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Network analysis, functional craniology, and the evolution of the human brain

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Craniocerebral morphology is influenced by constraints due to the spatial arrangement of its anatomical components [1]. Network theory can be applied in this context to perform analyses regarding the spatial arrangement of the human brain and skull, a methodology known as anatomical network analysis [2]. This approach can be used to reveal the basic architecture of the human head, which can influence or channel its ontogeny and phylogeny.

We generated a network model of the whole brain, based on its traditional macroanatomical division, and of the skull, based on its bone components at birth [3-4]. The model of the human head designed here consists of a set of 133 brain and skull elements, and 550 physical interactions.

Locally, the ethmoid and the body of the sphenoid bone are cranial elements with very high topological complexity, while the parahippocampal gyrus and the anterior lobe of the cerebellum are the brain elements with the highest spatial burden. This complexity, associated with geometric limitations due to spatial co-dependencies among craniocerebral elements, signals morphological significance and is likely to constrain regions' evolutionary plasticity [2-3,5]. Many of the craniocerebral elements with the highest topological load in the present anatomical network model are positioned in the head's inferior-medial regions, a result that is in agreement with previous studies [2-3,5]. Globally, the network model shows a clear topological compartmentalization of regions. Bilateral regions such as the frontal lobes are separated in their left and right sides. Isolated regions such as the viscerocranium or the cerebellum form separated and integrated topological blocks. This compartmentalization, or modularity, is interesting because it highlights groups of elements that undergo morphological evolution in a concerted way.

These results should be considered properly in ontogenetic and phylogenetic studies of morphological diversity in the human brain and skull.

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