# INFORMATION, SPACE AND STRUCTURE IN THE HUMAN BRAIN RESTING STATE

J. Goñi[*1], A. Kolchinsky[*2,3], M. Van den Heuvel[4], A. Griffa[5], L. Rocha[2,3], O. Sporns[†1]

[*] Both authors equally contributed.
[†] Correspondence: osporns@indiana.edu
(1) Dept of Psych. & Brain Sciences, Indiana University, Bloomington, IN
(2) School of Informatics & Computing, Indiana University, Bloomington, IN
(3) Instituto Gulbenkian de Ciência, Oeiras, Portugal
(4) Department of Psychiatry, Rudolf Magnus Institute of Neuroscience, University Medical Center Utrecht, The Netherlands
(5) Signal Processing Laboratory 5, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

During resting state, ongoing interactions among brain regions give rise to complex activity patterns across space and time. Novel magnetic resonance imaging (MRI) techniques reveal not only these functional brain dynamics, but also the underlying structural organization over which the dynamics take place. This allows us to investigate the relationship between brain structure and dynamics, a question of central neuroscientific interest.
We approach this relationship from the point of view of complex systems science, which has proposed fundamental connections between complexity, prediction, and scaling. Complexity relates to the amount of shared information (i.e. predictability) between different spatial or temporal components of a system, and how this information changes as regions are considered on different spatial scales. In a neural context, predictability reflects the integration of information across distributed neural regions, and permits to assess whether structure constrains the way information is integrated.
For this, we characterize the information shared between each region and its neighborhoods, at multiple resolutions and defined over three different structural networks, representing 1) the number of fibers, 2) average fiber length and 3) Euclidean distance between regions. We also contrast this to random (lower bound reference) and optimal (upper bound reference) connectivity patterns. Our approach allows us to obtain a global map of resting state information scaling at the cortical surface. Furthermore, graph-theoretical measures of network nodes (such as centrality descriptors) are compared with their predictability descriptors. This theoretical treatment is applied to two different MRI datasets collected at different institutions in order to evaluate the reproducibility of the results.