Title:

Matching structure to function in multi-scale brain networks: from basic concepts to clinics

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Summary:

Modern neuroimaging provides robust pipelines for obtaining brain networks at the mesoscale. Different imaging modalities provide different connectome classes, e.g., diffusion images provide structural connectivity (SC) and functional images provide functional connectivity (FC). Although brain modules in multiscale scenarios haven been studied for most than a decade, how the relation between structure and function preserves along several scales is not yet well understood. In my first lecture, I will review the brain hierarchical atlas [1], a brain partition that satisfies four conditions simultaneously: 1. It has high modularity in FC, 2. It has high modularity in SC, 3. The functional modules overlap with the structural ones, 4. It has a multiscale hierarchical organization, with different organization levels that go from one region of interest (the entire brain) to 2514 (approximately one region contains about 30 voxels of size 3*3*3mm^3). I will also discuss alternative strategies to integrate FC and SC matrices with a multiscale approach [2]. In my second lecture, I will review recent results where the multiscale nature of the brain hierarchical atlas can be successfully used for studying pathologies, and in particular, aging [3].

For the practical afternoon session, I have prepared two datasets:

D1. Multiscale FC and SC matrices from subjects with age ranging between 10 and 80 years old.
D2. Multiscale FC matrices in Autism syndrome (ABIDE).

I will also provide generic Matlab code to obtain multiscale SC and FC matrices of size M*M, with M varying from 1 (entire brain) to 2514 (high-spatial resolution).

Possible strategies to analyze these datasets are:

S1. Supervised classification using multiscale network features, eg., prediciting autism vs healthy control
S2. Multilayer community detection methods to integrate SC and FC
S3. Renormalization-kind of approaches for multi-scale SC and FC scenarios
S4. Modeling generic dynamics on top of multiscale SC matrices, using multiscale FC as ground-truth connectivity matrices to tune model parameters

References:

[1] Diez I, Bonifazi P, Escudero I, Mateos B, Muñoz MA, Stramaglia S and Cortes JM. A novel brain partition highlights the modular skeleton shared by structure and function. Sci Rep. 2015 Jun 3;5:10532. doi: 10.1038/srep10532. http://jesuscortes.info/jesusweb/publications/DBEMMSC_scirep2015.pdf

[2] http://jesuscortes.info/jesusweb/publications/OHBM_jesus.pdf

[3] Bonifazi P, Erramuzpe A, Diez I, Gabilondo I, Boisgontier MP, Pauwels L, Stramaglia S, Swinnen SP and Cortes JM. Structure-function multi-scale connectomics reveals a major role of the fronto-striato-thalamic circuit in brain aging. Hum Brain Mapp. 2018 Dec;39(12):4663-4677. doi: 10.1002/hbm.24312. http://jesuscortes.info/jesusweb/publications/Betal_HBM2018.pdf