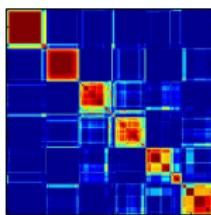


Bootstrap analysis of stable clusters in resting-state fMRI



Pierre Bellec

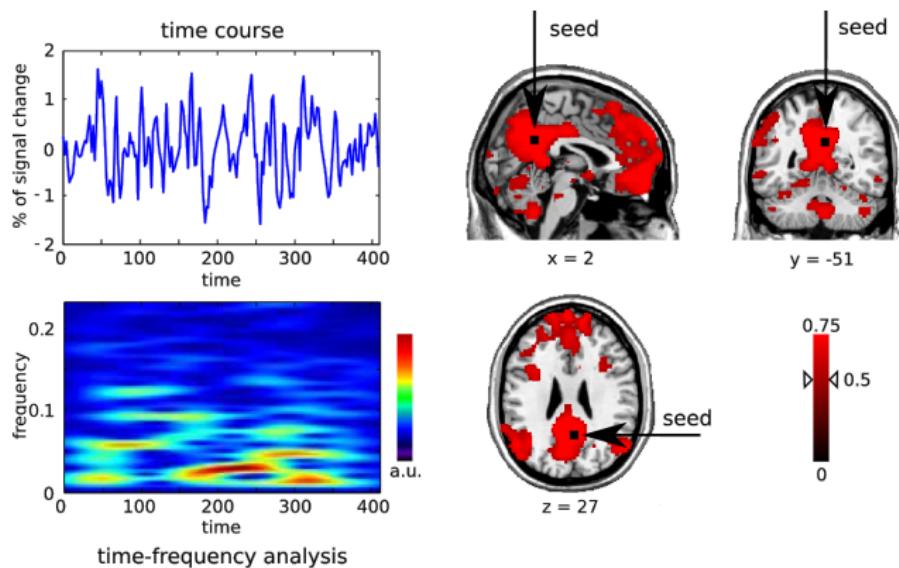
pierre.bellec@criugm.qc.ca

NeuroImaging Analysis Kit

Département d'informatique et de recherche opérationnelle, Université de Montréal

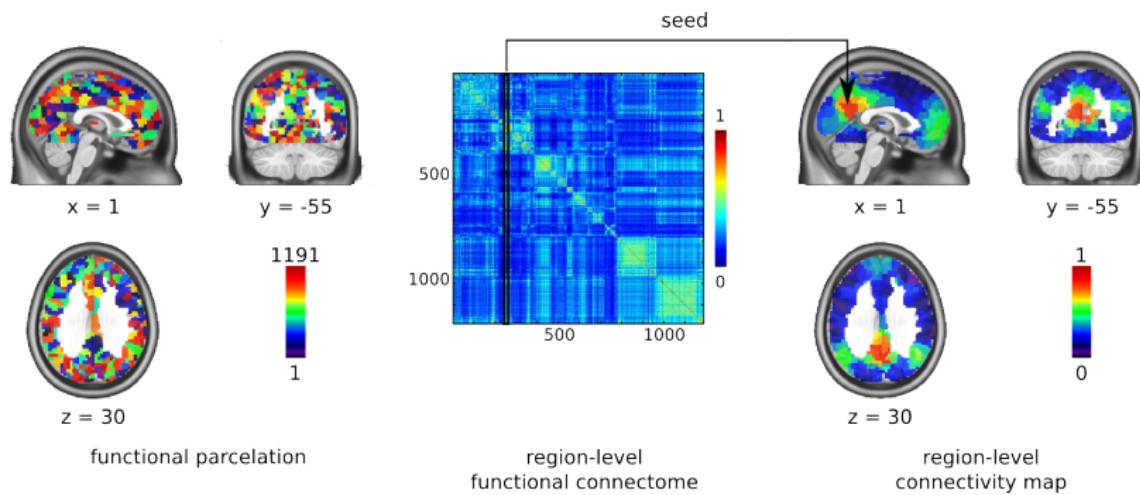


Resting-state fMRI: functional connectivity map



The posterior cingulate cortex is used as a seed to derive an individual resting-state functional connectivity map, identifying the default-mode network.

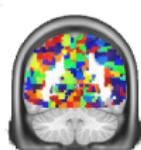
Resting-state fMRI: functional connectome



Resting-state fMRI: resting-state networks



$x = 1$



$y = -55$

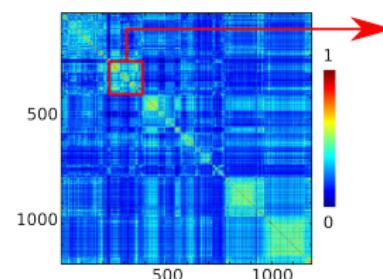


$z = 30$

functional parcelation



1



region-level
functional connectome



$x = 1$



$y = -55$



$z = 30$

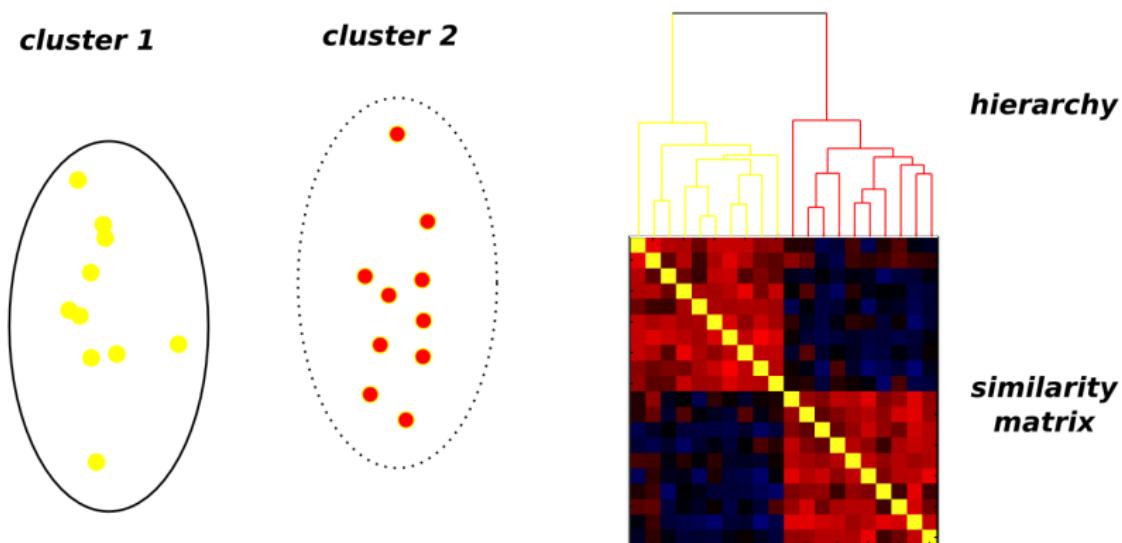
resting-state
network



1

0

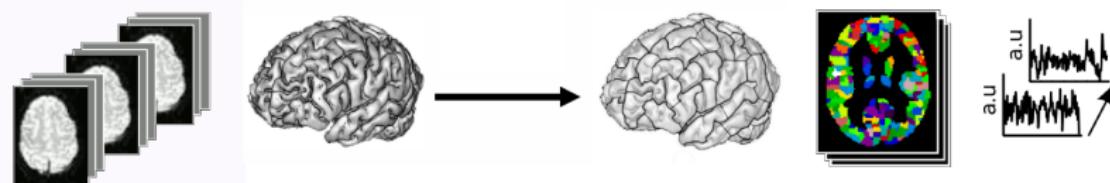
Clustering : unsupervised classification



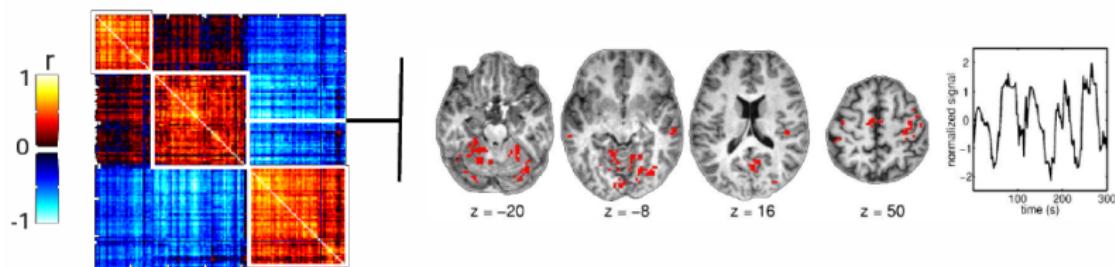
On the left, coordinates of individuals define their similarities; on the right, HC proceeds by iterative mergings. Many clustering algorithms exist, e.g. k-means, fuzzy k-means, spectral clustering, SOM, neural gas. See Jain, Pattern Recognition Letters, 2009, for a review.

Clustering : bi-scale approach in fMRI functional connectivity

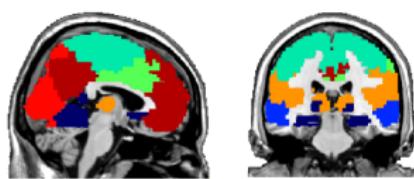
region growing at the voxel level



clustering at the region level



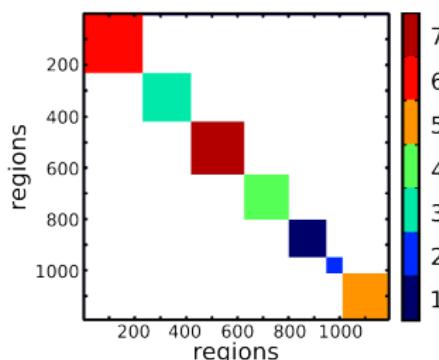
Adjacency matrix representation of a clustering



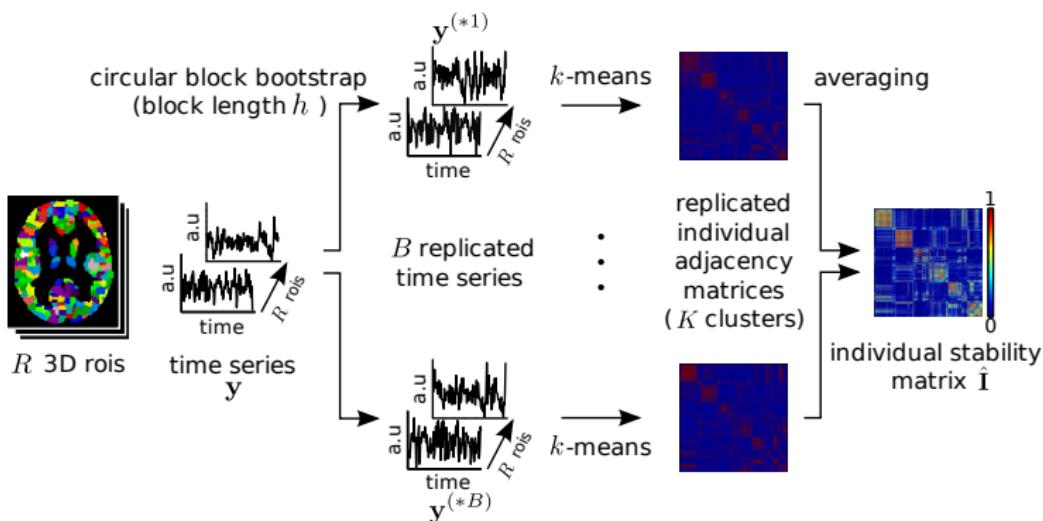
$x = 4$

$y = -27$

$z = 27$

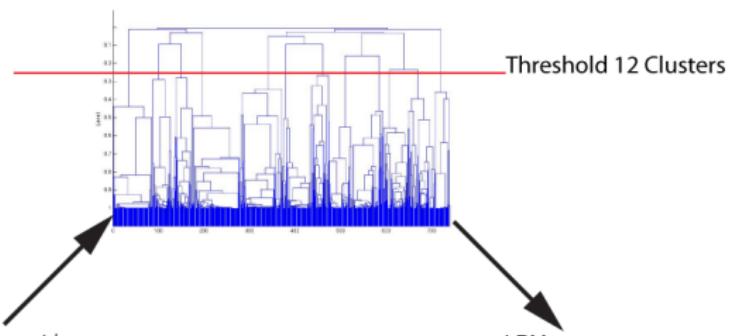


Individual-level bootstrap stability analysis

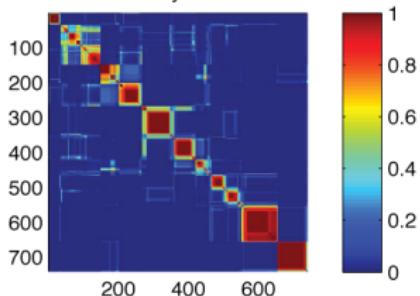


Consensus clustering

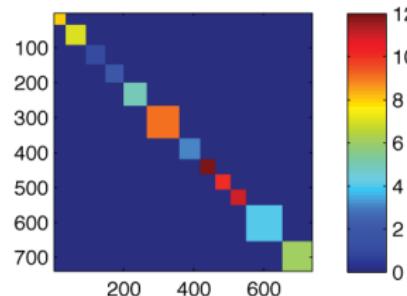
HAC (hierarchical agglomerative clustering)



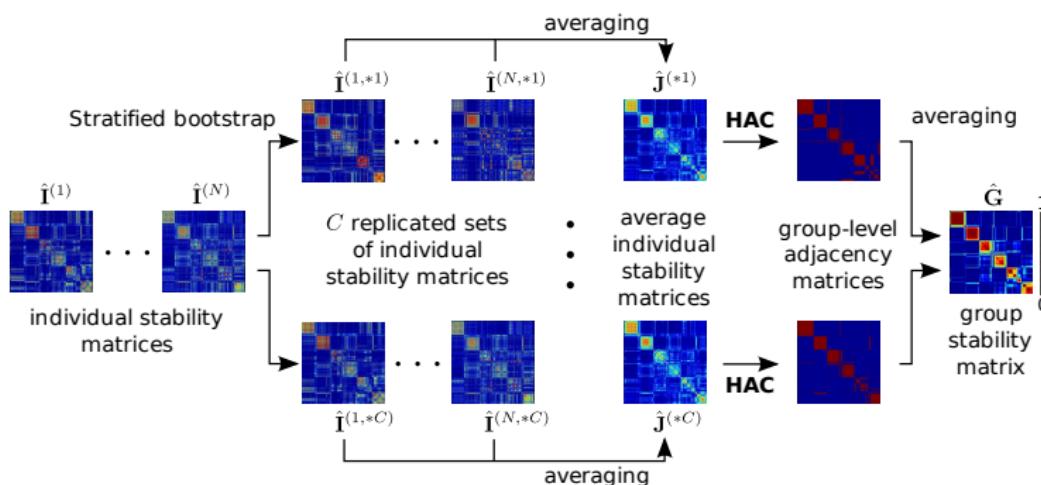
Stability matrix



LPM

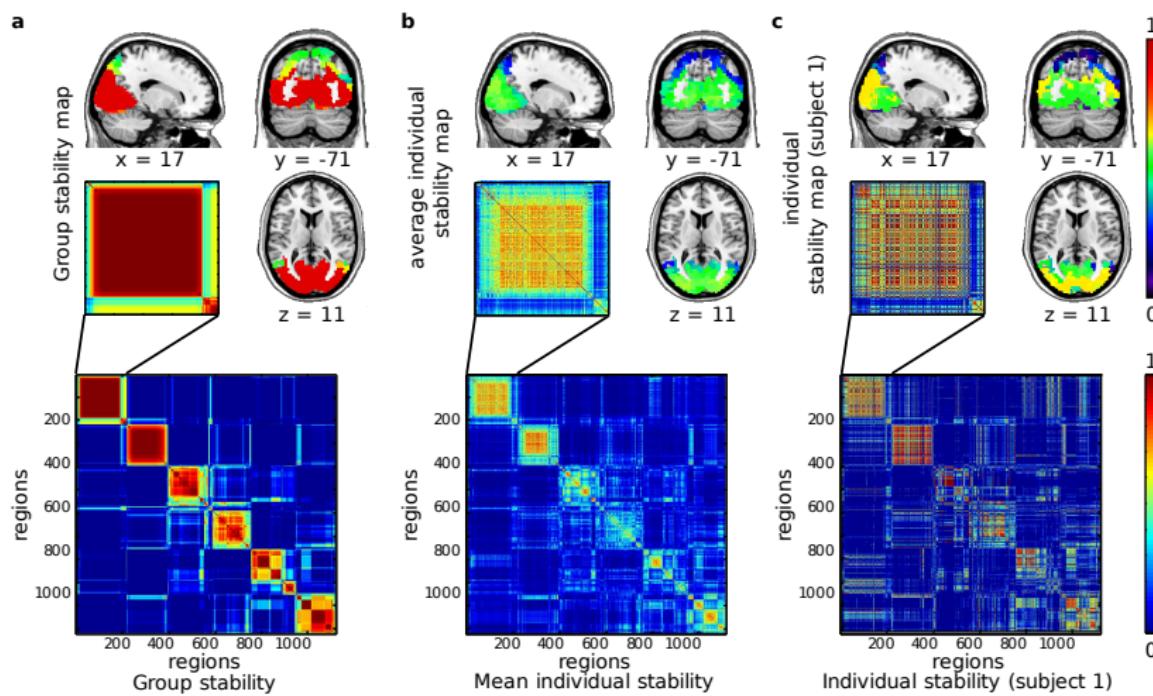


Group-level stability analysis

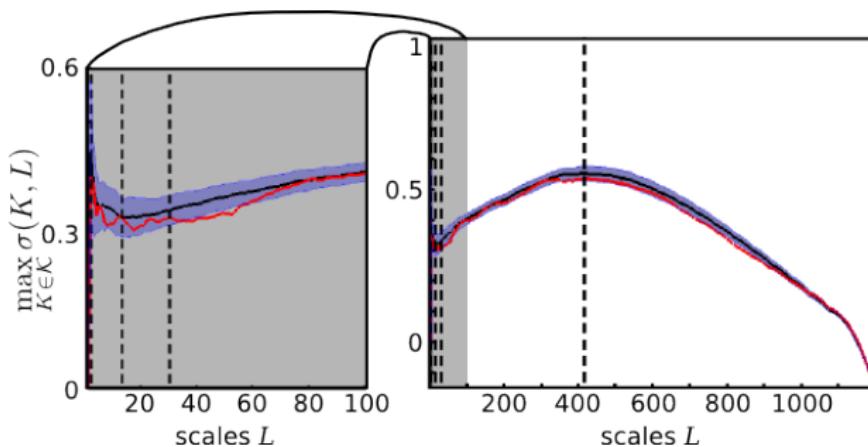


From Bellec et al., Neuroimage 2010.

Clustering : stability maps

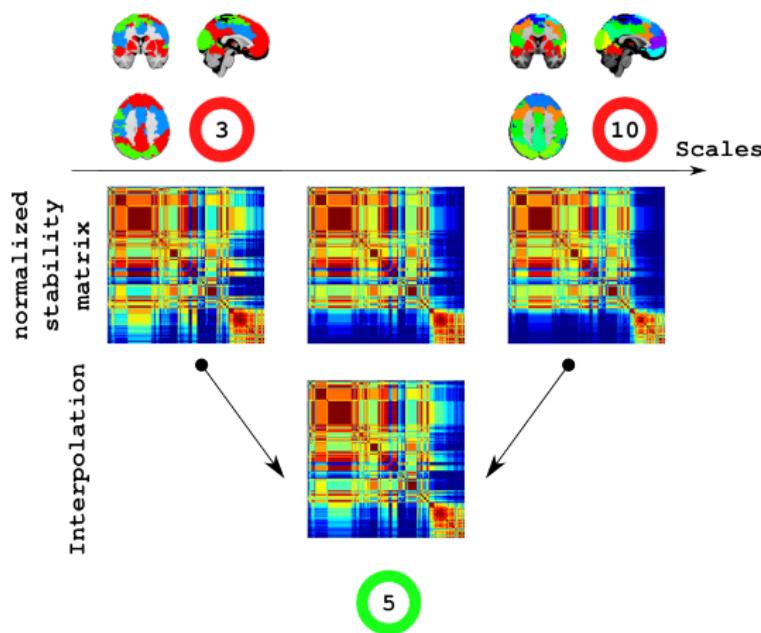


Local maxima of stability

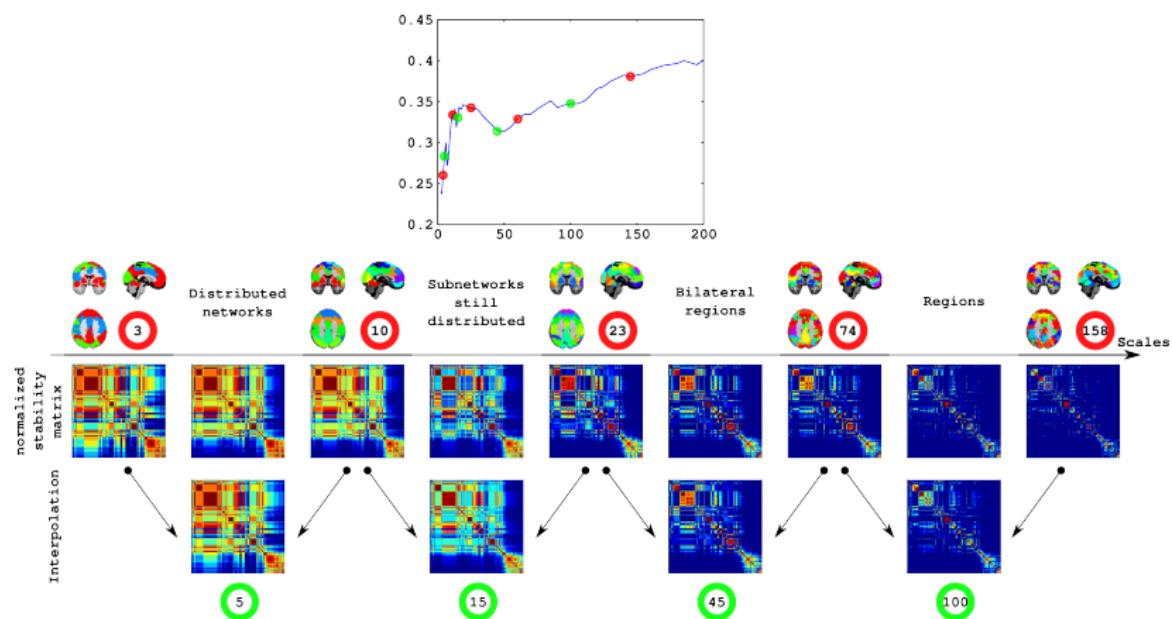


Individual stability contrasts for 43 subjects.

Interpolation of stability matrices I



Interpolation of stability matrices II



Multiresolution stepwise selection (MSTEPS) I

Forward MSTEPS procedure

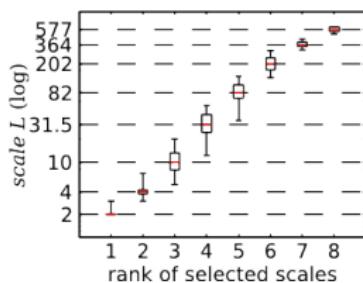
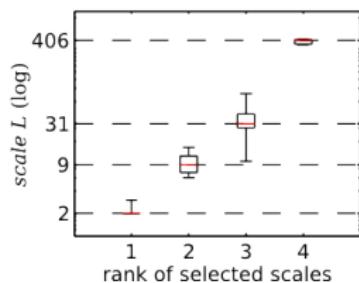
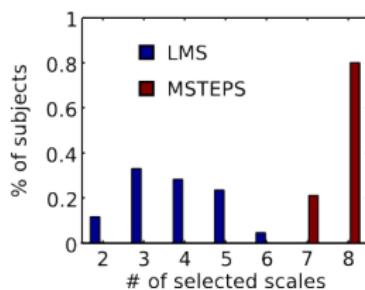
- 1 Initialization: no resolution is selected.
- 2 Select a resolution that has not yet been selected, with probability proportional to the residual sum of squares at this resolution.
- 3 Iterate (2-3) until a predefined percentage of residual sum of squares across all resolutions is reached.
- 4 Iterate the model selection B times, and keep the model with smallest residual sum of squares.

Multiresolution stepwise selection (MSTEPS) II

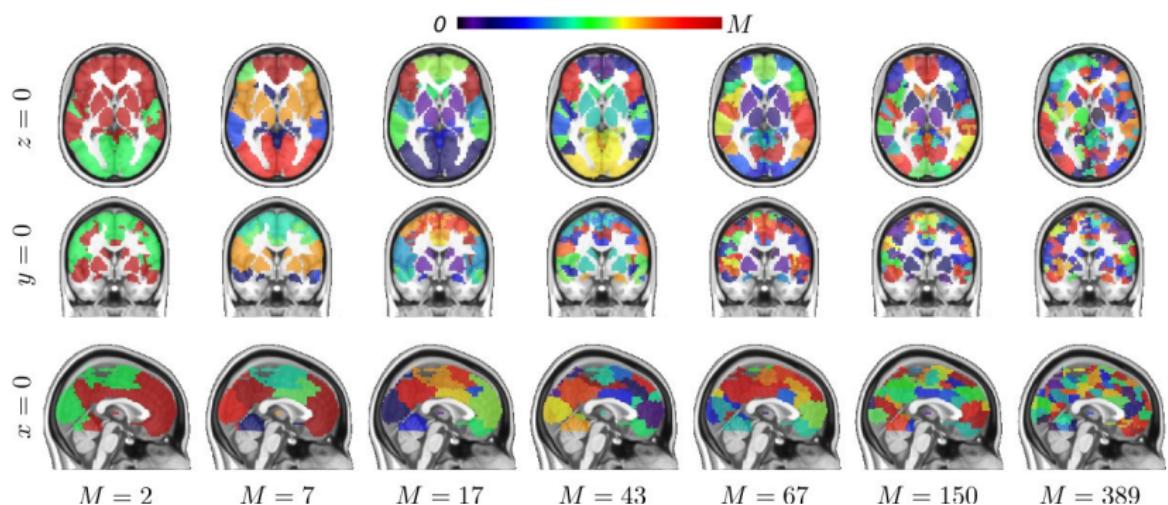
Component-wise MSTEPS procedure

- 1 Initialization: run a forward MSTEPS.
- 2 For each resolution of the model, try to replace it by any of the resolutions not currently in the model.
- 3 Keep the model with the minimal residual sum of squares across all resolutions.
- 4 Iterate (2-3) until it is not possible anymore to reduce the residual sum of squares.

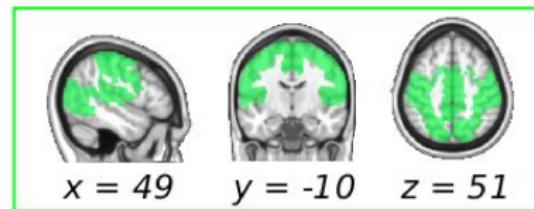
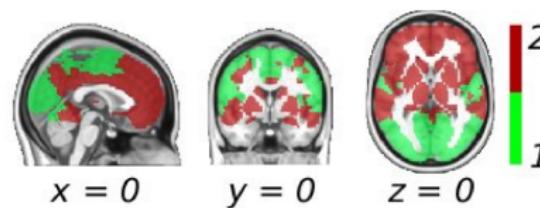
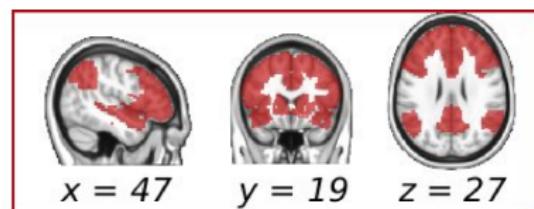
Reproducibility of resolution selection



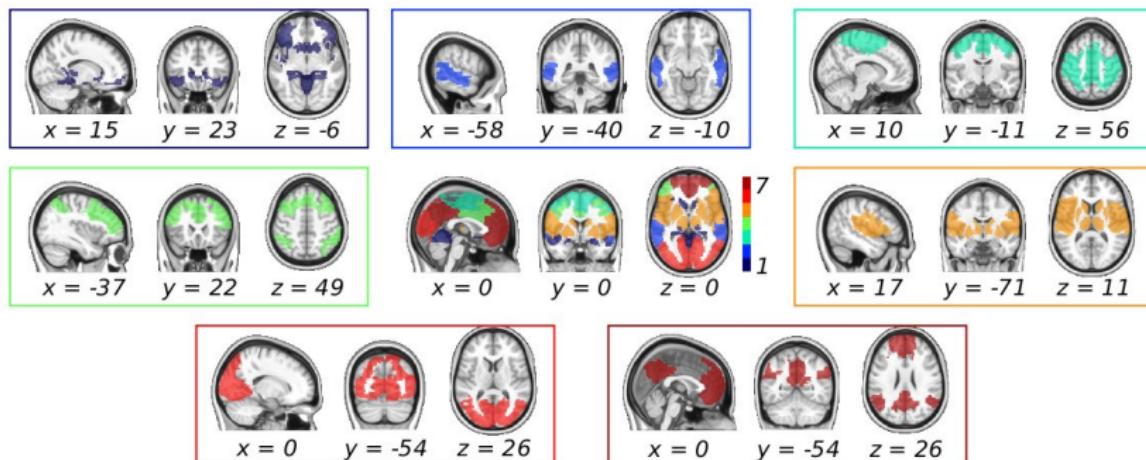
Group consensus clusters as a function of resolution



Group consensus clusters @ (resolution 2)

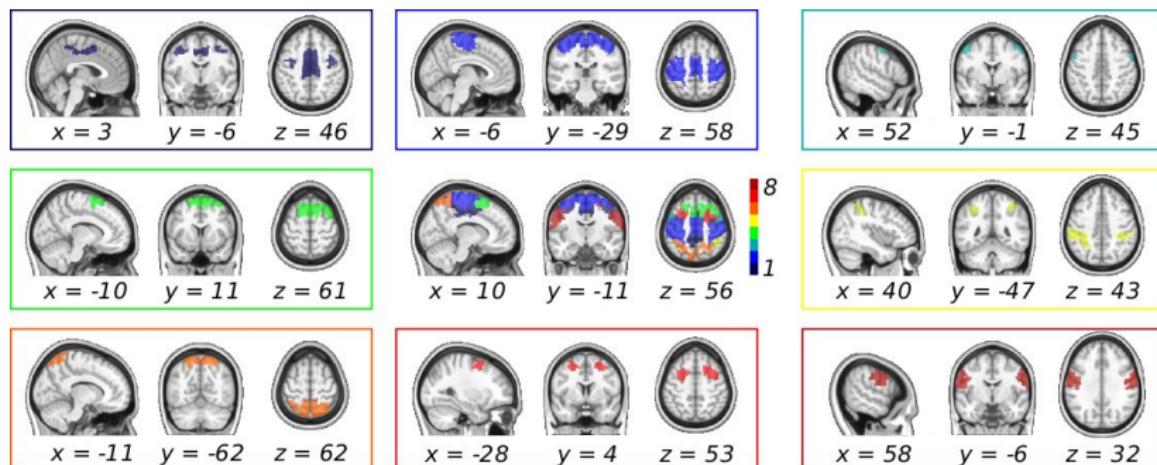


Group consensus clusters @ (resolution 7)



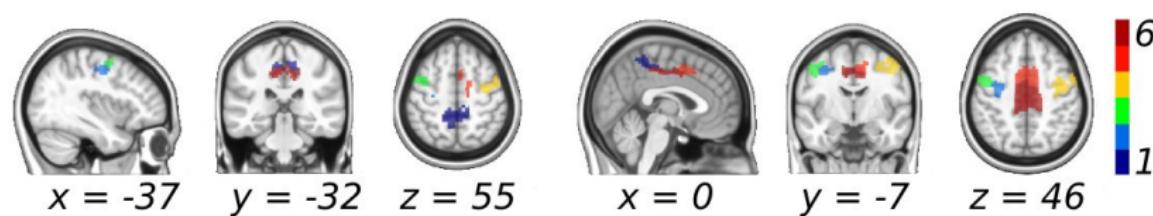
Bellec et al. HBM 2010. See Yeo et al., J Neurophysiol 2011, for more info on this resolution.

Sensorimotor network @ (resolution 43)



Bellec et al. HBM 2010.

Sensorimotor network, subnetwork 1 (resolution 43)@ (resolution 150)



Bellec et al. HBM 2010.

Summary

- It is possible to identify resting-state networks (RSNs) at different levels and resolutions of analysis, using BASC.
- The estimation of the stability of RSNs is an important validation step.
- Rather than identifying the “correct” resolution (an ill-defined problem in fMRI), MSTEPs seeks representative resolutions, to approximate accurately all stability matrices.

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Mr Phil Dickinson
Mr François Chouinard-Decorte
Mr Yassine Benhajali

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