【論　文】

Redefining the Position for Praxagoras of Cos in the History of Ancient Greek Medicine and Philosophy

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> He（i.e. Praxagoras）is very important for our purposes because of two doctrines attributed to him, namely the distinction of arteries and veins as separate systems, and the theory that arteries contained no blood, only pneuma.（…）The second of these doctrines, that of the air-filled arteries, was really one of the tragical mistakes in the history of Greek medicine, a mistake which more almost than any other prevented the discovery of the circulation.
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> C. R. S. Harris, *The Heart and the Vascular System in Ancient Greek Medicine from Alcmaeon to Galen*（1973）, pp.108–109.

Introduction

In what follows, I shall attempt to redefine the position for Praxagoras of Cos（fl. c.300 BC）in the history of ancient Greek medicine and philosophy, by answering the question how he was historically related to the tradition of Hippocratic medicine and philosophical and biological doctrines by Aristotle（384–322 BC）as well as to medical ideas and doctrines by other ancient physicians, including Diocles of Carystus（c.375–c.295 BC）and two early Alexandrian physicians, i.e. Herophilus of Chalcedon（c.330–c.250 BC）and Erasistratus of Ceos（c.320–c.240 BC）.[1] Through an analysis of some of his anatomical and

[1] The chronologies of all the physicians mentioned in this paper, including Praxagoras, are provisional, following the dating of them by modern scholars. For Praxagoras, see Fritz Steckerl, *Praxagoras of Cos and His School*（Leiden: E. J. Brill, 1958）, p.2, who dates his birth to around 340 BC and his *floruit* to 300 BC. For Hippocrates, see for example Jacques Jouanna, *Hippocrates*, translated by M. B. Debevoise（Baltimore / London: The Johns Hopkins University Press, 1999）, pp.10–37. I would follow the dating of Diocles of Carystus by Ludwig Edelstein, 'Review of *Diokles von Karystos*', *American Journal of Philology*, Vol. 61（1940）, pp.483–489, which I think is the most plausible dating of the physician. At the same time, I would refer to the dating of the physician by Philip van der Eijk, *Diocles of Carystus, A Collection of the Fragments with Translation and Commentary*, 2 vols.（Leiden / Boston / Köln: Brill, 2000–2001）, Vol. II: Commentary（2001）, pp.xxxi-xxxiv, who concludes that any reasonable pair of dates between 400–300 BC is theoretically possible as regards his chronology. On Herphilus and Erasistratus, see Heinrich von Staden, *Herophilus: the Art of Medicine in Early Alexandria*（Cambridge: Cambridge University Press, 1989）, pp.43–50.

physiological ideas and doctrines and his pathological arguments presupposing his own cardiocentric model of a human body, I want to make it clear that Praxagoras was undoubtedly a man of the highest originality in the field of medicine of the fourth and third centuries BC.

Modern Scholarship on Praxagoras of Cos: An Overview

Before I begin my discussion, I will make some preliminary remarks on modern scholarship on Praxagoras as concerns his medical theory and methodology as well as his contribution to the development of medical knowledge of a human body. Praxagoras, son of Nicarchus, was born on the island of Cos near the Asian Minor as a compatriot of Hippocrates (c.460–c.375 BC). He is reported to have belonged to a group of doctors called 'Asclepiades' (Ἀσκληπιάδαι), who claimed descent of their medical profession from Asclepius, a Greek hero and god of healing.[2] Praxagoras was regarded through antiquity as one of the most famous physicians after Hippocrates. In the tradition of medical doxography, for example, he was enumerated with Hippocrates, Diocles of Carystus, Herophilus and Erasistratus, etc., as one of the representative physicians of the 'Rationalist' School.[3] Praxagoras made a great contribution to the advancement of anatomical knowledge of a human body, by distinguishing between arteries and veins as constituting two separate vascular systems. On the other hand, he has been notorious for his doctrine that the arteries contain only pneuma (πνεῦμα), as C. R. S. Harris severely criticizes it as 'one of the tragical mistakes in the history of Greek medicine', because, Harris believes, it prevented ancient Greek physicians from discovering the circulation of blood.[4] It may also deserve to be noted that Praxagoras propounded a cardiocentric model of a human body, by following in the footsteps of Aristotle, who was one of the most influential advocates of cardiocentrism in the debate over the central organ of a human body, which may be traced back as early as the middle or early period of the fifth century BC.

There is no doubt, then, that Praxagoras was one of the most intriguing figures in the history of ancient Greek medicine and philosophy. However, modern scholars do not seem to have shown as much interest in his medical theory and methodology as they may deserve. It is because none of his medical treatises has now

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2 Galen, *Methodus Medendi*, I 3 [=Fr.45 Steckerl (1958)].

3 See ps.-Galen, *Introductio sive medicus*, 4 [=Fr.1 Steckerl (1958)]. According to Celsus, the first century Roman encyclopedist, *On Medicine*, Book I, prooem.7 [=Fr.3 Steckerl (1958)], Praxagoras belonged to a group of physicians who after Hippocrates developed medical art into three principal branches of healing. It is not clear, however, how much historical value such reports have, because they may only intend to establish intellectual relationships between physicians without making distinction between similarity of doctrine and actual historical contact, as P. van der Eijk (2001), pp.xxxi–xxxiii, already perceptively points out. Throughout this paper, I quote 'fragments' of Praxagoras, which include both verbatim citations from his medical treatises and indirect testimonies in the works of later authors, according to fragment numbers followed by an editor's name.

4 C. R. S. Harris, *The Heart and the Vascular System in Ancient Greek Medicine from Alcmaeon to Galen* (Oxford: Clarendon Press, 1973), pp.108–109. See the relevant passage cited from his book at the beginning of this paper above.

survived, so we need to depend on fragmentary citations from them in the works of later authors, including Galen（129–c.216）and the unknown author of the medical treatise, often known as *On Acute and Chronic Diseases*,[5] and their indirect testimonies on Praxagoras' anatomical and physiological ideas and doctrines and his pathological arguments to reconstruct his medical theory and methodology.

Let us describe a history of modern scholarship on Praxagoras and his medical theory and methodology. E. D. Baumann was the first among modern scholars to show particular interest in the physician, with a publication of his German article 'Praxagoras von Kos' in 1937.[6] It was over twenty years later when in 1958 Fritz Steckerl published a monograph entitled *The Fragments of Praxagoras of Cos and His School*, with a fairly large number of fragments of Praxagoras and his disciples collected from the works of later authors.[7] Steckerl's edition may well be valued as having been a decisive step forward then for modern scholarship on the physician to draw more specific attention of many people interested in ancient Greek medicine and philosophy. It turned out, on the other hand, that Steckerl's arguments focusing on the historical relation of Praxagoras' own medical system to Hippocratic medicine would not be so persuasive, as Josef-Hans Kühn made critical comments on them in 1962 in his review of Steckerl's edition,[8] and, much more recently, Diethard Nickel argued against them in 2005 in his German essay 'Hippokratisches bei Praxagoras?', which he contributed to the volume of papers read at the XIth International Hippocrates Colloquium（2002）.[9] Unfortunately, such critical comments on Steckerl's arguments did not lead modern scholars to regard Praxagoras as a physician who may deserve more of their academic interest. In fact, Steckerl's edition remained influential for more than fifty years since its publication as the only information sources available to modern scholars, since indeed J. C. Capriglione, who published an Italian translation of the fragments of Praxagoras entitled *Prassagora di Cos* in 1983, with a reconstruction of his medical theory and methodology,

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5 The treatise is preserved in a Paris manuscript（Codex Parisinus Supplementi Graeci 636）, with two other manuscripts（Codex Parisinus Graecus 2324, and Codex Vindobonensis Medicus Graecus 37）, in which parts of it are preserved. In this paper, I will call the author of the treatise 'the Anonymous of Paris', following the custom of modern scholarship. For details of its structure and contents, see P. van der Eijk, 'Anonymus Parisinus and the Doctrines of the 'Ancients'', in P. van der Eijk（ed.）, *Ancient Histories of Medicine: Essays in Medical Doxography and Historiography in Classical Antiquity*（Leiden / Boston / Köln: Brill, 1999）, pp.295–331.

6 E. D. Baumann, 'Praxagoras von Kos', *Janus* 41（1937）, pp.167–185.

7 See n.1 above. In my discussion below, I need to rely on Steckerl's edition, which I think is available even today, especially because Lewis' new edition（see text to n.13 below）does not offer us a comprehensive collection of fragments of the physician.

8 J. -H. Kühn, 'Review of *The Fragments of Praxagoras of Cos and His School* by F. Steckerl', *Gnomon* 34（1962）, pp.133–137.

9 D. Nickel, 'Hippokratisches bei Praxagoras?', in Philip van der Eijk（ed.）, *Hippocrates in Context, Papers read at the XIth International Hippocrates Colloquium, University of Newcastle upon Tyne 27–31 August 2002*,（Leiden / Boston: Brill, 2005）, pp.315–323.

was rather dependent on Steckerl's arguments.[10] Thus, modern scholars were almost dependent on his edition, when referring to Praxagoras in their discussions of the history of ancient Greek medicine,[11] or when discussing much wider topics concerning ancient Greek and Roman physicians and their contemporary philosophers, including the Stoics.[12]

It was the year 2017 that was most fruitful for modern scholarship on Praxagoras, because there came out two more publications with a focus on his anatomical and physiological ideas and doctrines and his pathological arguments presupposing his own cardiocentric model of a human body. One was a voluminous book under the authorship of Dr. Orly Lewis, entitled *Praxagoras of Cos on Arteries, Pulse and Pneuma: Fragments and Interpretation, Studies in Ancient Medicine*, Volume 48.[13] The other was an English article entitled 'Praxagoras of Cos against the Tradition of Hippocratic Encephalocentrism', which I contributed to *Historia Scientiarum: International Journal of the History of Science Society of Japan*, Vol.27(1).[14] It is obvious that Lewis' new edition on Praxagoras will be creating a turning point as one of the most significant and most valuable achievements in modern scholarship on the physician since the publication of Steckerl's edition in 1958. What characterizes most Lewis' edition is that it collects thirty-three fragments of Praxagoras from the works of later authors as principal sources for his conception of arteries (ἀρτηρίαι), pulse (σφυγμός) and pneuma, and examines these fragments in detail from a philological and historical point of view, with an intention to give us a surprisingly meticulous discussion over his anatomical and physiological ideas and doctrines and his pathological arguments. Lewis took a very strategic scheme for discussing the physician's anatomical and physiological ideas and doctrines, by posing herself and answering seven crucial questions about his definition of arteries as distinct from the veins, and his explanation of the pulse and its role in a human body as well as his definition of pneuma and its roles in a human body and its relation to the human soul (ψυχή). More interestingly, by answering these questions, she also tried to answer more fundamental questions, such as (I) how it was that anatomical and physiological observations contributed to the formation of Praxagoras' doctrines, (II) what role earlier ideas and sources, such as Aristotle, Diocles of Carystus and the Hippocratic authors played in shaping the physician's interests and doctrines, and to what extent his doctrines were a reaction to ongoing debates, and (III) to what extent the physician's own doctrines

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[10] J. C. Capriglione, *Prassagora di Cos* (Naples, 1983).

[11] See *e.g*. James Longrigg, *Greek Rational Medicine: Philosophy and Medicine from Alcmaeon to the Alexandrians* (London and New York: Routledge, 1993), and Vivian Nutton, *Ancient Medicine* (London and New York: Routledge, 2004).

[12] See *e.g*. Friedrich Solmsen, 'Greek Philosophy and the Discovery of the Nerves', *Museum Helveticum* 18 (1961), pp.150–197, C. R. S. Harris (1973), and Teun Tieleman, *Galen and Chrysippus on the Soul: Argument and Refutation in the De Placitis Books II–III* (Leiden, New York and Köln: E. J. Brill, 1996).

[13] Orly Lewis, *Praxagoras of Cos on Arteries, Pulse and Pneuma: Fragments and Interpretation*, J. Scarborough, P. van der Eijk, A. E. Hanson and J. Ziegler (edd.), *Studies in Ancient Medicine*, Volume 48 (Leiden / Boston: Brill, 2017).

[14] Masahiro IMAI, 'Praxagoras of Cos against the Tradition of Hippocratic Encephalocentrism', *Historia Scientiarum: International Journal of the History of Science Society of Japan*, Vol.27 (1), pp.82–107.

played a role in shaping the doctrines of Herophilus, Erasistratus and the Stoics.[15] (II) and (III) are the most important questions, I would insist, especially because answering these questions will enable us to redefine the position for Praxagoras in the history of ancient Greek medicine and philosophy.

As compared with Lewis' monumental work on Praxagoras, my article is nothing but a tiny contribution to modern scholarship on the physician. I would say, however, that it might possibly deserve noting, because it is the one and only paper on Praxagoras that has been published by a Japanese specialized over many years in the history of ancient Greek medicine and philosophy. The aim of my discussion there was to give an answer to the question how Praxagoras was historically related to Hippocratic medicine with a conclusion that the physician's accounts of epilepsy (ἐπιληψία) and other pathological conditions closely related to it (i.e. paralysis and madness), based on his cardiocentric model of a human body, may constitute a critical response to the arguments by the author of the Hippocratic treatise *On the Sacred Disease* in the tradition of Hippocratic encephalocentrism at the medical school in Cos. I drew this conclusion from the arguments which included not only an examination of the historical relationship of Praxagoras to the tradition of Hippocratic medicine but also that of his connections to Aristotle and his elder contemporary Diocles of Carystus. Thus, my arguments shared the common interest in Praxagoras and his historical and intellectual backgrounds with Lewis, as indeed she showed her own by answering the question (II) mentioned above. I wish that I could have referred to her edition on Praxagoras in my article, which would have been helpful for me to improve or even reorganize my arguments for this conclusion. Much to my regret, I could not, because I had to submit the final version of the draft of my article to the Editorial Board of *International Journal of the History of Science Society of Japan*, before it was published.

Thus, in my discussion below, I will specifically focus on the answers that Lewis gave to the questions (II) and (III) in her edition as a result of her most meticulous examination of fragments of Praxagoras from the works of later authors as informative sources for us to understand his anatomical and physiological ideas and doctrines and his pathological arguments. In doing so, we shall be able to redefine the position for the physician more precisely in the history of ancient Greek medicine and philosophy.

Praxagoras and the Tradition of Hippocratic Medicine

Praxagoras was a compatriot of Hippocrates on the island of Cos. And, if we rely on the report by Galen, both of them belonged to a group of doctors called 'Asclepiades' (Ἀσκληπιάδαι), who claimed descent of their medical profession from Asclepius, a Greek hero and god of healing. Thus, one would seem to be inclined to suppose that Praxagoras may have belonged to the Hippocratic medical school in Cos, and, as I would imagine, he may have been one of its leading members after Hippocrates at the end of the fourth

[15] See Lewis (2017), pp.9–11.

century and the early period of the third century BC.

Lewis is skeptical about the supposition that Praxagoras may have belonged to the Hippocratic medical school and he may have been one of its leading members, because, she argues, there is no reason for us to believe, by relying on a historical fact of his origin as a compatriot of Hippocrates on the island of Cos, that the physician was a follower of Hippocrates or of a Hippocratic tradition. Rather, she likes to describe him as an independent and innovative physician, who was busy training his disciples and striving to improve his understanding of a human body and its functions. On the other hand, she admits that there are some similarities between his doctrines and some of the ideas found in the medical treatises attributed to Hippocrates, including the treatise *On the Sacred Disease*. She concludes, however, that, despite of these similarities, there is no decisive evidence indicating that Praxagoras was familiar with these treatises. I will limit my arguments against Lewis' conclusion to the question whether Praxagoras was familiar with the Hippocratic treatise *On the Sacred Disease*, especially because Nickel, too, has doubts about the possibility of his connection to the author of this treatise, although he admits that there are some common elements in the pathological accounts of epilepsy between both of them. He argues that these common elements can be explained by supposing that Praxagoras and the Hippocratic author were connected to a more general network of relation.[16]

Now, I draw attention to the pathological account of epilepsy by Praxagoras, as reported by the Anonymous of Paris in the passage below, which I think is most significant for us to discern how it is that the physician was connected to the author of the Hippocratic treatise *On the Sacred Disease*.

> Πραξαγόρας περὶ τὴν παχεῖαν ἀρτηρίαν φησὶ γίνεσθαι φλεγματικῶν χυμῶν συστάντων ἐν αὐτῇ· οὓς δὴ πομφολυγουμένους ἀποκλείειν τὴν δίοδον τοῦ ἀπὸ καρδίας ψυχικοῦ πνεύματος καὶ οὕτω τοῦτο κραδαίνειν καὶ σπᾶν τὸ σῶμα· πάλιν δὲ κατασταθεισῶν τῶν πομφολύγων παύεσθαι τὸ πάθος.[17]

In this passage, Praxagoras is reported to have attributed the epilepsy to phlegmatic humours (φλεγματικοὶ χυμοί) gathering around the thick artery (ἡ παχεῖα ἀρτηρία). According to the physician, psychic pneuma (ψυχικὸν πνεῦμα), which has its origin in the heart as the central organ of a human body, is blocked by these humours in the form of bubbles (πομφόλυγες) from passing into the whole body through the thick artery, and in this way it turns the body into agitation and spasm.

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[16] Nickel (2005), pp.320–322.

[17] Anonymus Parisinus, *De morbis acutis et chroniis* 3, p.18, 11–15 Garofalo (1997) [=Fr.25 Lewis (2017)]. I follow the Greek text of the treatise *On Acute and Chronic Diseases*, edited with commentary by Ivan Garofalo translated into English by Brian Fuchs (Leiden: Brill, 1997).

Nickel admits that Praxagoras and the author of the Hippocratic treatise *On the Sacred Disease* were of the similar opinion about the cause of epilepsy, by explaining that it is caused by the flux of phlegm running into the vessels and thus blocking the flow of pneuma in the body. It does not necessarily follow from this, Nickel insists, that the physician may have taken over components of his physiology and pathology from the Hippocratic author. In fact, Nickel does so with a specific focus on some aspects in Praxagoras' own physiology and pathology, which he thinks differentiate them from physiological and pathological ideas propounded by the Hippocratic author. (1) The physician made a clear distinction between veins and arteries, while there is no such distinction found in the description of the vascular system given by the Hippocratic author. (2) According to the physician, the arteries, as distinct from veins, contribute to his vascular system as passages for psychic pneuma through which voluntary motion (ἡ κατὰ προαίρεσιν κίνησις) is distributed over the body.[18] It is true that the Hippocratic author posited almost the same function of pneuma as a medium for voluntary motion over the body, as indeed he explains that the air flowing into the vessels contributes to the body by distributing both intelligence (φρόνησις) and (voluntary) motion (κίνησις) to its parts.[19] However, Nickel insists, the physician may have had a conception of pneuma as constituent of human soul (ψυχή), as it is indicated by the term of psychic pneuma, which is different from the concept of pneuma given by the Hippocratic author, who referred to it as air drawn into the body from outside through respiration.

I would agree with Nickel to his opinion that Praxagoras posited some of ideas and doctrines, which may characterize his physiology and pathology and differentiate them from those of the author of the Hippocratic treatise *On the Sacred Disease*. But it does not necessarily follow from this, I would insist, that Praxagoras had no connections at all to the Hippocratic author. It would also seem to be possible that the physician may have propounded his own physiological and pathological ideas, which are different from those given by the Hippocratic author, as a critical response to his physiology and pathology. And further, I insist that (2) mentioned above should be reconsidered from a historical point of view, especially because it is doubtful whether we may legitimately attribute the conception of psychic pneuma to Praxagoras, as P. van der Eijk has already pointed out that the terminological distinction of various kinds of pneuma, such as vital and psychic pneuma, is usually assumed to have been initiated by one of the early Alexandrian physicians, Erasistratus of Ceos.[20] This leads us to have an idea of one of the most important aspects of Praxagoras' physiology and pathology, because it turns out that Praxagoras did not have any conception of human soul as the principle of

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[18] On this point, see text to n.43 below.

[19] Hippocrates, *Morb. Sacr.*, ch.7, p.15, 17–20 Jouanna (2003) [ch.10 W. H. S. Jones, *Hippocrates II*, Loeb Classical Library (1923)]. I follow the Greek text of the treatise edited by Jacques Jouanna, *Hippocrate, La maladie sacrée* (Paris: Les Belles Lettres, 2003).

[20] P. van der Eijk (1999), p.320.

our cognitive activities and voluntary motions of the body.

Lewis gives a decisive answer to the question as to the principle of human cognition and voluntary movement of the body in Praxagoras' physiology and pathology, by arguing that the heart (ἡ καρδία) itself is what we may call the mind, as Lewis herself uses this term to denote the principle of our cognitive activities and voluntary motions in his cardiocentric model of a human body.[21] She has come to her answer thorough a meticulous analysis of the details of the accounts of madness (μανία) and phrenitis (φρενῖτις), which are ascribed to Praxagoras by the Anonymous of Paris in the following passages of the treatise *On Acute and Chronic Diseases*.

> Πραξαγόρας τὴν μανίαν γίνεσθαί φησι κατ᾽ οἴδησιν τῆς καρδίας, οὗ περ καὶ τὸ φρονεῖν εἶναι δεδόξακε· μὴ ἐπιγίνεσθαι δὲ αὐτῇ πυρετοὺς διὰ τὸ μηδὲ τὰ ἐκτὸς οἰδήματα ποιεῖν πυρώσεις.[22]

In this passage, Praxagoras is reported to have attributed madness to the swelling (οἴδησις) of the heart, the organ to which the physician has also ascribed intelligence. His account of madness, as reported by the Anonymous of Paris, enables us to suppose that the physician held that intelligence belongs to the heart itself in its normal condition, while madness occurs to it when it is in its abnormal condition. In his account of phrenitis, the physician is more explicit in saying that the natural function of the heart *is* intelligence, as reported by the Anonymous of Paris in the passage below.

> Πραξαγόρας δὲ φλεγμονὴν τῆς καρδίας εἶναί φησι τὴν φρενῖτιν, ἧς καὶ τὸ κατὰ φύσιν ἔργον φρόνησιν οἴεται εἶναι· ὑπὸ δὲ τῆς φλεγμονῆς ταρασσομένην τὴν καρδίαν τοῦδε τοῦ πάθους συστατικὴν γίνεσθαι.[23]

In this passage, Praxagoras is reported to have attributed phrenitis to an inflammation of the heart, of which, he thinks, the natural function (τὸ κατὰ φύσιν ἔργον) is intelligence, and the heart itself brings about this affection when it is disturbed by the inflammation. His account of phrenitis, as reported by the Anonymous of Paris, enables us to suppose that the physician held that the heart is not simply the seat or place in which intelligence is located, but rather the heart itself generates intelligence in its natural condition, while it may cause phrenitis when it is in its unnatural condition.

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[21] Lewis (2017), pp.287–292.

[22] Anonymus Parisinus, *De morbis acutis et chroniis* 18, p.112, 18–20 Garofalo (1997) [=Fr.23 Lewis (2017)].

[23] Anonymus Parisinus, *De morbis acutis et chroniis* 1, p.2, 7–10 Garofalo (1997) [=Fr.22 Lewis (2017)].

What, then, is the role of pneuma in Praxagoras' cardiocentric model of a human body? Given that the heart is not the seat of psychic pneuma as the principle of our cognitive activities and voluntary motions of the body, but it itself may function as such, there is no room for us to regard it as constituent of human soul.[24] Lewis answers this question, by arguing that it may function as the transmitter of the motor impulse from the heart to particular parts of the body and of sensory impressions from particular sense organs to it, because it itself is the principle of our cognitive activities and voluntary motions of the body.

Her arguments concerning Praxagoras' cardiocentric model of a human body, focused on the function of the heart itself as the principle of our cognitive activities and our voluntary motions and its relation to the role of pneuma, as I have summarized above, are very persuasive indeed. It is most significant to note, I would insist, that there is a similar idea found in the physiological and pathological accounts by the author of the Hippocratic treatise *On the Sacred Disease*. I cite below one of the most informative passages from his treatise as evidence indicating that the Hippocratic author, who propounded his own encephalocentric model of a human body with a clear view on the brain as its central organ, seems to have held that the organ itself is identical with the principle of our cognitive activities and voluntary motions of the body, which uses pneuma as a medium for transmitting motor impulse from the central organ to particular parts of the body as well as for transmitting sensory impressions from particular sense organs to it.

> Κατὰ ταῦτα νομίζω τὸν ἐγκέφαλον δύναμιν ἔχειν πλείστην ἐν τῷ ἀνθρώπῳ· οὗτος γὰρ ἡμῖν ἐστι τῶν ἀπὸ τοῦ ἠέρος γινομένων ἑρμηνεύς, ἢν ὑγιαίνων τυγχάνῃ· τὴν δὲ φρόνησιν αὐτῷ ὁ ἀὴρ παρέχεται. Οἱ δ' ὀφθαλμοὶ καὶ τὰ ὦτα καὶ ἡ γλῶσσα καὶ αἱ χεῖρες καὶ οἱ πόδες οἷα ἂν ὁ ἐγκέφαλος γινώσκῃ, τοιαῦτα ὑπηρετέουσι. Γίνεται γὰρ ἐν ἅπαντι τῷ σώματι τῆς φρονήσιος, τέως ἂν μετέχῃ τοῦ ἠέρος. Ἐς δὲ τὴν σύνεσιν ὁ ἐγκέφαλός ἐστιν ὁ διαγγέλλων· ὅταν γὰρ σπάσῃ τὸ πνεῦμα ὥνθρωπος ἐς ἑωυτόν, ἐς τὸν ἐγκέφαλον πρῶτον ἀφικνεῖται καὶ οὕτως ἐς τὸ λοιπὸν σῶμα σκίδναται ὁ ἀὴρ καταλελοιπὼς ἐν τῷ ἐγκεφάλῳ ἑωυτοῦ τὴν ἀκμὴν καὶ ὅ τι ἂν ᾖ φρόνιμόν τε καὶ γνώμην ἔχον. εἰ γὰρ ἐς τὸ σῶμα πρῶτον ἀφικνεῖτο καὶ ὕστερον ἐς τὸν ἐγκέφαλον, ἐν τῇσι σαρξὶ καὶ ἐν τῇσι φλεψὶ καταλελοιπὼς τὴν διάγνωσιν, ἐς τὸν ἐγκέφαλον ἂν ἤει θερμὸς ἐὼν καὶ οὐκ ἀκραιφνής, ἀλλὰ ἐπιμεμιγμένος τῇ ἰκμάδι τῇ ἀπό τε τῶν σαρκῶν καὶ τοῦ αἵματος, ὥστε μηκέτι εἶναι ἀκριβής. [25]

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[24] Lewis argues against the traditional view proposed by Steckerl (1958), p.21, who insists that the physician identified the pneuma in the heart with the soul, by pointing out, quite perceptively, that the earliest appearance of the clearly defined notion of pneuma as soul is in Stoicism. It seems that Chrysippus (c.280–206 BC) was the first to argue that soul is pneuma. See Lewis (2017), pp.292–296.

[25] Hippocrates, *Morb. Sacr.*, ch.16, p.29, 4–p.30, 2 Jouanna (2003) [ch.19 Jones (1923)].

In this passage, the Hippocratic author assigns two important functions to the brain as the central organ of a human body. (1) He defines its role as the interpreter to us of the phenomena originating from the air (ἡμῖν … τῶν ἀπὸ τοῦ ἠέρος γινομένων ἑρμηνεύς). In his definition of the brain, the author offers a psycho-physiological model that will be described as follows. When our sense organs receives stimuli from external objects, the stimuli are transformed there into sensory impressions, which are then transmitted by the flow of pneuma running through the vessels to the brain, whereby they will be formed into our perceptual experiences of seeing or hearing some particular objects. And then, (2) he goes on to define another important function of the brain as the messenger for comprehension (ἐς τὴν σύνεσιν … ὁ διαγγέλλων), by explaining that eyes, ears, tongue, hands, feet act in accordance with the judgment of the brain. These parts or organs will do their function, he argues, when instructions of the comprehension are transmitted from the brain as its messenger by the flow of pneuma through the vessels to each part of the body. When, on the other hand, the flow of pneuma is blocked by the flux of phlegm which runs down from the brain flooded with this humour, there will be bodily abnormalities like paralyses and spasm as well as some kinds of unusual psychic states, such as lack of intelligence, speechlessness, and so on.[26]

There is no doubt, then, that both Praxagoras and the author of the Hippocratic treatise *On the Sacred Disease* shared almost the same opinion that the central organ of a human body itself is the principle of our cognitive activities and voluntary motion of the body, although the physician was standing in the opposition to the Hippocratic author in his identification of its central organ with the heart, not the brain.[27] As another significant aspect of this context, I would draw attention to the fact that neither Praxagoras nor the Hippocratic author does not use the term of soul (ψυχή) to denote the principle of our cognitive activities and voluntary motions of the body.[28] This is a very important point, all the more because the physician may have been acquainted with philosophical and biological works of Aristotle, who has been very well known to have defined the soul exactly as the principle of living things, responsible for our cognitive activities and voluntary motions of the body. These points enables us to suppose, quite legitimately, that the physician may have followed in the footsteps of the Hippocratic author, who was of the opinion that our psychic states and activities as well as our psychic disturbances can be assigned to the central organ of a human body as the

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[26] Hippocrates, *Morb. Sacr.*, ch.7, p.14, 21–p.16, 23 Jouanna (2003) [ch.10 Jones (1923)].

[27] I am reluctant to say that, although Lewis (2017), pp.290–291, admits that the Hippocratic author assigned the function of intelligence and cognition to the brain as the central organ of a human body, which uses pneuma as a medium for transmitting motor impulse from the central organ to particular parts of the body as well as for transmitting sensory impressions from particular sense organs to it, she does not seem to think of it as one of the most important points shared by both Praxagoras and the Hippocratic author.

[28] The author of the Hippocratic treatise *On the Sacred Disease* uses the term of comprehension (ἡ σύνεσις) to denote what we may understand as a psychic faculty which belongs to a human being. See text to n.25 above. There is no evidence, however, that he regarded it as human soul, as being distinct from the seat or place in which it is located as the principle of our cognitive activities and voluntary motions of the body.

principle of psychic faculties, while it is rather identified with human soul in the Aristotelian context of psychology.

Finally, I draw attention to the qualities of pneuma characterized by Praxagoras, who held that it is a substance denser, moister and warmer than external air, after it has entered the human body through respiration by the function of the lungs and has undergone such qualitative changes, when passing through pulmonary vessels, the heart and the arteries.[29] It deserves noting that the physician gives pneuma its qualities which are exactly the opposite of those given to it by the author of the Hippocratic treatise *On the Sacred Disease*. In the passage cited above, the Hippocratic author shows us his view of the essence of pneuma. According to his encephalocentric model of a human body, the air, which a human being draws into itself, reaches the brain first, having left there its quintessence (ἡ ἀκμή) and what is intelligent and contains judgment (ὅ τι ἂν ᾖ φρόνιμόν τε καὶ γνώμην ἔχον). And then, he gives an argument for it in the form of supposition that if the air reached the body first and then the brain, it would leave discernment (ἡ διάγνωσις) in the flesh and the vessels, and then reach the brain, being hot and not pure but mixed with the humid from flesh and blood (θερμὸς ἐὼν καὶ οὐκ ἀκραιφνής, ἀλλὰ ἐπιμεμιγμένος τῇ ἰκμάδι τῇ ἀπό τε τῶν σαρκῶν καὶ τοῦ αἵματος), so that it would be no longer perfect.[30]

We should take it to be reasonable to assume that Praxagoras definitely identified the role of lungs in respiration and it thus encouraged the physician to adopt a cardoiocentric view, following in the footsteps of Lewis, who maintains that the respiratory function of the lungs would have suggested to the physician that *inhaled air cannot enter the brain directly through the nose, but must reach the chest organs first* and, hence, that they hold some supremacy as regards bodily functions (*Italics mine*).[31] If, on the other hand, we can take it to be that her words exactly represent the threads of thought which made the physician to adopt a cardiocentric veiw, we shall then come to a quite legitimate conclusion that Praxagoras may have been familiar with the Hippocratic treatise *On the Sacred Disease*, and that his cardiocentric model of a human body may have been a critical response to his encephalocentric model given by the Hippocratic author.

Praxagoras and Philosophical and Biological Doctrines by Aristotle

It has generally been accepted as a common view by modern scholars that Aristotle was one of the most principal sources for Praxagoras to form his own cardiocentric model of a human body. Lewis herself positively argues that there are several indications pointing to his acquaintance with Aristotle's philosophical and biological works and doctrines, by focusing on (1) the similarity between their anatomical descriptions of vessels and (2) their common belief that the pulse is a natural and constant motion of vessels extending

[29] Galen, *An in arteriis natura sanguis contineatur ?* 2.1–2 [=Fr.18 Lewis (2017)]. See Lewis (2017), pp.296–297.
[30] See text to n.25 above.
[31] Lewis (2017), p.292.

throughout the body, not only in the temples, or only in the immediate vicinity of the heart.[32]

I would share the common view, by drawing specific attention to the following passage of Aristotle's *History of Animals*, Book III.

> Καὶ ἔστιν ἡ μὲν μεγάλη φλέψ ὑμενώδης καὶ δερματώδης, ἡ δ' ἀορτὴ στενοτέρα μὲν ταύτης, σφόδρα δὲ νευρώδης· καὶ ἀποτεινομένη πόρρω πρός τε τὴν κεφαλὴν καὶ πρὸς τὰ κάτω μόρια στενή τε γίνεται καὶ νευρώδης πάμπαν. [33]

In this passage, Aristotle gives us an anatomical description of the structures of two principal vessels originating from the heart as the seat of soul, i.e. (1) the great vessel (ἡ μεγάλη φλέψ) and (2) the Aorta (ἡ ἀορτή) respectively, by explaining that the former is membranous and skin-like, while the Aorta is narrower than it and very neuron-like (νευρώδης), and, as it extends farther towards the head and lower parts of the body, it becomes narrow and entirely neuron-like (νευρώδης πάμπαν). It deserves noting that Aristotle describes the structure of the Aorta as becoming narrow and entirely nerve-like at the head and at the lower parts of the body. His description of it reminds us of the structure of the arteries described by Praxagoras as appearing as a neuron (νεῦρον) at the extremities of the body, as reported by Galen in the following passage of his treatise *On the Doctrines of Hippocrates and Plato*, Book I.

> οὗτος γὰρ ὁ ἀνὴρ (i.e. Πραξαγόρας) ἐπειδὴ μηδὲν ἑώρα νεῦρον ἐκφυόμενον τῆς καρδίας, ἐφιλοτιμεῖτο δὲ πρὸς Ἱπποκράτην καὶ πάντως ἐβούλετο τὸν ἐγκέφαλον ἀφελέσθαι τῆς τῶν νεύρων ἀρχῆς, οὐ σμικρὸν ἀπετόλμησε ψεύσασθαι τὰς ἀρτηρίας φάμενος ἐν τῷ προϊέναι καὶ κατασχίζεσθαι στενὰς γιγνομένας εἰς νεῦρα μεταβάλλειν· τοῦ γὰρ δὴ σώματος αὐτῶν ὑπάρχοντος νευρώδους μὲν ἀλλὰ κοίλου, <καὶ> κατὰ τὴν ἐπὶ πλέον ἐν τῷ ζῴῳ σχίσιν οὕτως γιγνομένων μικρῶν τῶν κοιλοτήτων ὡς ἐπιπίπτειν ἀλλήλοις τοῦς χιτῶνας, ὁπόταν τοῦτο πρῶτον γένηται, νεῦρον ἤδη φαίνεσθαι τὸ ἀγγεῖον. Ἐρασίστρατος μὲν οὖν οὐδὲ ἀντιλο [λο] γίας ἠξίωσε τὸν λόγον ὡς ἀναισχύντως ἀποτετολμημένον. [34]

In this passage, Galen is severely criticizing a cardiocentric model of a human body by Praxagoras, who

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[32] Lewis (2017), p.304.

[33] Aristotle, *Historia Animalium*, III 3, 513b7–11, p.134, 11–15 David Balme (ed.), *Aristotle: Historia Animalium*, Vol.I: Books I–X: Text (Cambridge: Cambridge University Press, 2002).

[34] Galen, *De Placitis Hippocratis et Platonis*, I 6, 18–19, p.82, 1–10 Phillip De Lacy (ed.), Galen *On the Doctrines of Hippocrates and Plato*, Corpus Medicorum Graecorum [CMG] V, 4,1,2 (Berlin: Akademie Verlag, 1984).

is reported to have described the arteries as originating from the heart and, as they proceed and divide, becoming narrow and changing into neura (νεῦρα) at the extremities of the body, with an argument for it that their structure is neuron-like (νευρῶδες) but hollow (κοῖλον).[35] If we believe the report by Galen on the physician's words concerning the arteries in the passage cited above, it would seem be that Praxagoras may have taken over from Aristotle his description of the structure of the Aorta as becoming entirely neuron-like at the head and at the lower parts of the body with a view to give his anatomical description of the structure of the arteries, and used it as an argument for his conception of them as changing into the neura at the extremities of the body.[36]

It should be noted, on the other hand, that there is a crucial difference of opinion about the description of the Aorta given by Aristotle and that of the arteries given by Praxagoras. According to his cardiocentric model of an animal body, Aristotle explains that the neura also have their origin in the heart, by referring to the anatomy of the structure of the Aorta as an argument for it that it is a neuron-like vessel (νευρώδης φλέψ), and its extremities are entirely neuron-like. For Aristotle, however, the nature of the neura (ἡ τῶν νεύρων φύσις) does not constitute a continuous system from the heart as one origin. I cite below the relevant passage from his *History of Animals*, Book III.

> Τὰ δὲ νεῦρα τοῖς ζῴοις ἔχει τόνδε τὸν τρόπον. ἡ μὲν ἀρχὴ καὶ τούτων ἐστὶν ἐκ τῆς καρδίας· καὶ γὰρ ἐν αὐτῇ ἔχει νεῦρα ἡ καρδία ἐν τῇ μεγίστῃ κοιλίᾳ, καὶ ἡ καλουμένη ἀορτὴ νευρώδης ἐστὶ φλέψ, τὰ μὲν τελευταῖα καὶ παντελῶς αὐτῆς· ἄκοιλα γάρ ἐστι, καὶ τάσιν ἔχει τοιαύτην οἵαν περ τὰ νεῦρα, ᾗ τελευτᾷ πρὸς τὰς καμπὰς τῶν ὀστῶν. οὐ μὴν ἀλλ' οὐκ ἔστιν συνεχὴς ἡ τῶν νεύρων φύσις ἀπὸ μιᾶς ἀρχῆς, ὥσπερ αἱ φλέβες.[37]

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[35] The Greek νεῦρον (*pl.* νεῦρα) is the word from which the English 'nerve' is derived. In the history of medicine, it was not until the discovery of the nerves by Herophilus and Erasistatus in early Alexandria that the Greek came to mean the nerve in the exact sense of the word. In the time of Aristotle and Praxagoras, however, the word seems to have generally been used to denote sinews, tendons and ligaments. Galen uses it, somewhat anachronistically, as denoting the nerves to describe Praxagoras' cardiocentric medel of a human body. In this paper, I transliterate the Greek νεῦρον (*pl.* νεῦρα) to refer to it in Aristotle's cardiocentric model of an animal body as well as in Praxagoras' cardiocentric model of a human body.

[36] I would not agree with Lewis (2017), pp.234–236, who argues against those who have interpreted Praxagoras' conception of the arteries as an attempt to connect the vessels to the motor apparatus in the body. According to her interpretation, his description of the arteries as changing into neura is only related to their morphology (i.e. the similarity to neura). This is not the case, I think, because, as far as we follow the logic of his own words cited by Galen in the *PHP* passage above (n.34), we need to take the physician as referring to (1) the morphological aspect of the arteries (τοῦ γὰρ δὴ σώματος αὐτῶν ὑπάρχοντος νευρώδους μὲν ἀλλὰ κοίλου…) as an argument for (2) his physiology of the arteries, which change into neura (τὰς ἀρτηρίας … ἐν τῷ προϊέναι καὶ κατασχίζεσθαι στενὰς γιγνομένας εἰς νεῦρα μεταβάλλειν), and may function as such.

[37] Aristotle, *Historia Animalium*, III 5, 515a27–515b6, pp.139, 18–p.140, 3 Balme (2002).

This is a very important point, because it may lead us to have an idea of Aristotle's cardiocentric model of an animal body that the Aorta and the neura do not constitute the same system originating from the heart as the central organ of an animal body. Therefore, it still remains ambiguous that how it is that the neura can function as its instruments for imparting movements to particular parts of the animal body. It would be reasonable to assume, on the other hand, that Praxagoras may have made a decisive step farther than Aristotle, by giving the conception of the arteries as changing into neura at the extremities of the body, with a view to confirm that the arteries and the nerves constitute the one and same system originating from the heart as the central organ of a human body.

There is another crucial difference of opinion between Aristotle and Praxagoras about the concept of innate pneuma (σύμφυτον πνεῦμα). Aristotle believed that it exists within an animal body from its birth or from its embryonic stages, while there is no evidence that Praxagoras himself may have believed that there is such a substance existing within a human body, as Lewis points out, when she tries to answers the question about the source for pneuma in the physician's cardiocentric model of a human body.[38]

She gives her answer to the question, by arguing that the sole source for it seems to have been external air, which a human being draws into itself through respiration. If this is exactly the case, we shall have another aspect of his cardiocentric model of a human body, which may well be regarded as corresponding with the view on the source for pneuma given by the author of the Hippocratic treatise *On the Sacred Disease.*[39]

Praxagoras and Diocles of Carystus

Diocles was born in the city of Carystus on the island of Euboea, and he was an elder contemporary of Praxagoras. I want to draw specific attention to the historical relationship of Praxagoras to Diocles of Carystus, all the more because modern scholars have generally regarded Praxagoras as being almost dependent on his elder contemporary physician in his physiological and pathological ideas and doctrines. This is not a legitimate valuation on Praxagoras, I would insist, because, I believe, he was a man of the highest originality in the medical field of his time. I hope to have made it clear enough in my recent article on Praxagoras[40] that the physician, far from being almost dependent on Diocles, may have made a decisive step farther than his elder contemporary physician in his physiology and pathology presupposing his own cardoncentric model of a human body.

I am sure that Lewis' monumental work on Praxagoras will be the most reliable sources for us to elucidate the historical relationship of the physician to Diolces. Unfortunately, she is only referring to the

[38] Lewis (2017), p.297. To be more exact, she does not want to dismiss the possibility that the physician might have followed in the footsteps of Aristotle on this point.

[39] See n.25 above.

[40] See text to n.14 above.

possibility on the relation between the two physicians that Praxagoras regarded Diocles as an authoritative rival, or alternatively, as a praiseworthy authority to whom he had recourse while he argued against other authorities.[41] As a matter of fact, the two physicians seem to have differed from each other in their physiological and pathological ideas and doctrines, even though they shared some ideas in common.

I would insist as one of the aspects which may characterize their difference of opinion in physiology that Diocles was a faithful follower in the footsteps of Aristotle, by taking over from him the concept of innate pneuma as the instrument of the heart for imparting movements to particular parts of an animal body, while, as I have already mentioned above, Praxagoras does not seem to have shared it with Aristotle, but rather committed himself to the view on the source for pneuma by the author of the Hippoctaric treatise *On the Sacred Disease*.[42] And further, I draw attention to the pathological account of paralysis (παράλυσις) by Diocles and Praxagoras, as reported by the Anonymous of Paris in the passage below of the Treatise *On Acute and Chronic Diseases*, especially because it may probably give us a key to discern how it is that Praxagoras was related to his elder contemporary physician.

> Πραξαγόρας δὲ καὶ Διοκλῆς ὑπὸ παχέος καὶ ψυχροῦ φλέγματος περὶ τὰς ἀποφύσεις τὰς ἀπὸ καρδίας καὶ τῆς παχείας ἀρτηρίας γινομένην, δι᾽ ὧν περ ἡ κατὰ προαίρεσιν κίνησις ἐπιπέμπεται τῷ σώματι.[43]

In this passage, the Anonymous of Paris couples Praxagoras and Diocles, by reporting that they both attributed paralysis to thick and cold phlegm gathering around the offshoots growing out from the heart and the thick artery (ἡ παχεῖα ἀρτηρία), through which voluntary motion is distributed over the body. His report would make us have an idea that both of them may have been of the same opinion about the cause of paralysis, as though Praxagoras had depended on Diocles concerning the pathological account of it. In fact, it would seem to be more reasonable for us to assume that this account may have belonged to Praxagoras himself rather than to Diocles. There is every reason to believe that Praxagoras was accustomed to using a medical term of the thick artery to denote the Aorta, as confirmed by Rufus of Ephesus around the second half of the first century AD from a relevant passage of his treatise *On the Denomination of the Parts of Man*.[44]

These points may enable us to conclude that Praxagoras may have developed his own physiological and pathological ideas and doctrines presupposing his cardiocentric model of a human body, independently of his elder contemporary physician.

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41 Lewis (2017), p.305.

42 See also my article (n.14 above), p.105.

43 Anonymus Parisinus, *De morbis acutis et chroniis* 21, p.122, 24–p.124, 2 Garofalo (1997) [=Fr.28 Lewis (2017)].

44 Rufus Ephesius, *De nominatione partium hominis* 209, p.163, 6 Daremberg & Ruelle (1879) [=Fr.1 Lewis (2017)].

Praxagoras and Early Alexandrian Physicians

It is well-known that Herophilus of Chalcedon, who has been most valued as having contributed in early Alexandria to the advancement of the medical knowledge of a human body through many of his achievements in human anatomy and physiology, including the discovery of the nerves, was one of the disciples of Praxagoras. So it seems to be one of the most intriguing themes for us to have a definite image of the relation between the physician and his most successful disciple in the Hellenistic period.

What may characterize most Herophilus' human anatomy and physiology, as opposed to those of his teacher, is his encephalocentric model of a human body, according to which the brain, not the heart, is the central organ of a human body as responsible for all psychic functions, including cognition and voluntary movement of the body. The brain as the central organ of a human body interacts with all its parts through the system of nerves. The nerves are divided into two kinds, i.e. (1) sensory nerves (αἰσθητικὰ νεῦρα) and (2) motor nerves (προαιρετικὰ νεῦρα), which the Alexandrian physician defined respectively as being responsible for sense perceptions and for voluntary motions of the body.[45]

Now, a crucial question arises as to what it was indeed that may have encouraged Herphilus to reject his teacher's cardiocentric model of a human body and propound an encephalocentric view of his own in his human anatomy and physiology. Unfortunately, Lewis does not give any decisive answer to this question, by noting only some general points concerning the reception of the physician's doctrines by early Alexandrian physicians. I will give my own answer to the question, with a specific focus on Herophilus' disagreement with Praxagoras on his pathological account of affections of the body, such as tremor, spasm and palpitation, as reported by Galen in the following passage of his treatise *On the Differences of Pulses*, Book IV.[46]

> οὐ σμικρὰ δ' ἀντιλογία περὶ τῶν παθῶν τούτων γέγονεν Ἡροφίλῳ πρὸς τὸν διδάσκαλον Πραξαγόραν, οὐκ ὀρθῶς ἀποφηνάμενον ἀρτηριῶν πάθος εἶναι καὶ παλμὸν καὶ τρόμον καὶ σπασμόν, οὐ γένει διαφέροντα τῆς σφυγμώδους ἐν αὐταῖς κινήσεως, ἀλλὰ μεγέθει. κατὰ φύσιν μὲν γὰρ ἐχόντων ἄνευ πάσης περιστάσεως γίνεσθαι τοὺς σφυγμούς, αὐξηθείσης δὲ τῆς κινήσεως αὐτῶν εἰς τὸ παρὰ φύσιν πρῶτον μὲν σπασμὸν ἀποτελεῖσθαι, δεύτερον δ' ἐπ' αὐτῷ τρόμον, καὶ τρίτον τὸν παλμόν, ἀλλήλων διαφέροντα μεγέθει πάντα ταῦτα τὰ πάθη.[47]

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[45] Rufus Ephesius (?), *De anatomia partium hominis* 71–5, pp.184–185 Daremberg & Ruelle (1879) [Text 81 Von Staden (1989)].

[46] For the discussion below, see my article entitled 'Herophilus of Chalcedon and the Hippocratic tradition in Early Alexandrian Medicine', *Historia Scientiarum: International Journal of the History of Science Society of Japan*, Vol.21 (2), 2011, pp.1–20.

[47] Galen, *De pulsuum differentiis* 4.3, VIII, p.723, Kühn (1821–1833) [Text 150 von Staden (1989) = Fr.6 Lewis (2017)].

In this passage, Galen reports that there was a serious controversy (οὐ σμικρὰ ἀντιλογία) aroused by Herophilus against his teacher Praxagoras about the cause of palpitation (παλμός), tremor (τρόμος) and spasm (σπασμός), which sometimes affect the human body. According to Galen, the crucial point which we may assume that Herophilus made against his teacher is that Praxagoras did not differentiate between pulsating motion (ἡ σφυγμώδης κίνησις) and these affections of the body, arguing that they are caused when the motion of the arteries is increased to an unnatural extent, deviating from their natural condition, when the pulse occurs. Unfortunately, however, Galen's report does not give any more information about Herophilus' own account of the cause of these affections. But we find it in a passage of the treatise entitled *A Synopsis of Pulses*, ascribed with disputed authenticity to Rufus of Ephesus around the second half of the first century AD.

According to Rufus, who reports that Herophilus argued that the pulse is to be assigned only to the arteries and the heart, while the palpitation, spasm and tremor are found to occur in muscles as well as in nerves (γίγνεσθαι γὰρ τὸν σφυγμὸν περὶ μόνας ἀρτηρίας καὶ καρδίαν, τὸν δὲ παλμὸν καὶ τὸν σπασμὸν καὶ τὸν τρόμον περὶ μύας καὶ νεῦρα), the Alexandrian physician drew attention to some of the features specific to the pulse to differentiate it from the three affections of the body, with a focus on the observed facts (1) that the pulse is generated with an animal and disappears with it, (2) that the pulse occurs both when the arteries are filled and when they are emptied, while these others do not, and, most interestingly, (3) that the pulse always attends us involuntarily and exists naturally, while the others are within our power to choose (τὸν μὲν σφυγμὸν ἀπροαιρέτως ἡμῖν πάντοτε παρακολουθεῖν, ἐπεὶ καὶ φυσικῶς ὑπάρχει, ταῦτα δὲ εἶναι καὶ ἐν τῇ ἡμετέᾳ προαιρέσει).[48] His teacher Praxagoras did not distinguish between the pulse and these affections of the body, for he is reported by Galen to have argued that these affections are caused when the motion of the arteries is increased to an unnatural extent, deviating from their natural condition, when the pulse occurs.

We can assume from the reports by Galen and Rufus how Herphilus held that his teacher's cardiocentric model of a human body involves a serious problem. It cannot give an account of clinical cases in which any one of these affections does occur in our hands and feet, so that they may seriously impede our voluntary motions in these parts, while our heart and arteries are observed on the normality of the pulse as an involuntary movement to be functioning well. With a view to give a consistent account of these cases, Herophilus may have supposed it to be a theoretical necessity to regard the system of muscles and nerves as essentially different from that of arteries, which have their origin in the heart. This would seem to explain why the Alexandrian physician placed a great emphasis on the brain as the central organ of a human body, which interacts with its parts through the sensory and motor nerves as responsible for sense perceptions and

[48] Rufus Ephesius (?), *Synopsis de pulsibus* 2, pp.220–221 Daremberg & Ruelle (1879) [Text 149 Von Staden (1989)].

for voluntary motions respectively.

If we rely on the report by Galen on Praxagoras' doctrine of the arteries in the passage of his treatise *On the Doctrines of Hippocrates and Plato*, Book I, where we find a citation of his words from his treatise, it would seem to be reasonable for us to assume that the physician may have held that the endings of the arteries, which originate from the heart as the central organ of a human body, are neura as the motor apparatus, *pace* Lewis, who argues that the physician did not anatomically connect the motor apparatus with the pneuma and the arteries as its conduits.[49] Had the physician not maintained by his own words to the effect that the arteries, which have their origin in the heart as the central organ of a human body, change into neura at its extremities, his disciple Herophilus' arguments against his teacher would have made no sense. And further, Erasistratus would have not so severely criticized Praxagoras' doctrine as a venture done shamelessly done, because, the other Alexandrian physician insisted, it is not even worthy of refutation, as reported by Galen at the end of the *PHP* passage.

Conclusion

I discussed how Praxagoras of Cos was related to the tradition of Hippocratic medicine and philosophical and biological doctrines by Aristotle as well as to medical ideas and doctrines by other ancient physicians, including Diocles of Carystua and early Alexandrian physicians, i.e. Herophilus and Erasistratus, by focusing on the answers to the questions（II）and（III）given by Lewis in her monograph entitled *Praxagoras of Cos on Arteries, Pulse and Pneuma*（2017）.

The first section of my discussion concerned the relation of the physician to the tradition of Hippocratic medicine. I drew attention to the possibility that the Praxagoras may have shared some crucial aspects of human anatomy and physiology with the author of the Hippocratic treatise *On the Sacred Disease*, i.e.（1）the conception of the central organ of a human body as the principle of human cognition and voluntary movement of the body and（2）the source for pneuma as its medium for intelligence and voluntary motions of the body. And I think of these points as evidence for us to conclude that the physician was acquainted with the Hippocratic treatise, and that his cardiocentric model of a human body may be regarded as a critical response to the encephalocentric model of a human body given by the Hippocratic author.

In the second and third sections of my discussion, I drew attention to the possibility that Praxagoras may have developed Aristotle's philosophical and biological model of an animal body into his own cardiocentric model of a human body, by connecting the arteries, which has their origin in the heart as the principle of cognition and voluntary motions of the body, with the motor apparatus at its extremities. And I made it clear that Praxagoras, far from being almost dependent on his elder contemporary Diocles of Carystus, may have

[49] Lewis（2017）, p.306.

been a physician of more originality than him in human anatomy and physiology.

In the final section of my discussion, I drew attention to an aspect of the reception of Praxagoras' doctrine by early Alexandrian physicians, with a specific focus on the relation between the physician and his most successful disciple Herophilus of Chalcedon. I concluded that the Alexandrian physician propounded his own encephalocentrism in human anatomy and physiology, with his anatomical knowledge of nerves, by rejecting his teacher's cardiocentric model of a human body with the conception of the arteries as changing into neura at the extremities of the body, because he found it impossible to explain the mechanism of voluntary motions of the body, as distinct from an involuntary movement of the arteries.

I hope that these conclusions will help us to find a more definite position for the physician in the history of ancient Greek medicine and philosophy, though there still seems to be room for us to correct the details of each of them.

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