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Alcmaeon of Croton - Father of Neuroscience? Brain, Mind and Senses in the Alcmaeon's Study

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Abstract

The aim of this paper is to show Alcmaeon of Croton's medical views as groundbreaking and exceptionally innovative; some of them, at the general level, are still up-to-date. Particular attention was paid to issues related to the human nervous system. Alcmaeon was the first ancient scholar who recognized the human brain as the most important organ in the human body – connected with sensory organs; it was possible because he recognized primarily the construction of the optic nerve. Thus this philosopher initiated the approach to medicine called encephalocentrism. Alcmaeon regarded the brain as a place of intelligent mind, what in antiquity was not a frequent view. He lived in the 6th century BC, so the information about him is remnant. Therefore, reconstruction of his views and activities is extremely difficult. Certainly, this is one of the main reasons why he is not widely known today in the scientific world. But in spite of this, for the sake of his accomplishments, we can call Alcmaeon "the father of neuroscience".

Keywords: Nervous system; Neuroscience; Alcmaeon; Ancient Greece

Introduction

It is very difficult to reconstruct the archaic philosophers' views. But this challenge seems to be necessary if we want to understand the contemporary state of the science. This task is similar to the detective's work. We collect the smallest information hoping that it will bring us closer to the deep recognize of the ancient mentality. The risk is that we can never be sure our discoveries because large of the study so distant times is at most uncertain speculations. Much information on Alcmaeon and Presocratic philosophers come from later authors. These are papers describing the lives of philosophers or gathering their quotes (that kind of papers are called doxographic). The most prominent authors which we quote are Aristotle, Plato, Diogenes Laertius, Theophrastus. Fragments of works by other ancient chroniclers who referred the views of other philosophers were collected in the book by

Hermann Diels *Doxographi Graeci* which is an extremely important collection of fragments from missing books, being cited by other historical authors.

Although the earliest views of the ancient Greeks on the role of heart and brain come from Homer's epics, we will not refer to them in this paper. We shall only point out here that Homer regarded the heart as the chief organ in the human body, what Alcmaeon completely rejected. This does not mean that since the days of Alcmaeon – all the other thinkers have duplicated his view. On the contrary, Aristotle who is considered the greatest naturalist of antiquity ignored this major role of the brain underlying meaning of heart.

Alcmaeon's life

Information on Alcmaeon (ca. 540 -? BC), included in the *Lives and Opinions of Eminent Philosophers* by Diogenes Laertius, is no more than fragmentary [1]. Therefore it is not easy to reconstruct Alcmaeon's biography and to precisely determine the years of his life. Comparing Alcmaeon's age with Anaxagoras (ca. 500-428 BC) and Empedocles (ca. 495-435 BC), we come to the conclusion that they were not contemporaries, and at most the youth of these two philosophers fell on the decline of Alcmaeon's life. Clarke and O'Malley are of the same opinion believing that Alcmaeon wrote his work between 480 and 440 BCE [2].

Croton, which he came from, was a scientific metropolis thanks to excellent medical school, run by Alcmaeon for some time. To this city – Democedes (one of the most famous doctors in Hellas) arrived to practice medicine for five years (c. 530-525 BC) [3]. As G. Celestia points out, in Croton – there were both the Pythagorean school and the medical school [4]. Alcmaeon certainly had connections with both.

It is worth adding that Greek cities in Italy rivaled in the philosophical field with the Greek poleis in Asia Minor. These two extreme parts of the Greek world, they were the first centers developing philosophy. The philosophy practiced in Italy was more mystical, and that of Asia Minor was more natural.

Alcmaeon as a scientist

It should be underlined that pioneered by Alcmaeon empirical trend in Greek philosophy was later developed by Hippocrates (ca. 460-370 BC), Aristotle (ca. 384-322 BC), and Galen (ca. 130-210 CE). Importantly, Alcmaeon probably conducted autopsies on animal organisms [5]. In ancient times, he was considered as a father of anatomy, which is proof of his very knowledgeable [3].

Diogenes Laertius defined Alcmaeon as a teacher, whose leading field was a medicine. However, the writer pointed out that medicine was not the only of his interest. Philosopher from Croton also conducted research in the field of natural philosophy, which was guided by the principle of opposites, expressed in the saying, "Most human things go in pairs", which also Aristotle mentioned in the *Metaphysics* [1,6]. Thus, he rejected the possibility of learning by similarities – just as later Anaxagoras did [7].

Favorinus in the *Variou* stories admitted that Alcmaeon was the first Pythagorean philosopher who wrote a treatise *On nature* which title was given to many various papers in Antiquity [1,8]. Of course, sharing the views of the Pythagoreans did not mean personal contact with Pythagoras (ca. 570-495 BC). According to K. Panegyres, there is no evidence that Alcmaeon has ever met Pythagoras [9].

As it is known, Pythagoras did not leave any writings, and knowledge of his study was mainly due to Neoplatonic thinkers. Aristotle said that Alcmaeon defined the nature of the celestial bodies as eternal, comparing them to the soul – immortal (as opposed to the body) and which is like the sun, in constant motion [10].

The philosopher of Croton believed that a person can rely on a limited analysis of the facts. And in consequence that only gods can know anything about what imperceptible [1]. It is not a negation of religion but limiting its role to which transcends human cognition and what does not transfer directly into the life or health.

According to Alcmaeon, our health depends on the balance of properties, wet and dry, hot and cold, bitter, sweet, and so on, and that any disproportion leads to diseases. In his opinion, domination of even one is harmful to the body. He said that the disease develops, in some cases, the excess heat or cold, with some of the excess food in another fault of the blood, bone or brain. Moreover, we should take into account external factors as water quality, soil, environment and other factors causing disease. Thus, health depends on the equal distribution of proportion [11].

Alcmaeon in his medical studies also dealt with what is now called embryology. He disagreed with the prevailing view in Greek science (next centuries preserved by Aristotle) that the offspring were born solely from the seed of a father, without maternal material.

Censorinus underlined that the subject of the various authors' controversy is whether the offspring are born solely from the semen of the father, as Diogenes, Hippo and Stoic thought, or also from maternal seed material, as – according

to Censorinus – Anaxagoras, Alcmaeon, Parmenides, Empedocles and Epicurus [12]. Thus, Alcmaeon also explained the sex on a proportional basis. In his opinion, the sex of a child was the same as the sex of the parent from which the greater number of semen; moreover, he believed that semen is included in the brain [12]. Alcmaeon considered that equilibrium is a condition of health, what then Empedocles repeated [13]. This equilibrium will be called homeostasis, but it will only be in the twentieth century i.e., 1929, thanks to the Walter Cannon's article *The Organization for Psychological Homeostasis* [14].

Alcmaeon on human brain

As we know, Alcmaeon was the first scientist who thought that the brain plays a guiding role in the body (gr. *hegemonikon*). Exactly in the body, he invested the source of intelligence (unlike Empedocles) [15].

Alcmaeon's theory based on the Pythagorean beliefs that the brain is a source of mind, soul, and logic, and the heart he called the place of formation of feelings [16]. Alcmaeon claimed directly that the chief power in the human body is the brain, what Robert Doty compared to the Copernican or Darwinian breakthrough [17]. It should be underlined, that Alcmaeon certainly had a lot of courage and curiosity in conducting such studies. Therefore, he is similar to Copernicus or Darwin not only thanks to his discoveries but also because of his inner determination and huge obstinately. The Alcmaeon's discovery is even more significant when we realize that for many centuries the view of the dominant role of the brain (encephalocentrism) will compete with the view of the central role of the heart (cardiocentrism). Alcmaeon initiated the right path, which was finally confirmed in modern times.

Alcmaeon's neurological investigation concerns not only an adult brain, but also the fetal period, and then years of human adolescence. According to the philosopher's constations – the head is already full development in utero, which does not mean that the brain gets the fullness of their potential [11]. Finally, in the fourteenth year of life, as he claimed, the brain develops in man "perfect reason", which was also the conviction of Zeno of Kitio and Aristotle [3].

Therefore, Alcmaeon seems to be the precursor of the organic equilibrium theory, which has survived until modern times. As he pointed out, the moderation called substantial balance is the guarantee of human health (Alcmaeon used the term politically inspired – gr. *isonomia* which means equality before the law). He mentioned food as one of the possible causes of disease states; for Hippocratic medicine the question of nutritionist was crucial. Alcmaeon also wrote about the threat posed by the ongoing processes in the organs. It is all about the brain, which, like other organs, it can become a place where the various diseases are generated. Alcmaeon emphasized the importance of external factors from the environment – it seems to be the prototype of environmental medicine.

This is not only one resemblance to Hippocratic study. In fact, Alcmaeon in many ways seems like Hippocrates. As

mentioned, the life of these two philosophers is not well known. Both rather favored a practical philosophy, than speculative. Both attributed the brain functions as a general assumption acquired modern science. Alcmaeon like Hippocrates built a system of ethics, on which survived only mention in the writings of Clement of Alexandria [8]. Analogous to Hippocrates, a philosopher from Croton headed medical school – though his successors did not reach the level of his research [18].

Mind and cognition in Alcmaeon's views

It is impossible to understand how the Greeks discovered the meaning of the mind if we do not answer the question of what the mind is for us. Definitely there is easier to say what in relation to the mind is the brain, rather than the other way around. Briefly speaking, the brain is a substrate of the mind, and thus contributes to the creation of the mind. Going on a more detailed level we would say that the creation of the mind is an essential activity of neural circuits that organize themselves within a larger network and form a temporary activity pattern [19].

It must be remembered that the mind is not the same as consciousness. Awareness – as it is defined by Antonio Damasio – it is a state of mind, which is present knowledge about their own existence and the existence of the environment [19]. Therefore, the lack of mind is equivalent to lack of awareness, but the mind can exist without consciousness. State of mind, which is the awareness that stands out, it is enriched with a feeling of the organism in which the mind works; and that state of mind includes knowledge saying that the existence of it is located [19].

According to Alcmaeon, a sensory cognition is associated with the brain, which is the source of disorders of sensory organs. James Garber called Alcmaeon the father of scientific psychology because of his belief in the biological basis of mental processes of man [20]. This is a bold thesis, but it seems justified. Moreover, John Beare recognized Alcmaeon, Empedocles, Anaxagoras, Democritus (ca. 460-370 BC), Diogenes of Apollonia (5th century BC) and Plato (ca. 428-348 BC), as "psychologists" [21]. He also contends that the idea of separation of metaphysics from the considerations of the human psychic sphere makes them the "fathers of scientific psychology" [21].

Alcmaeon expressly stated that all feelings have connections with the brain, and on the other hand, its trauma causes damage to the sensory organs [9,11]. He suspected that the obstruction of the ducts (gr. poroi) connecting the sensory organs to the brain leads to cognitive impairment [13,22]. This theory resembles the concept of cognition according to Parmenides, who believed that since there are two elements, cognition follows the one who has the advantage.

As Crivellato and Ribatti emphasized – Alcmaeon used the term *ksynienai* which should be translated as "mixed" or "call together" [5]. It expresses the complexity of the process of cognition, in which information is perceived by the senses, which are processed by the brain. On the other hand, Friedrich

Solmsen believes that the term – which most fully reflects the Alcmaeon's belief about the role of the senses in the process of cognition (and their dependence on the brain) – is *dehesthai* or *diadidonai*, meaning "acceptance", "receive" [22].

Alcmaeon claimed that a man is the only creature having the ability to understand (in other words – thinking) and that the other animals receive only sensory impressions, without the possibility to submit their reflection. Theophrastus pointed out that according to Alcmaeon, a perception is not the same what thinking is, as Empedocles assumed [7,11].

Sensory cognition according to Alcmaeon

John Beare considers that Alcmaeon, as Pythagoreans, accepted that the eye flashes escape after contact with the object, and they form an image in the eye, especially in what were supposed to be two active elements: water and fire [21]. The first is a substance inside, acting in the center of the eye, the second of the elements operates outside the body and is an active element [21]. Probably this view stems from the observation of moist consistency of the eyeball, which is considered to be of key importance in receiving stimuli. Today, however, we know that the watery fluid filling the interior of the knob, it has a mechanical function by influencing the walls of hydrostatic pressure which allows maintaining the correct shape of the organ. Furthermore, Alcmaeon supposed that the eyes must contain the fire, which confirms the fact that after they hit "the fire shines" [11]. The presence of this fire (or parts of properties the state fire), he argued formation after injury specific flashes. Perhaps he formulated this assumption based on the illusion of vision sparks ("stars") being the result of trauma the occipital region of the head or sudden changes in body position.

As mentioned, according to Alcmaeon's theory, the sensory organs are connected to the brain, and their patency provides to the correct receiving impressions. It is possible that he observed the connection between the eyes and the brain at autopsy on the animal organisms [21]. Therefore, Alcmaeon probably noticed yet unnamed the optic nerve. Chalcydius reported that Alcmaeon knew in detail the construction of the eye, thanks to an autopsy. Codellas underlines that undertaking such risky (from a cultural and religious point of view) actions made him a real natural scientist who was a pioneer in that kind operation [3]. And although it is more likely that he was carrying out the animal dissections [13], neither does it take away the importance of his accomplishment. Solmsen and Longrigg share this point of view, claiming that Alcmaeon first noticed the optic nerve, so this discovery rightly attributed to him [15,22]. In turn, Crivellato and Ribatti call observed by Alcmaeon connection – one of the *poroi*, that is, channels or vessels which today are rightly identified as nerves [5]. Exactly in those *poroi* James Burnet looks for a starting point for the Empedocles' general theory of knowledge, based on outflows sensory channel called pores [23].

Alcmaeon did not question the concept of reflecting objects (today it can be compared to the camera), but also, he did not connect it directly to the fire (what Empedocles claimed in 5th

century BC). The not entirely clear explanation is found in Theophrastus, who wrote that according to Alcmaeon – we see, because this part of the eye sparkles and is transparent, so that it can reflect the things, and the more that part is clean, the better we see [11].

We can interpret Alcmaeon's concept of the vision as follows: inner fire escapes from the brain to the eyes, and then it performs the function of the detector in the eyes, recognizing objects and reflecting their image. This process can be compared to explore the environment by touch. From the modern science's point of view this explanation is not quite wrong (though trying to clarify the metaphors requires adequate reserve) – as we can see on the example of eyeballs' optokinetic movements and the kinesthesia and somesthesia participating in the creation of an integrated three-dimensional image. Because the image formed on the retina is two-dimensional as painted on a wall (with imperceptible thickness), the third dimension appears only on the path of integration with other senses, especially with the movement.

It is worth recalling Michael S. Gazzaniga, who emphasizes that we see the world in three dimensions, even though our volleyball falls two-dimensional image because we have a specialized visual system, which complements the visual information [24]. So, we need somesthesia and kinesthesia, that the image seemed to us a three-dimensional.

It should be noting that modern methods of correcting the image on the retina using a prosthesis (glasses) are possible because the system responsible for the formation of a sharp image on the retina is subject to the laws of geometrical optics. In this context, the Pythagorean observation of mathematical recognition processes occurring in the human body, it does not seem entirely inappropriate.

The second sensation that Alcmaeon paid attention is hearing. On the issue of receiving sound impressions, he argued that the sound is produced as a result of the vacuum occurring in the ears, in which the air is reflected back coming sounds [10,11]. This view was repeated by later philosophers. Alcmaeon believed that a person hears through the empty space in the ears, where the sound resonates due to the presence of air. Thus, all empty objects produce sound. Sound when entering the vacuum contained in the ears, then travels to the brain, where, according to Alcmaeon, it takes the proper reception [25]. Alcmaeon was probably the first Greek scholar who tried to explain the formation of sounds in relation to the anatomy of the ear [21].

Conclusion

Despite his great accomplishments, Alcmaeon seems to be a forgotten philosopher. His name is rarely found on the pages of textbooks for philosophy. It is a great injustice because probably as the first philosopher he not only studied nature but also wrote a book on it. Despite his views on the key role of the heart prevailing in pre-classic times, Alcmaeon bravely stated that the brain is the center of human mental life. He created the prototype of the theory of homeostasis and interpreted sensory cognition as closely related to the brain.

He also probably performed autopsies on animal corpses, observing the anatomical connections of sensory organs with the brain. Subsequently, his views were largely shared by Anaxagoras, Democritus and especially Hippocrates. We can agree that Alcmaeon's work is similar to the great discoveries of modern times, and his concept of the brain is largely up-to-date.

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