

Brain of the African elephant is three time larger than human brain. Why then elephants do not have better cognitive abilities than ours? Since human brain is obviously not the largest on Earth, our superior cognitive abilities cannot be accounted for by something as simple to measure as brain size, volume or mass. Yet, virtually all major hypotheses explaining the evolution of cognitive abilities use brain size as its proxy. They do so, because brain's structures do not fossilize, leaving brain volume/size as the only trait providing insight into evolutionary changes of cognitive capacities. Things get even more speculative when one considers energetic costs of having bigger or more complex brain by our ancestors. We know that they were not trivial: while reading this text, energy expenditures of your brain account for roughly one quarter of calories burnt by your body.

Although we cannot recreate our evolution, we can design experiments emulating their mechanisms, including those linking brain complexity and energy expenditures. The proposed project employs such approach through a set of cognitive tests along with neurophysiological and histological analyses of an animal model-- lines of laboratory mice divergently selected for basal metabolic rate (BMR), reflecting metabolic costs of maintenance of the brain, as well as the gut fueling brain's function. Apart from the between-line differentiation of metabolic rates, those mouse lines also differ with respect to cognitive abilities, which makes them exceptionally suitable for studies on the rise of associations between those traits. Interestingly, pilot analyses carried out in the course of preparation of this proposal also showed that mice with high BMR have stronger long-term potentiation of synaptic transmission associated with the capacity for storing and processing information. Yet, those mice did not have bigger brains than their 'dummier' counterparts. Obviously, their brains are more capable not because they are bigger, but because they are more complex. This finding provides foundation for verification of a hypothesis that the brain plasticity may incur metabolic costs reflected in BMR, which is not necessarily reflected in brain size.

Here I propose to test the above hypothesis by studying histological and neurophysiological underpinnings of the observed between-line variation of BMR, cognitive abilities and synaptic transmission in mouse lines, whose diversification mimics stages of their evolution not preserved in the fossils. I am going to use in vitro staining of brain slices to analyze size and density of neurons and glial cells and analyze morphological structure and dynamics of the synaptic connectivity in the brain cortex by means microscopy techniques allowing to visualize dendritic spines of neurons. The imaging will be performed on the mice of each line before and after battery of cognitive tests in, which are designed to elicit rearrangement of their brains' structures. The proposed research will therefore give us an insight into possible mechanisms of the rise of processing power of the brain, which must have had, at least to some extent, evolved independently from the brain size, but at the expense of higher rate of metabolism.