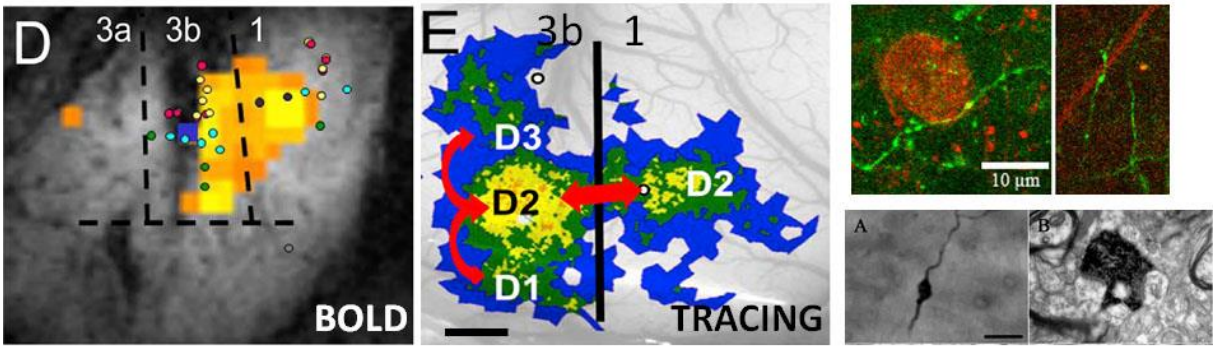
Major topics

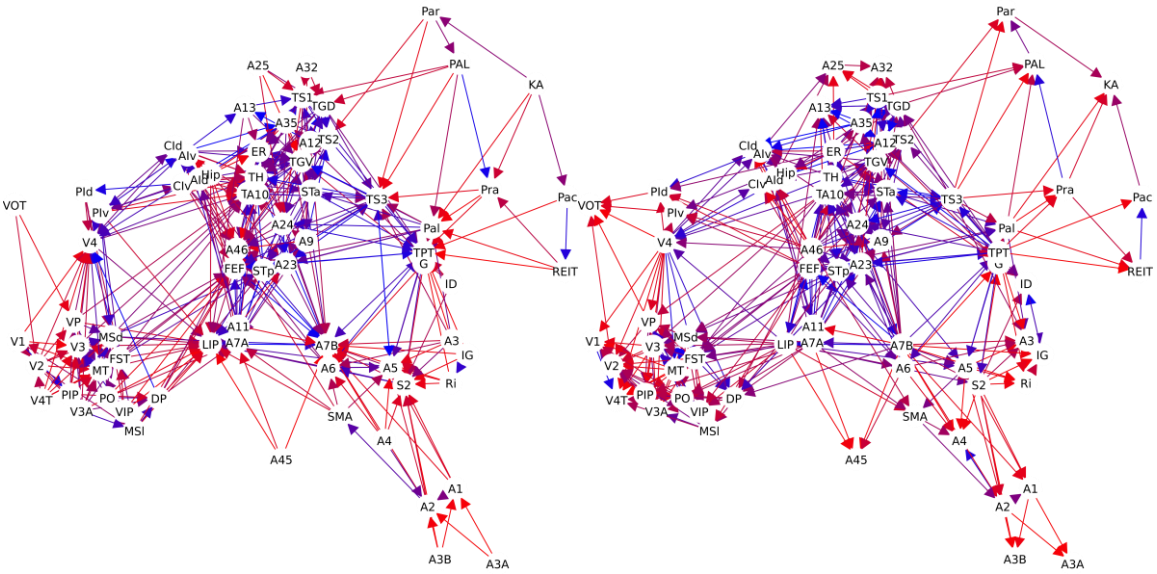
Connectional organization of the primate sensorimotor cortex



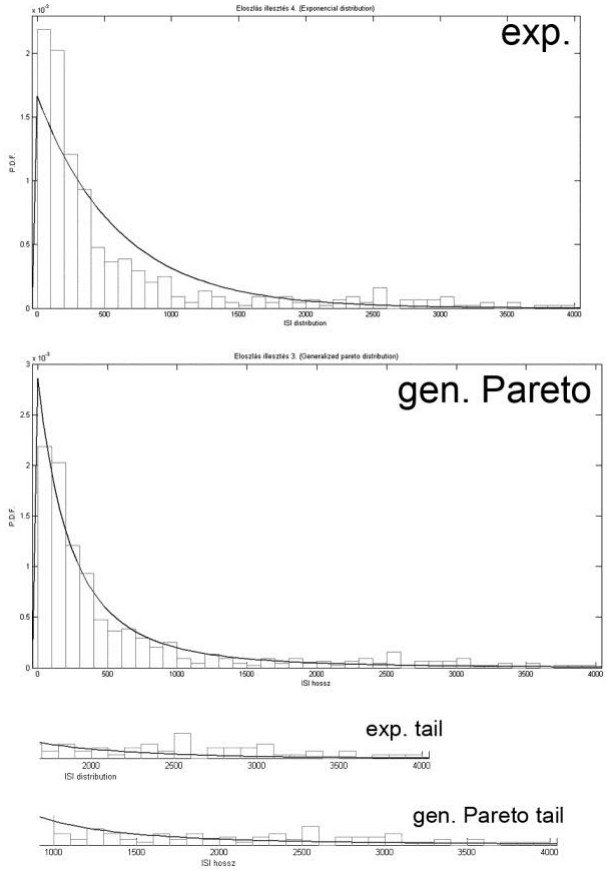
Left: Matching patterns of anatomical connectivity and BOLD signal correlation in the primate somatosensory cortex at the sub-millimeter scale. Scale bar: 1 mm applied for both figures.
Neuron. 2013, 78(6):1116-26. Right: Synaptic organization of somatosensory cortical connections shown on confocal, light and electron microscopic images.

We study the neuronal connectivity of functionally identified modules of the primate sensorimotor cortex. In this project we use neuroanatomical tracing aided by optical imaging and electrophysiological mapping. The function of such somatosensory and motor cortical modular circuitry is studied by examining the synaptic organization of inhibitory and excitatory connections by way of confocal, and electron microscopy in addition to electrophysiology. This project also aimed at understanding the neural mechanisms of tactile functions and fine finger movements, which, in the future, can help developing bionic devices including prosthetics to disabled persons.

Systems neuroscience approach to cortical organization



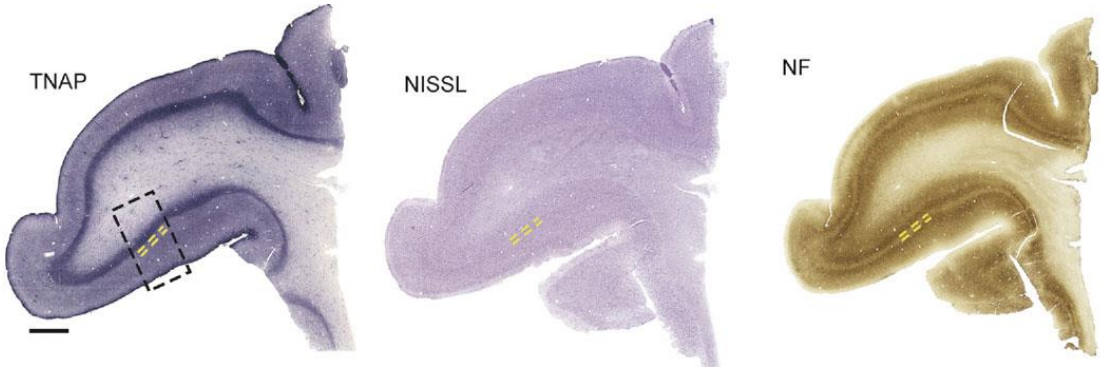
Convergence degree (CD) characterizes the signal flow properties of the cortical areas. The same cortical network with convergent (right) and divergent (left) connections. Color codes CD strength. *Proc Biol Sci. 2008 Oct 22;275(1649):2403-10., Journal of Statistical Mechanics: theory and experiment, P06001, 2011., Acta Biol Hung. 2012;63 Suppl 1:38-53.*



Exponential models do not correctly describe the behavior of cortical neurons as shown by fitting probability density functions to the interspike interval distribution recorded from behaving monkeys. *SISY 2008. Subotica, Serbia. DOI: 10.1109/SISY.2008.4664907., DOGS 2012, Kovacica, Serbia.*

We also apply graph theory to model cortical interactions and signal flow. At the long term we also aim to understand the dynamics of such model network by including the results of our ongoing studies on the analysis of neuronal behavior in alert, behaving monkeys. We approach neuronal behavior by analyzing inter spike interval (ISI) distributions using probability theory. The goal of these analyses is to find generative mechanisms, which can reproduce the behavior of neurons embedded into the neuronal network of the cerebral cortex.

The function of tissue non-specific alkaline phosphatese (TNAP) in the brain



Layer specific activity of TNAP in the human cerebral cortex. *Neuroscience. 2011. 172:406-18.*

We also study how tissue non-specific alkaline phosphatese (TNAP) modulates cortical functioning. TNAP is a ubiquitous ectoenzyme with wide substrate specificity, which exhibits highly specific laminar localization in the cerebral cortex with a unique pattern in the human. Cleaving phosphate groups this enzyme can potentially regulate different neurotransmitter systems depended on the so called B6-enzymes in addition to purinergic transmission. Given the localization and enzymatic functions we assume that TNAP is a key player in balancing cortical excitation and inhibition. However, the neural role of TNAP is largely unexplored. Patients of hypophosphatasia, resulted by mutation of the gene encoding TNAP, develop severe epileptic seizures. We combine enzymhistochemitry, immunohistochemistry both at light and electron microscopic levels, confocal microscopy, molecular biology and electrophysiology to understand the role of this enzyme in regulating the function of circuitries of the cerebral cortex under normal and diseased conditions. In this project, we also use the retina as a well explored and relatively simple model system of neural circuitries.