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The Brain from pharaoh to fMRI
An extraordinary journey through the history of brain science

Since the beginning of the twentieth century the output of neuroscientists doubles every ten years, which might even be a conservative estimation (Wickens, 2015). Such exponential growth of scientific knowledge of the brain asks for appealing and educational stories in order to elucidate the long way mankind went before reaching its present state of knowledge and to point out the fundamental questions that neuroscientists attempt to answer.

In his recent monograph in Dutch, Kees Brunia, professor emeritus of physiological psychology at Tilburg University (The Netherlands), tells that story in a very exciting way. The substantial volume, entitled The brain, from pharaoh to fMRI, tells the fascinating story of neuroscience, from Egypt's antiquity to the present day. It describes how we have come to understand that the function of the brain is inextricably bound up with the human body. Besides being a narrative history, this richly illustrated book develops into an overview of the neuropsychology of motor and goal-oriented behavior, consciousness, interpersonal communication, social behavior and inner experience. In writing, the author is lavish with examples derived from daily life and clinical neurology.

At the outset of his scientific career Brunia studied the influence of the reticular formation in the brain stem at the level of spinal reflexes in the human motor system. All behavior eventually is motor behavior. That goes for positioning and moving of the body itself, as well as for emotion and cognition. Emotion and cognition can only express their meaning through motor behavior, such as body language, gestures and spoken or written words. Even reading would be impossible without eye movements.

Brunia’s narrative on brain and bodily movement does not fail to emphasize how the brain creates a livable world where sensation and movement link up with each other perfectly, where people can be recognized and objects used. The brain organizes the unity of sensation and movement on numerous levels. The prefrontal cortex is involved in the initiation of goal-directed behavior, in communication with the basal ganglia, the cerebellum and several structures in the brain stem. Neural networks in the prefrontal cortex determine the personal value of objects and people, and provide the motives and concentration that guide our perception and actions. However, the unity of sensation and action is also to be recognized on other levels, such as the primary motor and sensory cortex, the spinal reflex and eventually even in single nerve cells. The premotor cortex of macaques contains visuomotor neurons that fire when the animal grabs an object or only looks at it. In the intraparietal cortex visuomotor and visually dominant neurons are found, besides motor neurons. The latter are silent when the animal is just watching, but fire as soon as the animal is going to grab an object. The old maxim: the frontal brain is motor, the posterior brain sensory, is an oversimplification.

That the motor system is needed to move the body may be a truism in these days, but neuroscience has enriched the motor brain with social function. Its start lies in the detection of peculiar neurons in the macaque premotor cortex that not only are active when the animal moves, but also when it watches a companion making the same movement. One neuron imitates the other, mirrors its behavior, the mirror neuron was born. Mirror neurons are another example of cells that combine sensory and motor activity. Their presence has been shown in humans by fMRI and transcranial magnetic stimulation, not only in the primary motor cortex but also in Broca’s area. Understanding the behavior of other people is grounded in a simulation of the observed behavior in our own brain. We activate in our brain the same structures that are active in the brain of the other. That is the beginning of a possible social contact. Emotions are the same story. Whether you experience the emotion yourself, or perceive the emotion in a fellow human being, the same brain structures in the anterior cingulate cortex and the insula ar activated. The mirror function of the brain enables the adoption of the emotional expression seen in the other, coupled with the bodily reactions of the autonomous nervous system. This is the neural basis of empathy, the means of understanding the subjective experience of another individual.

Of course, the modern view has a long history. Preliminary evidence for a sensor-motor loop over the primary cortex was found in 1984, which is 150 years after the discovery (by Marshall Hall in 1833) of the spinal reflex as an 'excito-motory system', where sensory input from the posterior roots of the spinal cord produces a co-ordinated muscle response via the anterior roots. This was preceded by the recognition of Charles Bell around 1810 that the anterior nerves served a motor function and the understanding by François Magendie who identified the sensory function of the posterior spinal cord roots in 1822. Before that, there were only conjectures, such as by the German physician Johann August Unzer, who in 1771 described ascending and descending tracts 'that make contact with the periphery of the body, they go to muscles or come from the senses'. This was written a century after Jan Swammerdam (1637-1680), the skilled Dutch microscopist from the University of Leiden, had drawn the butterfly shape in the severed spinal cord of a frog.

It was the achievement of Santiago Ramón y Cajal (1888) to deduce that sensory nerve cells in the spinal circuitry connected with motor nerve cells in the anterior root, whereupon Sherrington (1906) coined the term synapse, naming the junction he believed to exist between nerve cells. The question of whether synapses passed chemical or electrical messages was solved in 1921 by the discovery of neurotransmitters.

A history of neuroscience cannot get round the fact that the brain is an intricate part of the body. Whereas Galen of Pergamon stated that the blood comes and goes in the body like the tidal current of the sea, it was William Harvey who established (1628) the circulation of the blood ('as it were in a circle') and Marcelo Malpighi who identified the capillaries in the lungs which completed the link between arteries and veins. More than 1500 years after Galen, Harvey not only exorcized the vital spirits out of the heart, but he also made the time ripe for the discovery of that other circle, in the nervous system, between brain and muscles.

As the Redmond O'Hanlon of neuroscience, Kees Brunia takes us to the ancient Egypt to begin our journey into the history of the brain. In 1920, the then director of the Oriental Museum at the University of Chicago, James Henry Breasted, took all efforts to translate a very old Egyptian medical text, known as the Edwin Smyth papyrus. The papyrus describes 48 patients with head and neck injury, along with advice on treatment and surgical intervention. The author (who is presumed to be Imhotep, pharaoh Djoser's main architect and court physician) appears to have some understanding of the brain's function, since he describes the effects of brain lesions, including 'distant' motor disorder and hemiparesis.

Two thousand years went by before Hippocrates (460-370 BC) wrote his enlightened ideas about epilepsy as an illness of the brain instead of a divine punishment for some sin. Five hundred years later Galen of Pergamon entered the stage, to exercise an unchallenged authority in medical matters for more than 1500 years. During that time there would be virtually no further study of the brain and the nervous system. These dark ages came to an end by the arrival of the Flemish anatomist Andreas Vesalius, whose opus magnum De humani corporis fabrica (1543) concerned the structure and function of the human body and thoroughly revised the anatomical work of Galen. Brunia's volume puts the spotlight on the scientific breakthroughs taking place in the seventeenth century, such as the development of microscopes (Van Leeuwenhoek), the works by Thomas Willis and Christopher Wren on the anatomy of the brain, Descartes' first account of the reflex, and Niels Stensen's description of the heart as a muscle. The eighteenth century is the era of the distinction between muscular irritability and nervous sensibility by Albrecht von Haller, a student of Herman Boerhaave (Leiden). The nature of electricity was discovered by Galvani and Volta. The nineteenth century shows a very strong growth of neuroscientific knowledge, which is beginning to explode in the ensuing years.

The continuing development of neuroscience is mainly the consequence of increasingly sophisticated research techniques. Scientific and technological advancement enable a more precise insight into the minute brain structures and functions that give rise to our thoughts and feelings. What we still do not understand, however, is how the physical processes of the brain give rise to subjective experience. Feelings and thoughts are intangible, immaterial functions that cannot exist without the brain. But the most intractable mind-body problem has not been solved after three thousand years of philosophy and brain science. Some scientists think that it should theoretically be possible to find the answer, since it lies inside our heads. Others, Kees Brunia included, are not at all easy about it. In the near future we will be able to understand more about brain function. The horizon of our knowledge will broaden, but the holy grail, that ultimate insight into the relationship between body and mind, lies behind it, beyond any reach. Human intelligence will continue to explore the limits of what we can ever find out about the human mind. Brunia's exciting voyage through the history of brain science is the eloquent witness of this never ending fascination.

[In Dutch: Het brein van farao tot fMRI. Een fenomenale ontdekkingsreis] by Kees Brunia. Delft, The Netherlands: Eburon, 2015. 526 pp., illustrated in colour. € 44.95. ISBN 978-90-5972-936-0 (hardback). **In between a second edition (paperback cover, rest identical) will be published December 23.**