OPINION
Historical Depictions of the Brain: The Origins from the Non-Western World

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Any written work concerning the history of neuroanatomy would be difficult to imagine without acknowledging the pioneering works of Santiago Ramón y Cajal and Camillo Golgi. Cajal improved upon Golgi's staining technique at the turn of the 20th century. He implemented it to deliver the world's first incredibly detailed visualizations of cellular networks of the nervous system. Dating further back to the 15th century, most students of neuroanatomy or of the philosophy of science are familiar with René Decartes' depiction of mind-body dualism which illustrates the passing of visual information to the brain.

These illustrations (i.e., mostly Cajal's) have gone on to significantly influence future research, commonly featured as visual aids in neuroscience presentations. Like most of the historical depictions of the brain, including medieval illustrations of trepanning, these drawings are of western European origin. Little, if any work has attempted to compile or assess historical depictions of the brain from outside of the western world. It is very likely that non-western historical depictions of the brain exist, but are less popularized and have been scarce in the circulating historical literature. Thus, more historical investigations are required to balance these views for a complete historical lens on neuroanatomy.

Since early civilizations existed far across the globe, it is likely that depictions of the nervous system have existed before the aforementioned scholars who make up the mainstream approach to neuroanatomy history education. The present work aims to introduce students and instructors of neuroscience, and particularly neuroanatomy, to other early illustrated neuroanatomical works which may be less popularized. Additionally, this assessment seeks to provide a deeper understanding of the historical emergence of neuroscience and more specifically, neuroanatomy. This article attempts to start this conversation, utilizing what are thought to be the first modern neuroanatomical analyses of some of the cited illustrations from the non-western world.

Key words: neuroanatomy; pedagogy; curriculum; history

INTRODUCTION

Perspectives on the history of neuroanatomy might center the establishment of techniques such as serial sectioning, histology, and its propagation (Hakosalo, 2006). More recently, pedagogical insights suggest that neuroanatomy education may be enhanced through the use of historical vignettes, with an emphasis on the emergence of techniques, to accompany traditional curriculum (Neuwirth et al., 2018; Mitrano, 2019). In line with these student-centered approaches to neuroanatomy education focused on storytelling, it may be pertinent to ask if the field can extend even further back in time to glean insights from extant historical works. Using this frame, the present article seeks to promote extant neuroanatomical illustrations from the non-western world, many of which predate the work of Cajal and Golgi, respectively, spanning the 3rd to the 14th centuries.

Historical written descriptions of the brain may be of interest to neuroscientists. This article, in the style of a narrative review, focuses on extant historical illustrations of brain anatomy due to their pedagogical value in neuroanatomy instruction. Keywords including "neuroanatomy", "drawing", "illustration", and "historical" were used to search for relevant citations from PubMed and Google Scholar. Works citing historical scientific work predating those seminal works of Descartes, Cajal, and Golgi, from outside of North America and western Europe were collated. Only citations that included relevant illustrations as figures are highlighted in the following sections.

"KITAB AL-MANAZIR" BY HASAN IBN AL-HAYTHAM

One of the earliest known illustrations of the nervous system was cited from a manuscript of the *"Kitab al-Manazir"* or, the *"Book of Optics",* that was Hasan Ibn al-Haytham's depiction of the early visual system (Figure 1). al-Haytham AKA Alhazen, (b. 965) the "founder of modern optics" was born in Basra, Iraq but would go on to study philosophy, science, and medicine in Cairo, Egypt until his death in 1040.

His early studies of the human visual system seemed to have been inspired by his work on optics, describing how light enters the eye to initiate visual perception as opposed to Ptolemy and Euclid's idea that eyes themselves emit rays of light (Unal and Elcioglu, 2009; Daneshfard et al., 2016). He concluded that only the rays of light that enter the center of eye would be engaged in vision (Lindberg, 1967; Smith, 1992). Though later a more technical understanding of refraction and the workings of the peripheral retina would be developed, it was an early approximation of the cornea and lens' refraction of light, which positions light at the fovea for high-acuity colour vision. Light which falls away from the fovea can contribute to low-acuity vision, or if refracted far enough, is absorbed by choroidal pigment.

Not only does this important early image correctly depict the optic nerves forming a chiasma, but it leaves figuratively open-ended the downstream targets of the early visual system. The blank canvas of visual processing by the cortex, which al-Haytham had left us, continues to be filled in by modern neuroscientists.

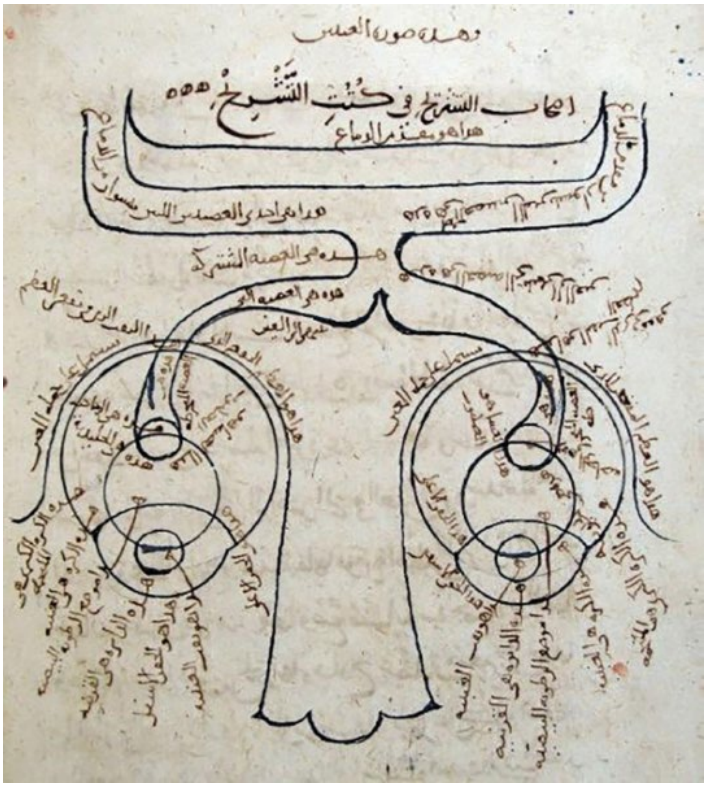

Figure 1. Illustration of the early visual system by Hasan Ibn al-Haytham's "Kitab al-Manazir". This image comes from an 11th century copy of al-Haytham's manuscript held in the Süleymaniye Library in Istanbul, Turkey (MS Fatih 3212, vol. 1, fol. 81b, Süleymaniye Mosque Library, Istanbul). Public domain from Wikimedia Commons. Original source.

IBN SINA

Ibn Sina AKA Avicenna (b. 980) was a Persian physician, philosopher, and scientist who wrote about the brain as the site where sensation interacts with reason. His early experiments on thought (i.e., considered today as cognitive or neuropsychological experiments) sought to determine the meaning of the self and the presence of a soul outside of any physical manifestation that directly aligned with Decartes' work centuries later.

Teachings by Ibn Sina inspired a medieval illumination of his five components or, the ventricles of the brain (Figure 2). Although this illustration was not by Ibn Sina himself and was almost surely completed in the western world; notably, it is included here as a highlight of an eastern philosopher's work. Five components of the brain are depicted as interconnected: common sense, imagination or creativity, judgement, visual imagination or the combination of images, and memory (Eldredge, 1989; Sarrafzadeh et al., 2001). Though this work is likely partly decorative, noted by the inclusion of a small creature drawn above the ear, other qualities reflect a more intentional regard for the biology. Of greater note is the detail given to the anatomical illustration (i.e., orange lines). The presumptive smooth optic nerves are contrasted by the wrinkled lines of the presumptive cortex, perhaps suggesting evidence for the acknowledgement of the convulsions of the cortical sulci and gyri at that time-period.

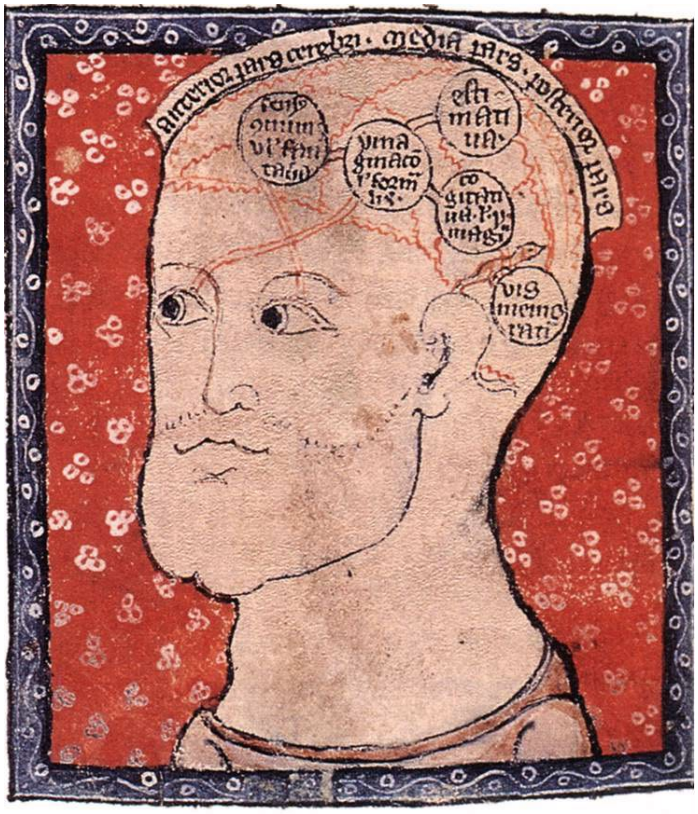

Figure 2. c. 1300 Illumination of Ibn Sina's description of the five ventricles. This image comes from a manuscript at the University Library of Cambridge University. Public domain from Wikimedia Commons.

"TASHRIH-I BADAN-I INSAN" BY MANSUR IBN ILYAS

The anatomical illustrations of the entire human body from *"Tashrih-i badan-i insan"* or *"Anatomy of the Human Body"* by ibn Ilyas (b. 14c) was likely the earliest of its kind that was preserved from the Islamic world and comprised what is possibly the world's first anatomical colour atlas (Smith-Savage, 1996; Khalili et al., 2010). This treatise, often called *"Mansur's Anatomy",* includes a wide array of full-body anatomical illustrations with much attention devoted to the vascular system that has been previously discussed elsewhere (Loukas et al., 2016). In the text of *"Mansur's Anatomy",* the only mention of the accompanying illustrations was given about the diagram of the nervous system (Figure 3) where it is indicated that pairs of nerves are drawn in particular colours (Smith-Savage, 1996).

Many features of this illustration are impressive with respect to today's neuroanatomical standards. Though only 30 vertebral components of the cord are illustrated, a few key choices are apparent, indicating a deep understanding of the spinal nerves at that time-period. Correctly, (albeit simplistically) the spinal nerves which innervate the lower limbs were conceptualized to have exited the spinal cord at the location of the lumbar enlargement, prior to the end of the spinal cord, where correctly, the shorter pudendal nerves innervate the perineum. Another interesting detail is that of the red pair of nerves which exit the cord at the

cervical level, drawn as if approaching the head. Whether this is an acknowledgement of the spinal accessory nerve (cranial nerve XI) remains unclear, but certainly a curiosity.

Of further note is the cylindrical covering of the spinal components, continuous with the depiction of what may be the brain stem and the two hemispheres. One interpretation of this could be an acknowledgement of the meninges which are continuous over the central nervous system. The two hemispheres are drawn very simplistically but are drawn as the target of at least two red nerves, one pair of which arrives from behind the eyes, possibly the optic nerves. Another illustration from the same treatise is described in prior work relaying an in-depth history of anatomy in Persia (Shoja & Tubbs, 2007).

EAST ASIAN DEPICTIONS OF THE BRAIN

Despite the evidence of the popularization of anatomical work from Arab and Persian scholars, early neuroanatomical depictions are found elsewhere, but possibly with less direct attention afforded to the nervous system.

Texts from as early as the 3rd century China commonly featured diagrams of the viscera with bodies in y*ance tu* or, supine and lateral positions (Shumin et al., 2018)**.** These anatomical drawings, intended as tools for early acupuncture practitioners, also show the brain as continuous with the spinal cord, illustrated as enclosed within the spinal column. Similar extant work is found attributed to Hattori Noritada with specific intentions for the education of physicians (Michel-Zaitsu, 2014). Taken together, the aforementioned examples raise a holistic addendum to the mainstream history of the human brain with recorded illustrations from the non-western world.

CONCLUSION

Many ancient depictions of the brain from all over the world have likely been lost, due to war, violence, shifts in power, improper record keeping, rapid changes in written and oral language, historicist and presentist interpretations, etc. Provided herein are depictions of the brain from the non-western world that prominently feature aspects of the central nervous system and can be properly cited back to the collections where they are housed. The historical records pre-date the work of Decartes, Cajal, and Golgi and suggest a different and yet parallel construction of the history of the brain and early neuroanatomy on a more global level. A more accurate and inclusive history between the non-western and the western literature will serve to widen the scope of what is traditionally considered as the historical emergence of an academic practice of neuroanatomy, at least in most common English language texts. This is only one way in which neuroscience education could be served by an equitable lens. Future work is necessary to ensure the endeavour of equity in neuroscience education is successful in all possible areas of study, to the benefit of its students.

This article serves as an attempt to provide a more inclusive timeline of historical depictions which have contributed to the earliest reports of the evolution of medical neuroanatomy but may have been overlooked in neuroscientific education. The intention is that future

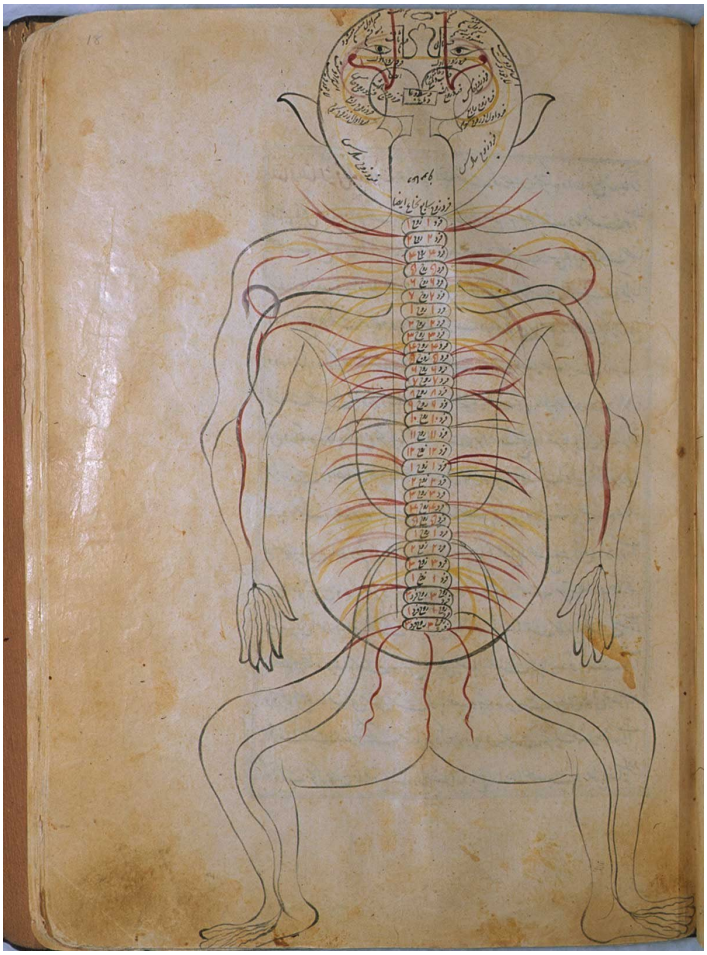

Figure 3. An illustration of the nervous system from ibn Ilyas' *"Tashrih-i badan-i insan"* c. 1390. This illustration is part of a collection at the National Library of Medicine in Bethesda, Maryland, USA. Folio 18a from the National Library of Medicine Historical Anatomies on the Web. Public domain from the National Library of Medicine.

neuroscience students may appreciate and continue to elaborate on the diversity of the history of neuroanatomy. In addition, it is also offered that medical educators, in referencing the history of neuroanatomy, will apprise students of a more expansive curriculum that reframes neuroanatomical investigations to occur much earlier in time and on a more global scale.

POSITIONALITY

The author is a visibly racialized and queer Assistant Professor of Teaching, living as an immigrant settler with Egyptian heritage on Syilx Okanagan territory. His neuroanatomy education has informed his engagement in relevant ethical standards, centering the privilege of learning from the gift of human body donors. He is grateful for these opportunities and aims to pass on these teachings to his own students by expanding the breadth of what neuroanatomy can offer, in part, through a holistic approach to its pedagogy.

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