Modular organization of functional connectivity in schizophrenia patients beyond the resolution limit

Cécile Bordier[1],Carlo Nicolini[1,2], Angelo Bifone[1]

[1]**Center for Neuroscience and Cognitive Systems, Istituto Italiano di Tecnologia, Rovereto (Italy).** [2] **University of Verona, Verona(Italy)**

cecile.bordier@iit.it

Goal

Abnormal patterns of brain functional connectivity have been observed in a number of neuropsyhiatric conditions, including schizophrenia (SZ). The effects of these alterations in the modular organization of brain connectivity networks can be investigated using a graph representation of resting state fMRI data and analytical methods derived from graph theory [1].

Problem/Solution

Problem:

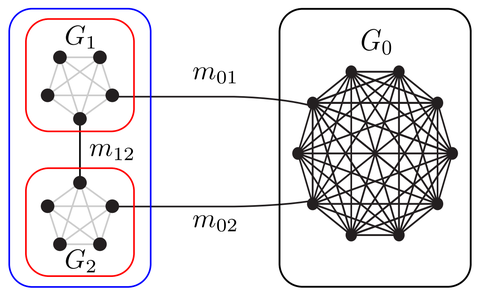
Recently, it has been shown that clustering methods based on optimization of a global function suffer from a resolution limit [4], as they are unable to resolve modules that are smaller than a scale determined by the size of the entire network.

Solution:

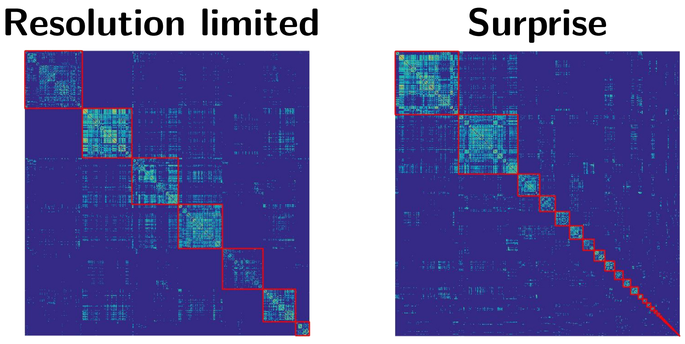
Surprise, a conceptually different fitness function grounded in probability theory, behaves like a resolution-limit-free function.

Maximization of Surprise, based on an algorithm dubbed FAGSO, revealed a heterogeneous distribution of modules within brain resting state [5, 6].

Brain connectivity network comprises heterogeneous distributed modules.



Resolution limited **Surprise**



Material

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Resting state fMRI data from the Center for Biomedical Research Excellence (COINS: `http://coins.mrn.org/dx`):

- 78 schizophrenia (strict) patient
- 91 healthy control subjects

Connectivity matrix:

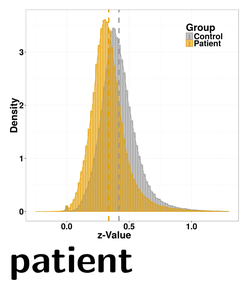
- Brain parcellation of 638 regions [3];
- Edge weights define as inter-regional Pearson correlation coefficients;
- Sparsification of the network by percolation analysis;

Community detection method: Surprise

Results

General Information

Connectivity matrix distribution difference t-test p$< 10^{-16}$



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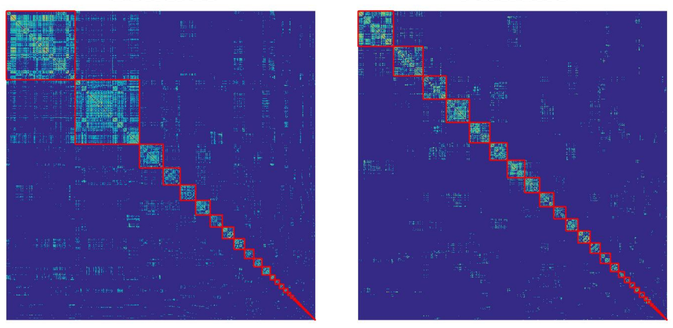
Weaker connectivity in SZ patient

NMI Control-Schizophren = 0.737

Surprise comunity detection

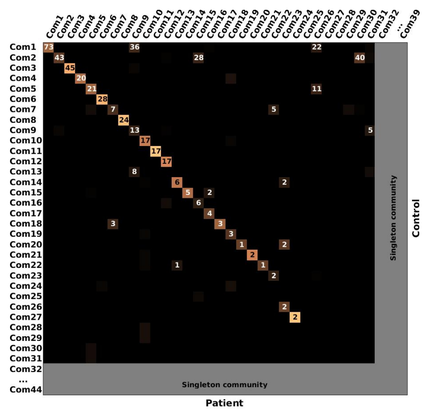
Control **Patient**



Control: 44 communities Patient: 39 communities

Patients have fewer, uniformly distributed communities

Overlap Jaccard index

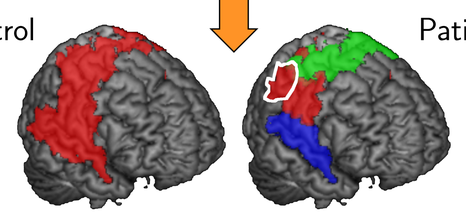


∗ color= minimum 10% overlap
number= nb of commun nodes

General modular reorganization

Example

Control Patient



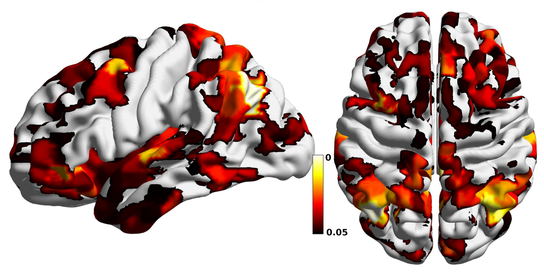
Some communities are breaking apart, others are merging

Participation coefficient

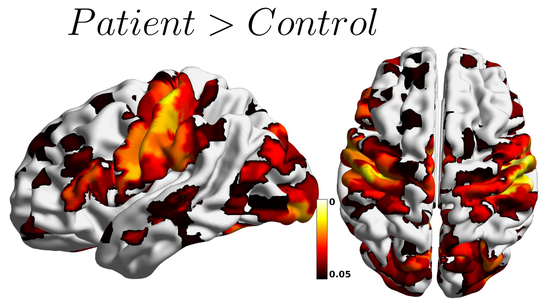
Participation coefficient is a measure of intermodular connections of individual nodes. Value between 0 and 1.

0 ⇒ node with only intramodule links;
1 ⇒ node with only intermodule links

$Patient < Control$



$Patient > Control$



The participation coefficient changes in both directions: higher than control in certain regions, lower in others

Take home message

Surprise method, recently proposed as resolution limit free method, enables the detection of finer details of the brain modular structure. It revealed a smaller number of modules in the SZ brain despite an overall reduction in connectivity. A wide spread reorganization of the modular structure is observed, with large communities break up, and smaller communities merging.

Acknowledgement

Data was downloaded from the COllaborative Informatics and Neuroimaging Suite Data Exchange tool (COINS;`http://coins.mrn.org/dx`) and data collection was performed at the Mind Research Network, and funded by a Center of Biomedical Research Excellence (COBRE) grant 5P20RR021938/P20GM103472 from the NIH to Dr. Vince Calhoun.[2]. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 668863.

References

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