Perspective

Open Access Journal of
Biomedical Science
ISSN: 2690-487X

Where lies the Human Conscience - Addressing a Central Philosophical Question in Neuroscience

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ABSTRACT

Conscience is an aspect of the human mind, which carries the moral judgment, used in our choices between right or wrong, and is also responsible for the control, evaluation and execution of our actions. Through the past centuries, philosophers such as René Descartes have contributed to the idea that it would be centered in the human brain. The evidence brought up by clinical cases, such as Phineas Gage, have confirmed that theory by demonstrating how lesions to the brain parenchyma can affect one's personality and morality.

PERSPECTIVE

Conscience is usually referred to as one aspect of the human mind, which carries the moral judgment, used in our choices between right or wrong, and is also responsible for the control, evaluation and execution of our actions. It needs to be differentiated from consciousness, a different aspect of the central nervous system, which enables the reception, the processing, the integration and the storage of information to create our own perception of the external world and of our body [1]. As opposed to the strict human capability to present and develop conscience, consciousness could be seen as ubiquitously spread in different degrees on animals [2]. Some of the oldest philosophical and scientific inquiries may be those related to conscience and where it would be located in the brain. In this essay, we will summarize possible answers for this question.

René Descartes was a pioneer in the assumption that there was a *situs* for rational thought in the human brain, although he misplaced it on the pineal gland. This proposition came with a dichotomised aspect, as a manner to convey his metaphysical and neurophysiological perceptions in his theory, conceiving two different entities (*Res extensa* and *Res cogitans*) responsible for all our thoughts through a soul-body interaction. Descartes' theory was broadly criticized on its neuroanatomical, metaphysical and theological fundamentals, however its originality of conceiving a dualistic theory in the man-machine influenced neuroscientists and philosophers from the following centuries [3].

In 1848, an accidental brain injury and its consequences in the patient's behavior would change the previous ideas scientists had from localizing the rational thought in the brain. Phineas Gage, a north American railway foreman, used to be a well-tempered, shrewd businessman, obstinate in concluding all his plans of action. After having a dynamite tamping iron transfecting his brain, through his left cheek to his sagittal suture on his frontal bones, he turned into a "fitful, irreverent, indulging at times in the grossest profanity" according to Dr. John Martin Harlow, his physician after the accident. Thirteen years later, Phineas Gage would be deceased, after presenting status epilepticus as a consequence of his brain lesion. He would be buried with the tamping iron which changed his life and immortalized him in neuroscience history. His brain would never be recovered for autopsy evaluation, the only remaining evidence is his skull [4].

By that time, some theories for the origin of his behavioral changes were formulated. One of the most coherent theories was accredited to the British physiologist David Ferrier. In 1878, right after Wernicke's and Broca's discoveries, he postulated that the lesion didn't damage the motor or language centers, it did

Quick Response Code:

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Received: August 20, 2022 **Published:** September 07, 2022

How to cite this article: Júnia VS. Where lies the Human Conscience - Addressing a Central Philosophical Question in Neuroscience. 2022- 4(5) OAJBS.ID.000484. **DOI:** 10.38125/OAJBS.000484

indeed injure his left prefrontal cortex, producing the remarkable behavioral deviations, furtherly described by Dr. Ferrier as "mental degradation". However, the damaged area related to his personality alterations could not be precisely determined to endorse any theory, leaving a puzzle to be solved by the next generation of scientists with more powerful tools [4].

Only 133 years later, Phineas Gage's puzzle would be finally solved. Using a Talairach stereotaxic model of Gage's Skull, Damasio et al. [5] reconstructed a three-dimensional, computerized tomography skull and deformed it accordingly to the possible trajectory of the tamping iron and the neurological sequels described by Dr. Harlow. Through a detailed analysis of twelve different trajectories, they concluded that only five were coherent with the patient's neurological deficits. After comparing the trajectories with a collection of normal brains, one was chosen as the most probable trajectory, which made them conclude that the Broca's area and motor cortices were spared, and that the ventromedial regions of both frontal lobes were injured, while sparing the dorsolateral region [5].

More recently, using diffusion weighted (DWI) and magnetic resonance imaging (MRI) data from one hundred and ten right-handed subjects, aged 25-36, the most likely connectivity defects presented by Phineas Gage were revealed. In this study, they estimated the loss of white matter volume in approximately 11%, comprising structures as the uncinate fasciculus, cingulum bundle and superior longitudinal fasciculus, which disrupted central hub structures in the left frontal midline, temporal pole and limbic system. Moreover, the lesion also affected regional network hubs also connected to other brain areas, generating secondary effects on the hemispheric interconnections, centrality and reduction of node's degree connectedness [6].

In summary, the total loss of white matter and gray matter could explain Gage's personality alterations and executive functions deficits as a matter of network topological changes, which would disturb left basal forebrain hubs and its connections within the right hemisphere, and also damage the circuits related to episodic memory encoding and emotion's processing. Furthermore, they also concluded that the right hemisphere was possibly not affected by the tamping iron, thus the impairment resulting from his lesion would be increased by the disconnection and damage of important networks in his dominant frontal lobe [6].

Phineas Gage's case is an important representation of the essential role of determinate brain regions in social behavior and moral cognition. In the last century, many studies have been conducted to clarify the function of different regions in the formation of human conscience. The advent of functional MRI was a fundamental milestone for behavioral and cognitive evaluations, expanding our previous knowledge in the brain regions related to moral judgement.

Different methodologies have been applied to enhance neuronal activity in conscience related areas, like exposing normal individuals to visual stimuli, depicting social interactions resulting in personal harm or personal assistance, and asking them to think about the "motive" or "outcome" while in the scanner [7]. Another example of methodology is to let normal individuals play a "Cheat" card game with a computer, having the free choice of lying or telling the truth as the computer wouldn't know the participant's card, while in the scanner [8].

With respect to the moral cognition and behavior in patients affected by antisocial personality disorder, different clinical sources can be used to evaluate the brain centers related to moral judgement. One can be delineated by clinic-anatomical evaluations of previously normal individuals who presented persistent antisocial behavior after a brain lesion. Another possible experimental design can be outlined by the analysis of morphological and functional abnormalities in patients with antisocial behavior and poor social adjustment since childhood and adolescence [9].

Through the last decade, different brain regions have been implicated in human moral cognition, mostly in the neocortex, as the frontopolar cortex, medial and lateral ventral prefrontal cortices, right anterior dorsolateral prefrontal cortex, anterior temporal lobes, and superior temporal sulcus region, but also subcortical structures as the amygdala, the hypothalamus, the basal forebrain, the basal ganglia, and the midbrain [9]. The variety of systems involved in moral cognition made some researchers propose a valid answer for "Where in the brain is morality?" that it is "everywhere". However, when considering that many brain regions are not completely task/ domain-specific, should we really talk about moral cognition as a specialized function of the brain when there is no evidence of morality specific networks? Further research may clarify these inquiries [10].

Based on current evidence from the scientific literature, we can conclude that there is not a singular region responsible for human moral cognition, but different network between association cortices in the frontal and temporal lobe and structures from the limbic system, basal ganglia and brainstem, which interact to produce our moral reasoning and social behavior. Damages to these structures and the white matter tracts which connect them may culminate with behavioral and personality alterations as observed in the case of Phineas Gage.

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