ION BEAM TECHNIQUES AND NEUROSCIENCE: WHAT IS NEXT?

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Particle accelerator based techniques, including PIXE and STIM, have been used to address biological questions. On the other hand, cognitive neuroscience research has used high- resolution techniques to understand the neural mechanism behind cognitive processes. It is well established that humans are among the species with higher mental capacities, such as mind theory, self-transcendence, and spirituality. The human brain is considered the most complex natural system in structural and functional terms. We have tried to define with precision the brain cytoarchitecture, however histological techniques traditionally used for this purpose have some limitations. In principle, none of them provides the unambiguous and non-subjective definition of the edges of the studied structures. The design of different brain structures commonly done by the Nissl technique has the disadvantage that the intensity of the staining depends on the level of protein synthesis of each cell. Because of this, there is an inherent degree of subjectivity when the researcher uses it to make the definitions of the edges of the studied structures. Our goal was to analyze the brain structure that makes us humans, the neocortex. The neocortex has a cytoarchitecture composed of a *continuum* of six cellular layers, some with varied features and/or subdivisions that serve to characterize adjacent areas along different lobes. Brain samples were obtained from two males aged 51 and 83 years who died of non-violent causes and with no previous neurological or psychiatric diseases. Tissue blocks were fixed by immersion in 10% non-buffered formaldehyde and stored at room temperature until experimental processing. Samples were coronally sectioned into 40 μm thick slices using a cryostat, with the cutting chamber at -15°C, prior to being dehydrated using a freeze-drier. The elemental concentrations of gray matter (GM) and white matter (WM) obtained by PIXE were compared under the same sample preparation and acquisition data conditions. The concentrations of Mg, S, Ca, Fe, Cu and Zn were higher in the GM when compared to the results obtained from the adjacent WM ($p < 0.05$). From these elements, the GM layers II and V showed higher values of Zn. STIM results from the cerebral cortex revealed different areal densities for the human cerebral cortex sampled: WM denser than GM, which might be related to the higher amount and packaging pattern of the myelinated axons in the WM. In addition, detailed STIM scans were performed on the cortical GM, looking for the possibility of distinction of the six cellular layers based on their areal density characteristics. Our data showed an areal density that decreases from layer I towards layer II. This pattern reduced even more from the middle of layer III towards layer IV. The areal density increases in layer V, presenting a similar level as observed in layers II and III, and a higher value in layer VI. These results presented potential new approaches that could add to the study of human neocortical layers with high precision data from ion beam techniques.

REFERENCES

[1] PALOMERO-GALLAGHER, N., ZILLES, K. Cortical layers: Cyto-, myelo-, receptor- and synaptic architecture in human cortical areas, Neuroimage (2017) 30682–30691.

[2] DEFELIPE, J. The evolution of the brain, the human nature of cortical circuits, and intellectual creativity. Front Neuroanat (2011) 5(29) 1-17.

[3] GAHR, M. How should brain nuclei be delineated? consequences for developmental mechanisms and for correlations of area size, neuron numbers and functions of brain nuclei. Trends Neurosci (1997) 20, 58–62.