "vis distinctiva" of the eye inspired Leonardo's invention of the *imprensiva* is difficult to ascertain. Once again, Leonardo's labeling of this faculty as *imprensiva* is justified neither by Alhazen's nor by Bacon's terminology ("vis distinctiva," "ultimum sentiens").

107 Alhazen, *De Aspectibus* [2001], vol. 1, p. 112 [3.46] (2:439): "Cum ergo extenditur forma a superficie membri sentientis usque ad concavum nervi communis, quelibet pars corporis sentientis sentiet formam. Et cum pervenerit forma in concavum nervi communis, comprehendetur ab ultimo sentiente, et tunc erit distinctio et argumentatio." Alhazen, *De li aspecti*, 25r: "[…] quando si stende la forma da la superfitie del membro sentiente perfino al concavo del nerbo comune ziascheduna parte de lo corpo sentiente sentirà la forma e quando pervirà la forma in lo concavo del nerbo comune si comprenderà da l'ultimo sentiente e alora serà distintione e argumentatione."

108 Bacon [2006], pp. 64–67: "Quoniam autem Alhacen dicit quod istud ultimum sentiens est in anteriori parte cerebri, videretur sic alicui quod esset sensus communis et ymaginatio vel fantasia, que sunt in anteriori cerebro […]. Aliter est ultimum sentiens specialiter in visu vel auditu vel odoratu vel aliis, loquendo de uno sensu particulari. […] dicendum quod non sumitur hic anterius cerebri pro cellula prima cerebri, sed locus propinquus ei, scilicet in foramine cranei ubi est concursus nervorum […]. Et sic patet quod non solum oculi iudicant de visibili; sed incipitur iudicium in eis, et completur per ultimum sentiens, quod est virtus visiva frontalis in nervo communi."

Even though seeing entails immediate judgment, knowledge of the visible is certified only through repeated, insisted, and focused seeing. In Alhazen's opinion, "sight determines the true properties of a visible object and its form" by evaluating all of its parts and "by subjecting all of the characteristics that can be seen in the visible object through visual scrutiny."[109] Guided by the faculty of discrimination, the eye is willed again and again into probing the object thoroughly, and this investigation relies on ocular motion. "Thus," Alhazen affirms, "perception of the proper form of a visible object will occur only through visual scrutiny, and the scrutiny through which the form of the visible object is determined will only be accomplished through the motion of the eye."[110] In assessing the form of any object in view of certified knowledge, the mind necessarily resorts to sight. The function of the eye as the instrument of both immediate judgment and mediated scrutiny of the visible is therefore crucial in Alhazen's epistemology. In this regard, it cannot be denied that Leonardo's notion of *sperienza* not only as sensate knowledge, but especially as a verification process grounded in the reiterated scrutiny of the visible through the eyes and by means of graphic reproduction bears the greatest affinity to Alhazen's concept of *intuitio*. Most importantly, the continuous reiteration of visual scrutiny is also conducive to an uninterrupted creation of visual and mental "forms." In scrutinizing the object, the faculty of discrimination compares and contrasts its properties with those of previously known objects, thereby perceiving "the form comprising all of them." In this way, Alhazen remarks:

> The form comprising all similar characteristics is impressed in the imagination, and thus the visible object's form, which provides the means by which the visible object itself is apprehended by the sensitive faculty, is determined. This, therefore, is how the sensitive faculty determines the forms of visible objects by means of visual scrutiny.[111]

In Alhazen's statement, it is unclear whether the "form" impressed in the imagination through visual scrutiny is the particular form of the object or the universal form of all the objects sharing the same characteristics. It can be established, however, that the act of comparing the properties of the scrutinized object with those of previously known objects requires recourse to universal forms, that is,

109 Alhazen, *De Aspectibus* [2001], vol. 1, p. 218 [4.4] (2:513): "Secundum ergo omnes dispositiones non certificat visus formam rei vise nisi per considerationem omnium partium rei vise et per intuitionem omnium intentionum que possunt apparere in re visa." Alhazen, *De li aspecti*, 51r: "Sicondo adonche ogne dispositione non certifica el viso la forma de la cosa visa sinò per consideratione de tute le parte de la cosa visa e per lo sguardare de tute le intentione le quale posseno aparere in la cosa visa."

110 Alhazen, *De Aspectibus* [2001], vol. 1, p. 220 [4.9] (2:515): "Comprehensio ergo forme vere rei vise non erit nisi per intuitionem, et intuitio per quam certificatur forma rei vise non complebitur nisi per motum visus." Alhazen, *De li aspecti*, 51v: "La comprensione adonche de la forma vera de la cosa visa no si compierà sinò per lo sguardamento, e lo sguardamento per lo quale si certifica la forma de la cosa visa non si compierà sinò per lo moto del viso [...]."

111 Alhazen, *De Aspectibus* [2001], vol. 1, p. 222 [4.11] (2:516): "Et comprehendit ex distinctione omnium istarum intentionum et comparatione istarum intentionum ad ea que cognoscuntur ex similibus earum formam compositam ex omnibus istis. Et sic signatur in ymaginatione forma composita ex omnibus similibus intentionibus, et sic certificatur forma rei vise per quam appropriatur illa res visa apud sentientem. Secundum ergo hunc modum certificat sentiens per intuitionem formas visibilium." Alhazen, *De li aspecti*, 52r: "E comprende da la distintione de tute queste intentione e da la comparatione de queste intentione ad esse cose le quale si cognoscono da le simile de esse la forma composita de tute queste. E significasi così ne la imaginatione e così si certifica la forma de la cosa visa per la quale se apropria quella cosa visa apreso el sentiente. Sicondo adonche questo modo certifica el sentiente per intuitione ovoi per risguardamento le forme de' visibili."

mental patterns produced by the abstracting activity of the soul. Explicitly, Alhazen posits that "the forms of individual visible objects, as well as the forms that sight perceives, persist in the soul and are impressed in the imagination, and the more often they are perceived by the eye, the more firmly implanted they will be in the soul and in the imagination."[112] As a consequence, visual scrutiny unfolds through a dialectics of individual and universal forms, with the latter fixing themselves more solidly in both the imagination and the soul through reiteration of the visual experience. In other words, universal forms are subjected to continuous modification and validation. Through strenuous ocular inspection, they become more definite and therefore more reliable in terms of epistemological certainty.

Nowhere in his annotations does Leonardo touch upon the universal forms, or their formation and role in buttressing knowledge. Nevertheless, a passage from the *Libro di pittura* proves the importance of universal forms within Leonardo's notion of painting. "If painting," Leonardo argues in addressing a hypothetical poet, "embraces all the forms of nature in itself, you have nothing but words, which are not universal like the forms."[113] The "universal" painter, indeed, is able to "counterfeit with [his] art all the qualities of the forms produced by nature, which [he] would be unable to do unless [he] sees them and portrays them in [his] mind."[114] By defining the forms as "universal," Leonardo undoubtedly implies that they can be understood by all without the mediation of words: they constitute a universal language of self-evident knowledge.[115] But there is another way in which natural forms, once portrayed in the mind, are universal: they are also visual templates perfected through observation and collected in the imagination in view of re-employment not only for pictorial purposes, but especially in the process of acquiring knowledge.[116] Moreover, in Leonardo's time, the notion of universal forms was associated with a specific understanding of the intellect. As already pointed out, in sharp contrast to the philosophical and medical tradition, Leonardo considered the *imprensiva* to pertain to the intellect.[117] It now remains to attempt an explanation of this point.

112 Alhazen, *De Aspectibus* [2001], vol. 1, p. 226 [4.17] (2:518): "Forme ergo individuorum visibilium et forme modorum visibilium quas visus comprehendit remanent in anima et figurantur in ymaginatione, et quanto magis iterabitur comprehensio earum a visu tanto erunt fixa in anima et in ymaginatione." Alhazen, *De li aspecti*, 54r: "E le forme de' modi di visibili le quale el viso comprende rimanghono ne l'anima e se figono ne l'imaginatione, e quanto più se iterarà la comprensione de esse dal viso tanto più serano fisse ne l'anima e in l'imaginatione."

113 Leonardo, *Libro di pittura* [1995], vol. 1, p. 143 (19): "Se la pittura abbraccia in sé tutte le forme della natura, voi non avete se non i nomi, i quali non sono universali come le forme." See further Farago 1992, p. 211.

114 Leonardo, *Libro di pittura* [1995], vol. 1, p. 172 (56): "Adunque conoscendo tu pittore non poter essere bono se non sei universale maestro di contraffare con la tua arte tutte le qualità delle forme che produce la natura, le quali non saprai fare se non le vedi e ritrarle nella mente."

115 See, for instance, Summers 1987, pp. 137–139.

116 For Leonardo, the eye does not only see, but also "represents" nature in its variety to the soul. The soul thus is able to visualize through the eyes. See Leonardo, *Libro di pittura* [1995], vol. 1, pp. 148–149 (24): "L'occhio, del quale la bellezza de l'universo è specchiata dalli contemplanti, è di tanta eccellenzia che chi consente alla sua perdita, si priva della rappresentazione de tutte l'opere della natura, per la veduta delle quali l'anima sta contenta nelle umane carcere, mediante li occhi, per li quali essa anima si rappresenta tutte le varie cose de natura." See further Farago 1992, pp. 227–229.

117 One of the earliest surviving notes by Leonardo, which has been dated as early as 1479, seems to suggest that Leonardo identified the intellect not with the *imprensiva*, but with the *senso comune*. See Leonardo, *Codice Atlantico* [2000], vol. 1, p. 365 (232r): "[…] e essa popilla, ricevute le cose dalla luce, immediate le riferisce e porge allo intelletto per la linia a b. E sappi che la popilla non porge nessuna cosa perfettamente allo intelletto ovver senso comune, se non quando le cose a lei date dalla luce si dirizzano per la linia a b […]." However, the context is ambiguous. Leonardo may be saying that the pupil conveys the image directly

Whether or not Leonardo was acquainted with the debates over Averroes's unity of the intellect as developed in late fifteenth-century Florence, it is fair to assume that he was familiar with Aristotle's general interpretation of the intellect as expressed in *On the Soul*.[118] It is extremely likely that manuscript copies of John Argyropoulos's Latin translation of and commentary upon this work circulated when Leonardo first sojourned in Florence and that these continued to be discussed with great interest. Later on, among the "books" owned or sought by Leonardo, we find mention of an "Argyropoulos" that cannot be more clearly identified.[119] In Aristotle's opinion, between sensation and the intellect (discursive thinking) stands an intermediary faculty of the soul: imagination. Unlike sensation, imagination "lies within our power": "it is possible to call up mental pictures, as those do who employ images in arranging their ideas under a mnemonic system."[120] But unlike discursive thinking, imagination does not involve judgment, although judgment cannot exist without imagination. Albeit triggered by sense, imagination endures even "when the sensible object is at a distance."[121] In this case, imagination can be either true or false. According to Aristotle, imagination similarly guides the actions of animals, and thus is not specific to humankind, unlike the intellect. Leonardo introduces a well-known corollary to this notion of imagination in one of his annotations in W 19019v (ca. 1489): "The idea, that is, the *imaginativa*, is the helm and bridle of the senses insofar as the thing imagined moves the sense."[122] In late medieval and early modern natural philosophy, the principle that fantasy through imagination foregrounded practical action was unanimously accepted. Already in Aristotle, imagination is likened to sight: "Since sight is the chief sense, the name φαντασία [imagination] is derived from φῶς [light] because without light it is impossible to see."[123] As construed by generations of commentators, this statement related to both the spiritual faculty of seeing "forms" or "likenesses" in the common receptor and the soul's ability to bring to light these "forms" as working parameters in the evolving process of knowledge.

to the *imprensiva* (*intelletto*) as established in W 12626 and W 12627r, and through this to the *senso comune*.

118 See Brown 1974 for the notes taken by Donato Acciaiuoli from Argyropoulos's oral comments on Aristotle's *On the Soul*, particularly in connection with the difference between active and passive intellect and Averroes's "aberrant" position on this. See further Garin 1979; and Field 1988, pp. 107–126. See also Kemp 1971, pp. 128–129 (Leonardo and Averroes).

119 See Solmi 1976, pp. 70–71; and Vecce 2017, pp. 63–64.

120 Aristotle [1957], p. 157 [427b]. Argyropoulos (ca. 1460) 1535, p. 71: "Hic enim affectus [imaginatio] in potestate nostra sine controversia collocatur. Licet namque cum libet fingere quicquid volumus, atque ante oculos ponere, perinde atque ii faciunt, qui artificiosae memoriae comparatis atque dispositis locis imagines fingunt atque simulacra collocant."

121 Aristotle [1957], p. 163 [428b]. Argyropoulos (ca. 1460) 1535, p. 74: "Motus igitur is, qui fit a triplici tali sensu, differentiam ob id ipsum nimirum habebit. Atque primus quidem, cum operatio sensus adest, est verus caeteri vero falsi etiam esse possunt, et praesente atque absente, praesertim cum a sensu longe sensibile distat."

122 Leonardo, *Windsor*, vol. 1, 1979, pp. 92–93 (39v) [W 19019v]: "La idea, ovver immaginativa, è timone e briglia de' sensi imperò che la cosa immaginata move il senso."

123 Aristotle [1957], p. 163 [429a]. Argyropoulos (ca. 1460) 1535, p. 74: "Cum autem visus maxime sit sensus, hinc est quod nomen imaginatio ab ipso lumine sumpsit, phantasiaque dicitur, quia sine lumine visio fieri nequit." Avicenna [1972], vol. 2, pp. 126–127 (V, 5), equally develops the metaphor of light and sun to explain the function of the active intellect: "Dicemus quod anima humana prius est intelligens in potentia, deinde fit intelligens in effectu. Omne autem quod exit de potentia ad effectum, non exit nisi per causam quae habet illud in effectu et extrahit ad illum. Ergo est hic causa per quam animae nostrae in rebus intelligibilibus exeunt de potentia ad effectum. Sed causa dandi formam intelligibilem non est nisi intelligentia in effectu, paenes quam sunt principia formarum intelligibilium abstractarum. Cuius comparatio ad nostras animas est sicut comparatio solis ad visus nostros, quia sicut sol videtur per se in effectu, et videtur luce ipsius in effectu quod non videbatur in effectu, sic est dispositio hiuius intelligentiae quantum ad nostras animas."

Aristotle ranked the intellect above the imagination. The part of the soul that "knows and thinks," Aristotle contends, must (although impassive) be receptive of the form of an object."[124] The receptivity of the soul is similar to that of the sensory organs, however its object is not an external sensation, but the mental forms stored in the imagination. "It has been well said," Aristotle concludes, "that the soul is the place of forms, except that this does not apply to the soul as a whole, but only in its thinking capacity, and the forms occupy it not actually but only potentially."[125] In other words, the intellect is the locus where the universal forms of all the intelligible entities are potentially present, but in order to be activated, they require the intervention of an active faculty: one that 'sheds light' upon them by revealing them to the soul.[126] Although Aristotle does not specify how exactly these mental operations occur, he clearly distinguishes between two functions of the intellect, one potential and the other actual. As a result, intellect is both active and passive. In connection with the active intellect, Aristotle stresses that this power or agency bears affinity with that of light: "For in a sense light makes potential into actual colors."[127] In the same way, the active intellect discloses the properties of the dormant mental forms to the soul. It is noteworthy that Aristotle conceives of the active intellect as an action of seeing characteristic of the soul: "Now for the thinking soul images take the place of direct perceptions […] hence the soul never thinks without a mental image."[128] And again: "So the thinking faculty thinks the forms in mental images […] but sometimes by means of the images or thoughts in the soul, just as if it were seeing, [the intellect] calculates and plans for the future in view of the present."[129]

For all its numerous obscurities and inconsistencies, Aristotle's epistemology impressed upon generations of natural philosophers the conviction that seeing offered an authentic model of interpretation not only of the mechanisms through which sensations engender and foster mental "forms," but also of the ways in which these mental "forms" instruct human action and, most remarkably, enable the human soul to transcend the physical world and contemplate the divine. It is not a coincidence that late medieval theology appropriated Aristotle's simile of the intellect as light in order to demonstrate that the highest degree of knowledge arises through divine illumination. It is through the light of God's intellect that the most abstract intelligible forms loom into comprehension: a glimmer of unreachable knowledge.[130]

124 Aristotle [1957], p. 165 [429a]. Argyropoulos (ca. 1460) 1535, p. 74: "De animae autem ea parte qua cognoscit atque sapit […] vacare igitur ipsam passione, sed formae susceptivam esse oportet."

125 Aristotle [1957], p. 165 [429a]. Argyropoulos (ca. 1460) 1535, p. 75: "Atque bene recteque censent qui formarum locum animam inquiunt esse, attamen neque tota est locus, sed intellectiva, neque est actu, sed potentia, formae."

126 For a discussion of the active intellect in Thomas Aquinas's epistemology, see Pasnau 2002, pp. 310–318. On the question, especially in relation to epistemology and brain ventricles theory, see more recently Smith 2015, pp. 249–255.

127 Aristotle [1957], p. 171 [430a]. Argyropoulos (ca. 1460) 1535, p. 77: "Atque quidam est intellectus talis ut omnia fiat, quidam talis ut omnia agat atque efficiat, qui quidem ut habitus est quidam, et perinde ac lumen, nam et lumen colores qui sunt potentia actu colores quodammodo facit."

128 Aristotle [1957], p. 177 [431a]. Argyropoulos (ca. 1460) 1535, p. 80: "Animae autem quae principium est ratiocinandi ipsa phantasmata perinde atque sensibilia sensui ipsi subijciuntur […]. Quapropter ipsa anima sine phantasmate numquam intelligit."

129 Aristotle [1957], pp. 177–179 [431b]. Argyropoulos (ca. 1460) 1535, p. 81: "Intellectivum igitur ipsas formas in phantasmatibus ipsis intelligit […] at nonnumquam hisce quae sunt in anima phantasmatibus aut mentis conceptibus, quasi videns, ad ea quae sunt praesentia ratiocinatur atque deliberat de futuris."

130 On divine illumination, its origins in Plato's innate ideas, its elaboration by Augustine, and its systematization within an Aristotelian understanding of the active intellect by Thomas Aquinas, see Pasnau 2002, pp. 302–310.

As already seen, Leonardo did not care much for transcendence. Yet, given his fascination with the prodigious machine of the eye, it is easy to understand how the idea of the intellect as the noblest "seeing faculty" would have stuck with him. While Avicenna and his acolytes felt compelled to multiply the functions of the imagination by assigning to each faculty of the soul its own kind of imaginative power (one for the common receptor, one for the *cogitativa*, and one for the intellect), Leonardo seems to have reduced the tripartite articulation of the Avicennian and scholastic imagination to two operative faculties: the *imprensiva*, which he identifies with the *inteletto*, and the *imaginazione* or *imaginativa*, lodged within the central ventricle of the brain, the common receptor. With interpretive audacity, he seems to have extended the primary property of the Aristotelian active intellect – its ability to mentally "visualize" – to encompass the *imprensiva*. In a sense, Leonardo may have conceived the *imprensiva* as a perceptual faculty equipped with the intellective power of "coloring" forms through light, thereby actualizing the passive visual schemes arising or stored in the "tenebrous" imagination. Thus, the *imprensiva* may have been an 'internal eye' actualizing the contents of the imagination in view of both representation and verification. It befits Leonardo's predilection for sight as the *nec plus ultra* of knowledge that for him no intellectual faculty seems to operate more efficiently than the sensorial organ of seeing itself: the eye.

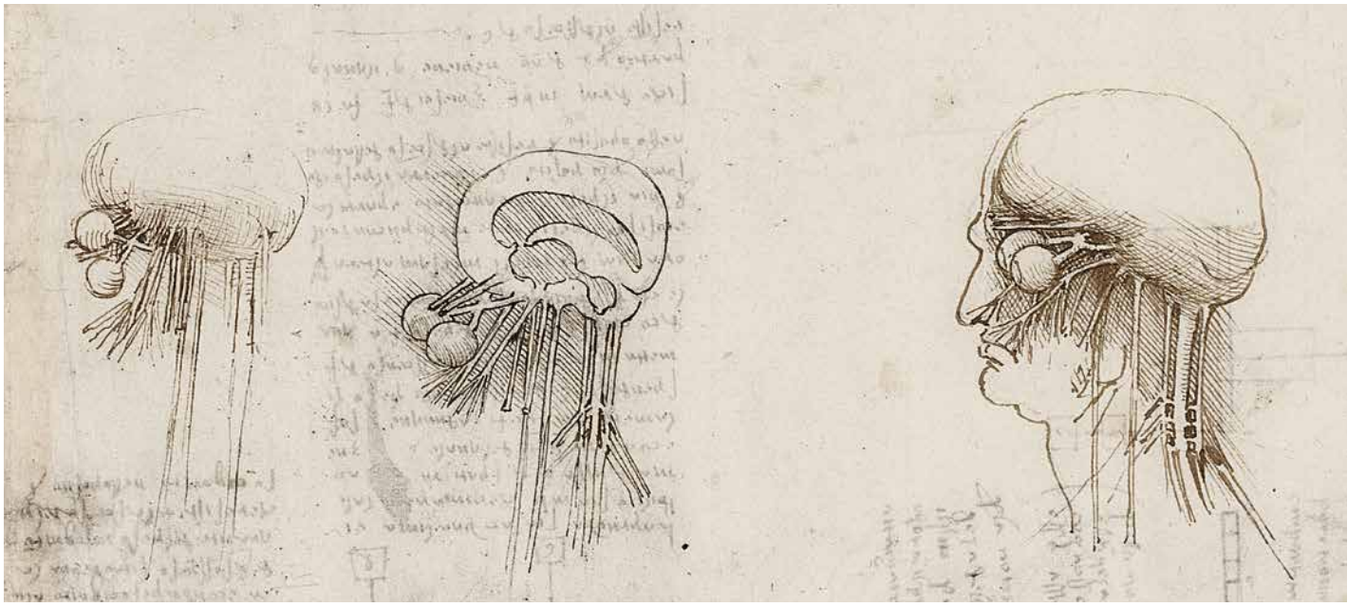
Just as the divine intellect reflects all of creation within it, so too does the mind of the painter (as Leonardo proposes in some of his annotations) mirror nature, thereby becoming one with it.[131] It would not be fair to conclude that Leonardo equated the human mind with the divine mind, given his belief that the "essence of God" cannot be the object of certainty, divinity becoming ipso facto an indifferent category in terms of knowledge. But if we consider nature as the primordial and innermost principle underpinning the visible world – the only principle susceptible to experience – then it is undeniable that for Leonardo, thanks to the eye, humankind can propel itself beyond its own intellectual limits by grasping the 'essence' of the natural cosmos: an 'essence' that can be explicated or, in Leonardo's terminology, demonstrated not only with the technical apparatus of geometrical equations, but also – and most cogently – with images.

The Opacity of the Brain

Leonardo's eye never concretely penetrated the surface of the brain. Fearing perhaps the unpredictable outcome of dissecting the brain of an ox, Leonardo resorted to injecting a solidifying material (wax, in this case) into its ventricles in order to obtain a three-dimensional cast (fig. 4). Whether he felt satisfied with the results cannot be known, but he certainly never succeeded in cracking open a human cranium, so he made do with what he had to hand.[132] Indeed, in later drawings he modeled the ventricles of the human brain after those of the ox he had studied, probing the question no further. At the bottom of W 12602 r (executed ca. 1509–1510), Leonardo sketched three diagrams of the brain in black

131 See Leonardo, *Libro di pittura* [1995], vol. 1, p. 164 (40): "La pittura è di maggiore discorso mentale e di maggiore artifizio e maraviglia che la scultura, con ciò sia che necessità constringe la mente del pittore a trasmutarsi nella propria mente di natura, e sia interprete infra essa natura e l'arte, comendando con quella le cause delle sue dimostrazioni constrette dalla sua legge, et in che modo le similitudini delli obbietti circonstanti a l'occhio concorrino con li veri simulacra alla popilla de l'occhio […]"; *Libro di pittura* [1995], vol. 1, pp. 171–172 (56): "L'ingegno del pittore vol esser a similitudine dello specchio, il quale sempre si trasmuta nel colore di quella cosa ch'egli ha per obbietto, e di tante similitudini s'empie quante sono le cose che li sono contraposte." See further Farago 1992, p. 273.

132 On brain dissection before Vesalius, see Singer 1956.



21 Leonardo da Vinci, W 12602r, The Nerve Pathways to the Brain, ca. 1509–1510, pen and ink over traces of black chalk, 29 × 21.4 cm. Windsor, Royal Collection, inv. RCIN 912602r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

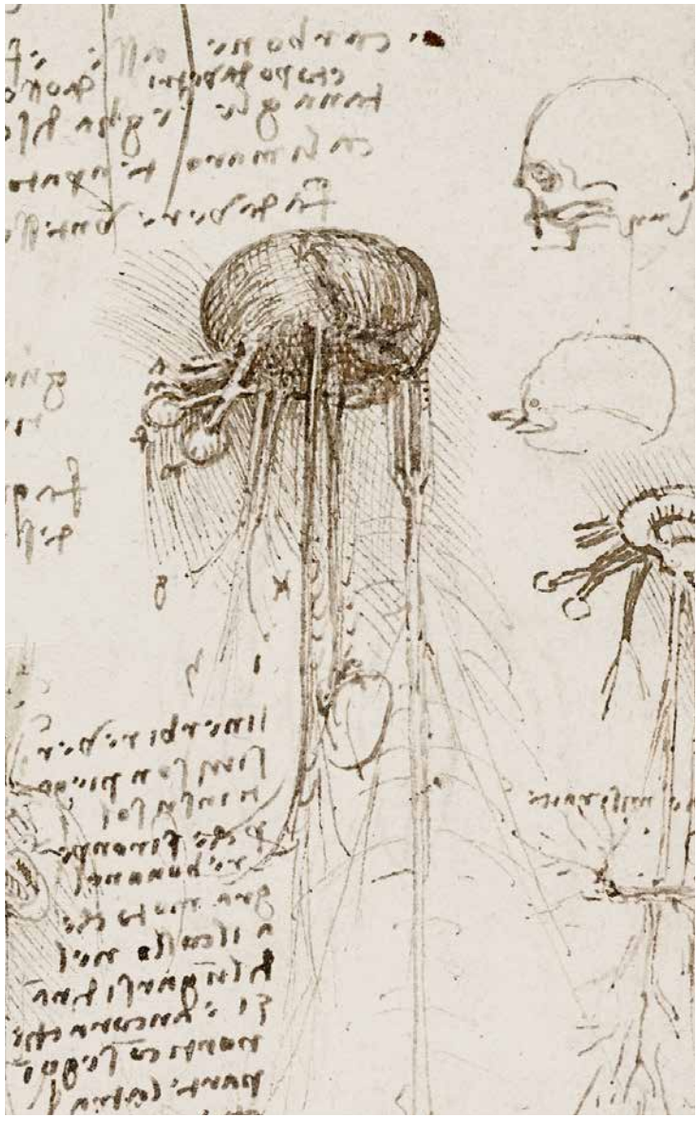
chalk, retracing their contours in pen (fig. 21).[133] To the left, he envisioned the brain in the form of an elliptical mass, impenetrable to the eye, from which a network of cranial nerves dangle, some more prominent than others, most of them undoubtedly oversized. In the central sketch, he offered a cross section of the brain, its three ventricles crisply outlined and their insides hatched with oblique strokes. Between the ventricles and the cranial nerves that intrude into or protrude from the brain, Leonardo literally and figuratively drew a blank: an intermediate, indefinite space that occludes the connections between nerves and ventricles. While the specific linkages between nerves and ventricles can easily be inferred, when it comes to the optic nerves Leonardo's sketch proves inconclusive. In the third diagram, Leonardo created a hybrid: part of the man's face appears in profile, while a sort of exploded view of the cranium displays an intact brain and, below this, the circuitry of nerves originating within it.

The partial blankness, ambiguity, and hybridity of these diagrams betray not only an anatomical, physiological, and epistemological impasse, but – above all – Leonardo's tenacity. The brain remained for him terra incognita, an unchartered territory that had not lent itself to visual scrutiny. Instead of surrendering in the face of the unknowable and invisible, however, Leonardo took the black chalk and pen, imitated whatever he had seen and could surmise from experience, and left the blank and opaque surfaces as open questions. Leonardo's obduracy is systematic – that is, it comes with a method, an angle of approach. In another sheet of the same period (W 19070v), Leonardo jotted down a heterogeneous group of notes (fig. 18).[134] In one of them, he remarked: "Observe the porosities of the substance of the brain where there is more or less of them. Do this from three aspects on one and the same surface."[135] Leonardo is probably here referring to the delicacy of the cerebral matter, which Galen related to the subtlety of the

133 See *The Drawings of Leonardo da Vinci* 1968–1969, vol. 1, p. 122; Keele 1983, p. 66; and Del Maestro 2011, pp. 179–180.

134 See O'Malley/Saunders 1952, p. 338, note 146; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 3, pp. 29–30 [C.I.13]; Keele 1983, pp. 203–204; Todd 1991, pp. 100–102 (suggesting that the sensory nerves end in the third ventricle, Leonardo's *memoria*); and Klemm 2013, pp. 148–150.

135 Leonardo, *Windsor*, vol. 1, 1979, pp. 360–365 (113r) [W 19070v]: "Guarda la porosità della sustanzia del cervello, dove l'è più o men. Fa' questa per tre aspetti 'n una medesima faccia."



22 Leonardo da Vinci, W 19070v, Miscellaneous Notes and Anatomical Studies, ca. 1508–1510, pen and ink, 32 × 22.1 cm. Windsor, Royal Collection, inv. RCIN 919070v (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

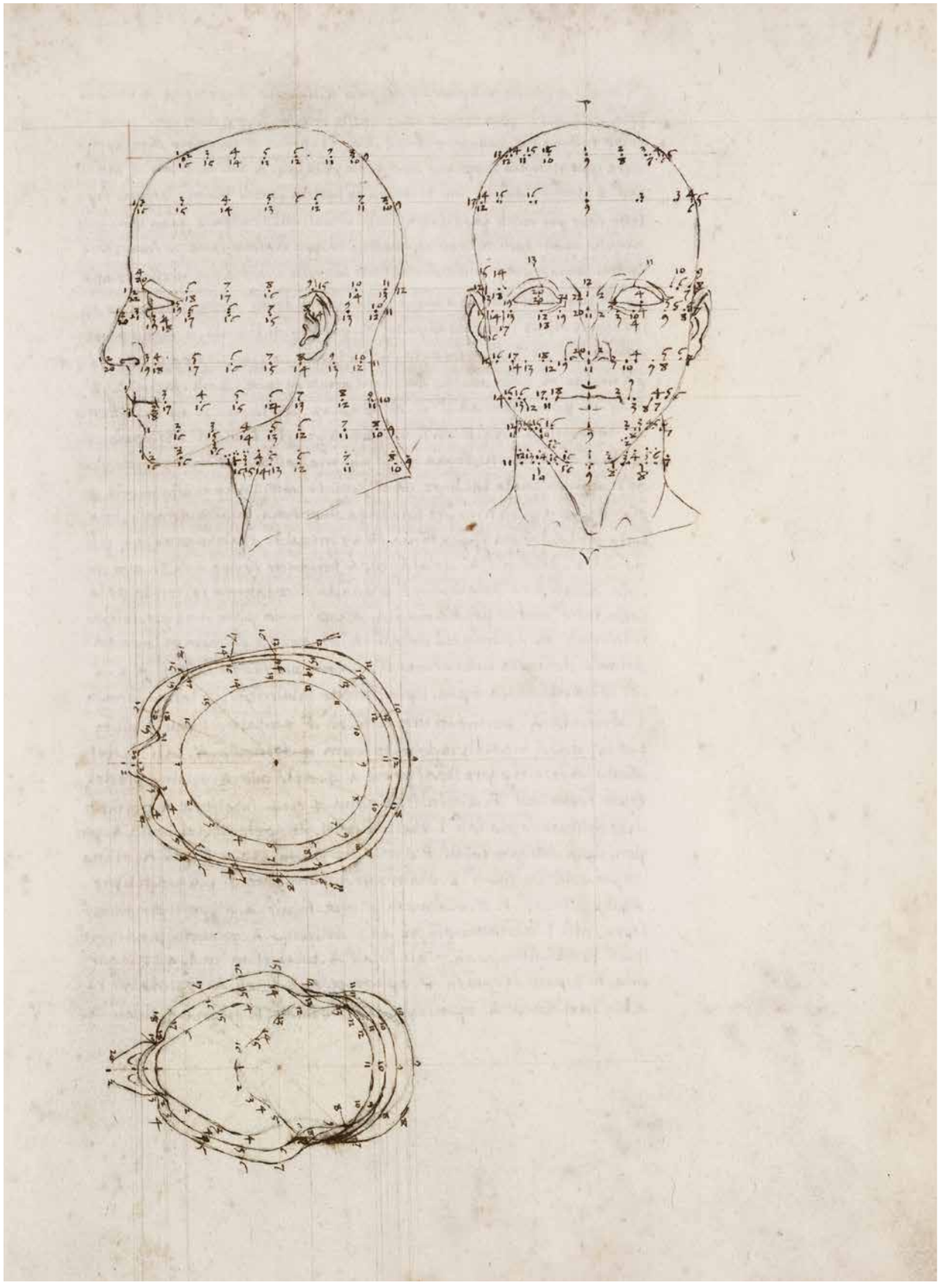
sense organs and their nerves.[136] In writing this remark, Leonardo was clearly still anticipating the prospect of dissecting a human brain. What seems to me most revelatory is Leonardo's intention to analyze a section of the brain from three different vantages: perhaps laterally, obliquely, and from above. In the margin of this annotation, Leonardo sketched in pen the diagram of the brain with its dangling nerves, almost identical with the one on W 12602r (figs. 21–22). This time, however, he also added a small drawing depicting only the three brain ventricles with the attachments of the cranial nerves. Not surprisingly, Leonardo here plugged the optic nerves into the base of the frontal ventricle – that is, the *imprensiva* (fig. 21). In the absence of a proper dissection, it was impossible for Leonardo to know where to locate the attachments of the chiasma and optic tract within the brain, but he remained faithful to his conviction that sight was the privilege of the *imprensiva*. That said, the primary diagram on Weimar's KK 6287r (fig. 7), shows the optic nerves directed to the common receptor instead of the *imprensiva*: a detail that betokens Leonardo's quandaries in reconciling his own theories with his anatomical findings (cf. fig. 21).

With his sketch on W 19070v, then, Leonardo once again visualized an epistemological postulate: one that his anatomical experience had nearly cast into doubt but that could by no means be definitively refuted. Despite the hypothetical nature of some of his visualizations, Leonardo never shied away from giving them demonstrative form (*dimostrativa forma*) by submitting them to the eye in the guise of a vivid drawing. He did this on the assumption that, albeit partially fictive, these "prospects" should be accessible to the viewer from every possible viewpoint as if they were known natural objects. As noted above, the ability of the eye to create and validate knowledge relied upon what Alhazen had defined as visual scrutiny, or *intuitio*. In keeping with Alhazen's epistemological and optical doctrine, Leonardo exploited graphic technologies derived from the quattrocento tradition with the intention of accurately mapping out the natural world and its objects, whether factually or hypothetically. On the verso of W 12603r, where Leonardo drew, in diagrammatic form, the layers of the human brain and the brain ventricles, a series of cursory sketches indicate that he planned to use the technique of parallel projection in order to propose a quasi-axonometric view of the interior of the cranium seen from behind according to two different angles, which are oriented upward and downward (fig. 23). As a result, the beholder would have been able to perceive the sequence of the ocular globes and brain ventricles as if receding in perspective.

In terms of graphics, Leonardo's three-dimensional diagrams could pass for the earliest attempts at a 3D rendering of the human face, were it not for the fact that Piero della Francesca had preceded him in the illustrations he devised for his *De prospectiva pingendi* (mid-1470s). On folio 61r of one copy of Piero's manuscript work now in the Biblioteca Palatina, Parma, the frontal and lateral views

136 See Galen [1968], esp. vol. 1, pp. 402–403.

23 Leonardo da Vinci, W 12603v, Studies of the Head, ca. 1490–1494, pen and ink, 20.3 × 15.3 cm. Windsor, Royal Collection, inv. RCIN 12603v (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)



24 Piero della Francesca, *De prospectiva pingendi*, 1470.
Parma, Biblioteca Palatina, Ms. Parmense 1576, 61r

of a human face appear side by side and on the same plane, and they are interrelated through a common set of geometrical coordinates (fig. 24).[137] Use of this procedure enabled Piero to visualize multiple cross sections of the head in sagittal view. By looking more closely at W 12603 v, it can be observed that Leonardo intended to apply this same technique to his "prospects" of the human brain (fig. 23).[138] At the bottom right, a frontal and a lateral view of a male face – both placed on the same plane – confirm the point. Notably, the frontal view appears to be sliced into sections lengthwise, thereby intimating that, by heeding the principles of parallel projection, the designer's or anatomist's eye could smoothly access any given point inside the human head at will. It is hardly a coincidence that Vesalius resorted to an analogous approach in illustrating the brain in his *De humani corporis fabrica* (1543).

While it is useful to compare Leonardo's graphic technologies to those developed early on by Piero della Francesca and subsequently perfected by Vesalius, in so doing one might overlook the incommensurability of Leonardo's hermeneutics. For Leonardo, visualization is not just about reproducing the visible or validating what is known through representation. As I have pointed out, the *imprensiva* seems to be capable of granting visual form to the ideas that stem from the imagination. This implies that a mental abstraction, a hypothesis, can be invested with visual properties in the form of a drawing and can serve as a linchpin for ratifying, correcting, or debunking mental assumptions. Because the *imprensiva* primarily operates through the eyes, it is particularly capable of visualizing minutely: a visualized hypothesis may thus assume the subtlest characteristics of optical perception. At the bottom right of Weimar's KK 6287 r (fig. 25), Leonardo drew a brain diagram consisting of three parts: an axonometric view of a human head dissected all around just above the ear level; a representation of a brain with its wiring of nerves suspended mid-air; and the upper shell of the cranium. Each of these views is rendered through chiaroscuro and foreshortening; prodigiously, the veins on the surface of the brain seem to react, with delicacy, to light falling from above.

The degree to which Leonardo animates his diagrams with visual notations is not a sign of virtuosity, but the lively record of an ever-unfolding cognitive process. Convinced that knowledge cannot progress without seeing, and that the eye and its visual power are the most reliable interface between the senses and the mind, Leonardo could not help but use the image as an epistemological instrument, a testing device, and a working hypothesis. Of course, Leonardo was not the first to appreciate the value of the image as a vector of knowledge. Unlike late medieval and early modern scholars, however, for Leonardo the image is not just the illustration of a text or a pedagogic tool.[139] Neither is it the figurative or symbolic epitome of transcendental, metaphysical, or moral knowledge. Nor is it a mnemonic device.[140] As a visualized hypothesis, the drawn image subsumes and condenses the argumentative structure of a discourse not merely through abstraction, but by recourse to empirical connotations.[141] In this way,

137 See *Piero della Francesca* 2015, pp. 301–302, no. I.6.

138 See O'Malley/Saunders 1952, p. 332, note 143; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 1, p. 123; Keele 1983, p. 62; *Leonardo: Anatomical Drawings* 1983, p. 51, no. 9B; Pedretti 2007, pp. 63–65, no. 5B; and Bambach 2019, vol. 2, p. 212.

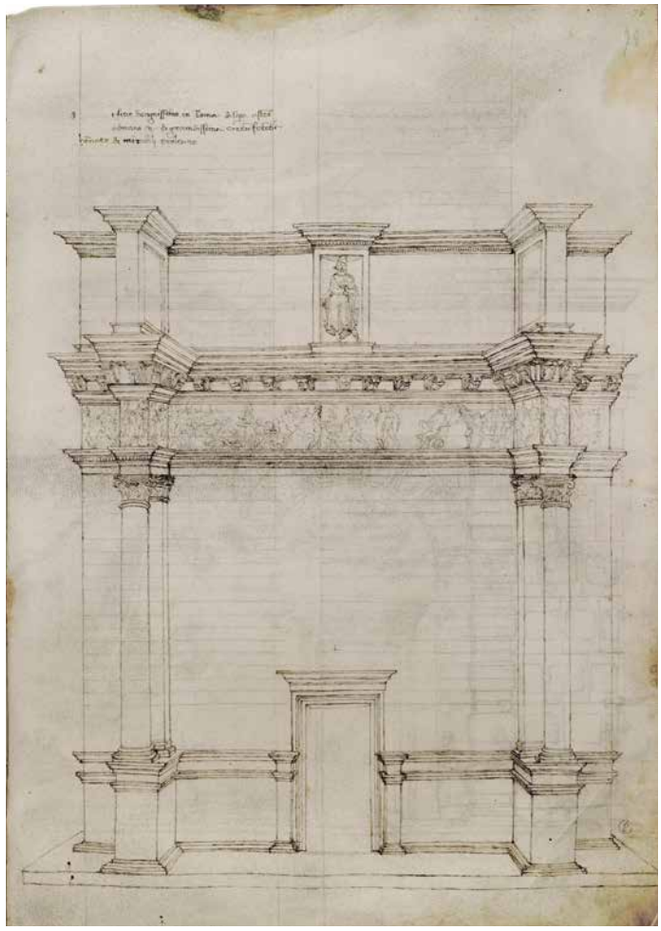
139 On Leonardo and "scientific" drawing, see Benesch 1943. For anatomical illustration before Leonardo, see Todd 1991, pp. 31–45. For drawing of machines before Leonardo, also in connection with architectural practice, see Zwijnenberg 1999, pp. 35–46; Camerota 2004; Nanni 2013. On the evolution of architectural drawing in the quattrocento, see more recently Di Teodoro 2015. See further Long 2004.

140 In this regard, see, for instance, Carruthers 2000; Bolzoni 2002; Hamburger 2014; and Hamburger 2020. For the "hypothetical" nature of medieval diagrams, see Bogen/Thürlemann 2003, esp. p. 10.

25 Detail of fig. 7

141 This becomes particularly evident, for instance, in Leonardo, *Windsor*, vol. 2, 1980, pp. 642–647 (162 r) [W 19071 r]: "O scrittore, con quali lettere scriverai tu con tal perfezione la intera figurazione qual fa qui il disegno? Il quale tu, per non avere notizia, scrivi confuso e lasci poca cognizione delle vere figure delle cose, la quale tu, ingannandoti, ti fai credere poter saddisfare appieno all'ulditore, avendo a parlare di qualunque cosa corporea circundato da superfizie. Ma io ti ricordo che tu non t'impacci colle parole se non di parlare con orbi, o, se pur tu vuoi dimostrar con parole alli orecchi e non all'occhi delli omini, parla di cose di sustanzie o di nature e non t'impacciare di cose appartenenti alli occhi col farle passare per li orecchi, perché sarai superato di gran lunga dall'opera del pittore. Con quali lettere descriverai questo core che tu non empia un libro e, quanto più lungamente scriverai alla minuta, tanto più confonderai la mente dello ulditore e sempre aria bisogno d'isponitori o di ritornare alla sperienzia, la quale in voi è brevissima, e dà notizia di poche cose rispetto al tutto del subbietto di che desidera integral notizia." See also Gründler 2011, pp. 134–135, who points out that "the act of drawing, as an act of form-giving and conceiving, can be seen as analogous to the (philosophical) act of conceptualization."

the hypothesis takes on the form of a "natural" object. Complementary to words, Leonardo's diagrams and sketches aspire to become immediately understandable to the eye and the mind. Furthermore, they subject themselves to immediate comparison and validation through visual scrutiny. It could be argued that Leonardo's use of the image as a conjectural "prospect" parallels the then nascent architectural practice of reconstructing ancient buildings from ruins. In this context, Leonardo's friendship with Francesco di Giorgio Martini comes to mind. On folio 78r of his manuscript on architecture (Biblioteca Reale, Turin), Martini represented the elevation of a section of the Forum of Nerva, the so-called "Colonnacce" (fig. 26).[142] In his drawing, Martini moved the entrance of the structure to the center and imagined an elegant plinth running along the lower part of its facade. Most probably, parts of the building were off-bounds and out of sight at the time Martini visited the site, and his "interpolations" may have been intended to replace what he could not see with what he deemed plausible. In fact, his outlook on ancient architecture and his study of Vitruvius may have led him to make the architectural elements more symmetrical and recognizable.



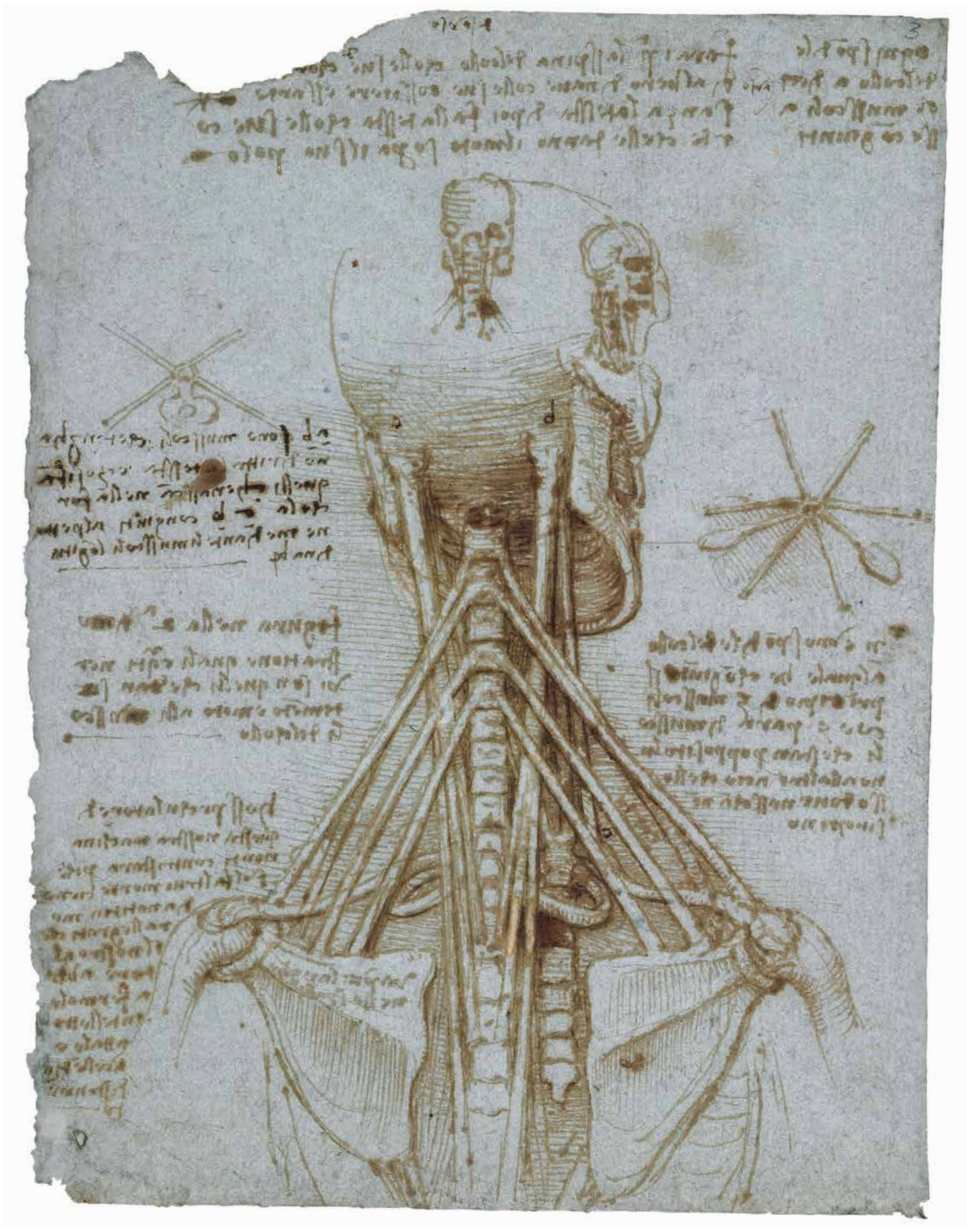
26 Section of the Encircling Wall of the Forum of Nerva, ca. 1478–1481, from Francesco di Giorgio Martini, "Le Colonnacce," *Codice Torinese Saluzziano*, Turin, Biblioteca Reale, 148, fol. 78

Leonardo owned a copy of Martini's treatise on architecture, and it is undeniable that both Martini's reconstructive drawings and Leonardo's brain ventricle diagrams incorporate hypothetical additions. Yet the scope of Leonardo's conjectural diagrams is not only more vast by far but is also predicated upon an interpretation of sight and knowledge unparalleled in Martini or, for that matter, in any other of Leonardo's contemporaries. Leonardo's pervasive idea that vision and the visual could to a great extent replace the textual as a more effective and expeditious way of thinking and demonstrating is as groundbreaking as it is unparalleled. Of course, Leonardo gradually became aware that representing nature with optical accuracy does not necessarily facilitate comprehension and that, in order to be comprehensible, images may need to distance themselves from nature and resort to the intermediary of words. Advancing in his anatomical studies, Leonardo was forced to admit that the intricacy of the body machine and the messiness that the anatomist encounters in dissecting the body required simplification in order for it to make sense. In W 19075v (1512–1513), Leonardo depicted a sizable cord diagram of the tendons attached to the vertebral spine (fig. 27).[143] In an adjacent annotation, Leonardo advised draftsmen to first "make the cervical spine, without the skull, with its cords like the mast of a ship."[144] By adding the skull on top of his illustration, Leonardo intended to show how the cords allow the head to partially pivot upon its axis. As it is, the diagram can hardly be mistaken for an optical "reproduction," even at a schematic level. The unnaturally rigid vertical configuration of the vertebral spine, which enhances its elongation, and the diminution in number of the muscles attached to it,

142 See Martini (ca. 1477) 1967, vol. 1, p. 280.

143 See O'Malley/Saunders 1952, p. 76, note 18; *The Drawings of Leonardo da Vinci* 1968–1969, vol. 3, p. 31 [C.II.5]; Keele 1983, p. 288; *Leonardo: Anatomical Drawings* 1983, p. 91, note 24; Bambach 2019, vol. 3, pp. 304–305.

144 Leonardo, *Windsor*, vol. 2, 1980, pp. 728–729 (179v) [W 19075v]: "Farai prima la spina del collo colle sua corde a uso di albero di nave colle sue costiere, essendo sanza la testa. Dipoi fa' la testa colle sue corde che le danno il moto sopra il suo polo."



27 Leonardo da Vinci, W 19075r, Anatomy of the Neck, ca. 1512–1513, pen and ink over blue paper, 27.6 × 20.7 cm. Windsor, Royal Collection, inv. RCIN 919075r (photo Royal Collection Trust / © Her Majesty Queen Elizabeth II 2021)

denature the image. In other words, Leonardo amplified the metaphorical implications of his illustration, the ligaments visually equated with sail chords tethered to the spine-mast. Seeking to stimulate comprehension, the scientific image requires a certain degree of denaturation and schematization, but these graphic devices are not without consequences in the case of Leonardo.[145] Indeed, these practices intimate the actual opacity of the visible world, thereby undermining Leonardo's claim that nature manifests itself self-evidently as pure visibility. In this, as in many other cases, Leonardo was faced with an irremediable conundrum: graphic technologies pose limitations in the representation of both the appearance and the essence of nature in all its complexity.[146] In his *Libro del cortegiano* (first published in 1528), Baldassare Castiglione notes in connection with Leonardo: "He despises the art in which he is most singular and has set out to learn philosophy, in which he has such strange concepts and new chimeras that he himself with all his painting would be unable to depict them."[147] Whether ironic or not, Castiglione's statement does not hit the mark at all. Leonardo was always successful in his attempts to visualize his "strange concepts" and philosophical "chimeras." Paradoxically, he never doubted that his drawings would fail to embody his views on natural philosophy, anatomy, and epistemology. Through his practice, however, and unwittingly, he came to demonstrate that nature's visibility is shot through with opacity and inscrutability, thereby imperiling his own notion of images as carriers of epistemological certainty.

145 A discussion of the extent to which Leonardo's anatomical drawings can be defined as instruments of knowledge can be found in Nova 2010; and Nova 2011. In particular, Nova 2010, p. 161, bearing in mind the relationship between the conventions of architectural drawing and their application to anatomy by Leonardo, points out that some of Leonardo's anatomical drawings should be construed as "ein Symbol." While Nova rightly insists on the "strategies of visualization" through which Leonardo manipulated his anatomical illustrations in view of clearer understanding, I argue here for Leonardo's use of drawing also as a visualization of unverified assumptions or hypotheses. See further Fehrenbach 2013, esp. pp. 166–171, on another aspect of the question.

146 It is noteworthy that before Leonardo, Francesco di Giorgio Martini declared the limits of drawing in conveying knowledge, although specifically in connection with architecture, warning that what drawing cannot show must remain to the "discretion and judgment of the artist," and therefore cannot be shared with anyone. See Martini (ca. 1477) 1967, vol. 2, p. 484: "Oltre a questo, quelli disegni che sono messi per esempli in ogni parte, non possono essere in tutto dichiarati, perché le superficie estrinsiche coprono le intrinseche, onde non volendo multiplicare in infiniti esempli è necesario che, overamente le parti esteriori sieno imperfette facendo perfette le interiori, overo per contrario et conversamente."

147 Castiglione (1528) 1965, p. 144: "Un altro de' primi pittori del mondo sprezza quell'arte dove è rarissimo ed éssi posto ad imparar filosofia, nella quale ha così strani concetti e nove chimere che esso con tutta la sua pittura non sapria depingerle."

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