Human brain dynamics are shaped by rare long-range connections over and above cortical geometry | Jakub Vohryzek

A fundamental topological principle is that the container always shapes the content. In neuroscience, this translates into how the brain anatomy shapes brain dynamics. From neuroanatomy, the topology of the mammalian brain can be approximated by local connectivity, accurately described by an exponential distance rule (EDR). The compact, folded geometry of the cortex is shaped by this local connectivity and the geometric harmonic modes can reconstruct much of the functional dynamics. However, this omits the fundamental role of the rare long-range cortical connections, crucial for improving information processing in the mammalian brain, but not captured by local cortical folding and geometry. In this talk, we show the essential contribution of harmonic modes combining rare long-range connections with EDR (EDR+LR) in describing functional dynamics (specifically long-range functional connectivity and task-evoked brain activity) compared to geometry and EDR representations. Importantly, the orchestration of task dynamics is carried out by a more efficient manifold made up of a low number of fundamental EDR+LR modes. In summary, these results unify the different anatomical constraints by showing the importance of rare long-range connectivity together with EDR in capturing the complexity of functional brain activity.