Introduction à un outil d'analyse de la connectivité fonctionnelle en IRMf : Conn
(principes généraux, nettoyages des signaux, ...)

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Références

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Conn: A Functional Connectivity Toolbox for Correlated and Anticorrelated Brain Networks

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http://www.nitrc.org/projects/conn

Procédure générale

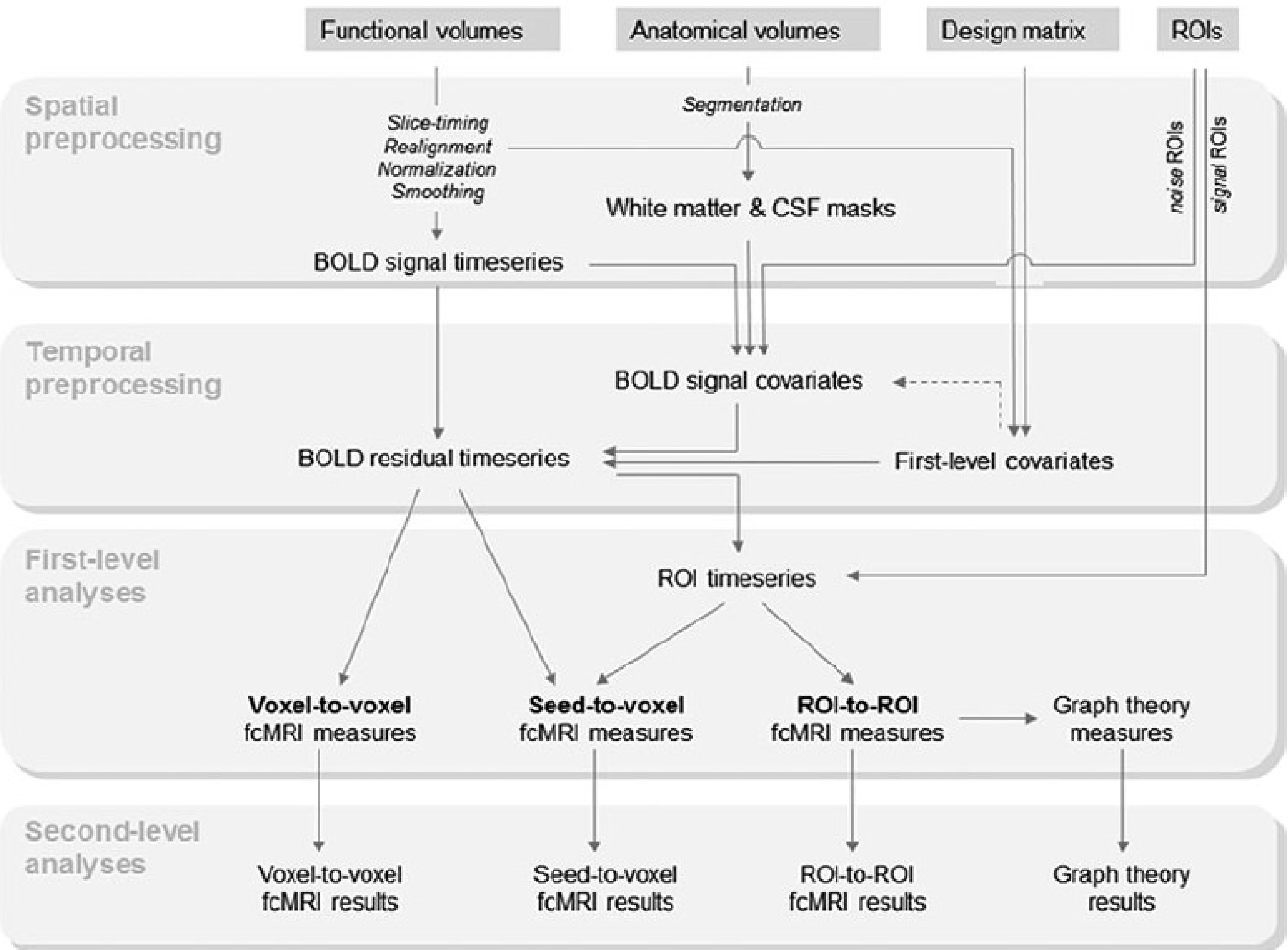


FIG. 1. Schematic representation of fcMRI analysis steps. BOLD, blood oxygen level-dependent; CSF, cerebrospinal fluid; fcMRI, functional connectivity magnetic resonance imaging; ROI, region of interest.

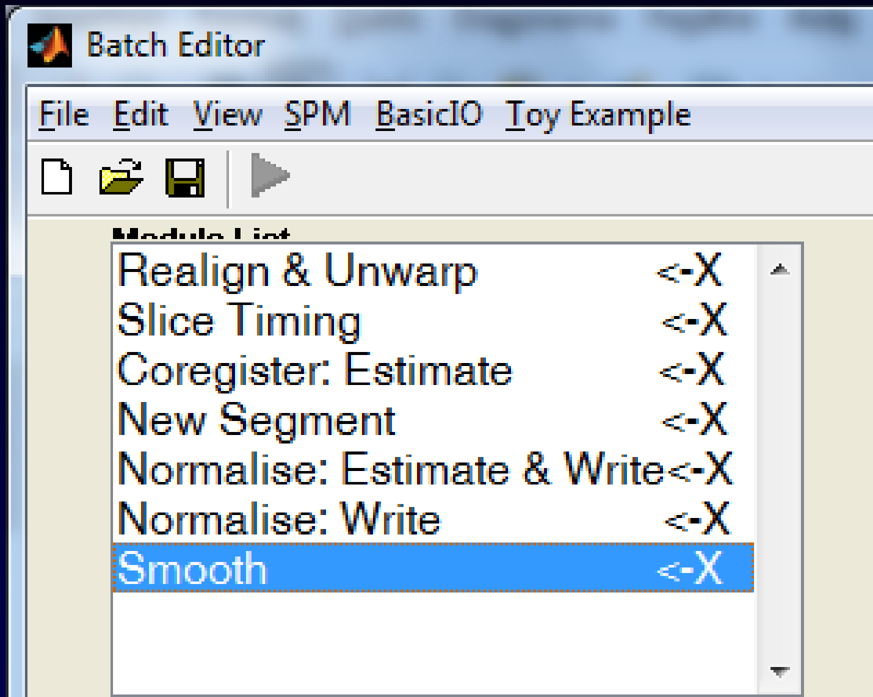
Importance des pré-traitements

In functional connectivity analysis, it is critical to appropriately address noise in order to avoid possible confounding effects (spurious correlations based on non-neuronal sources).

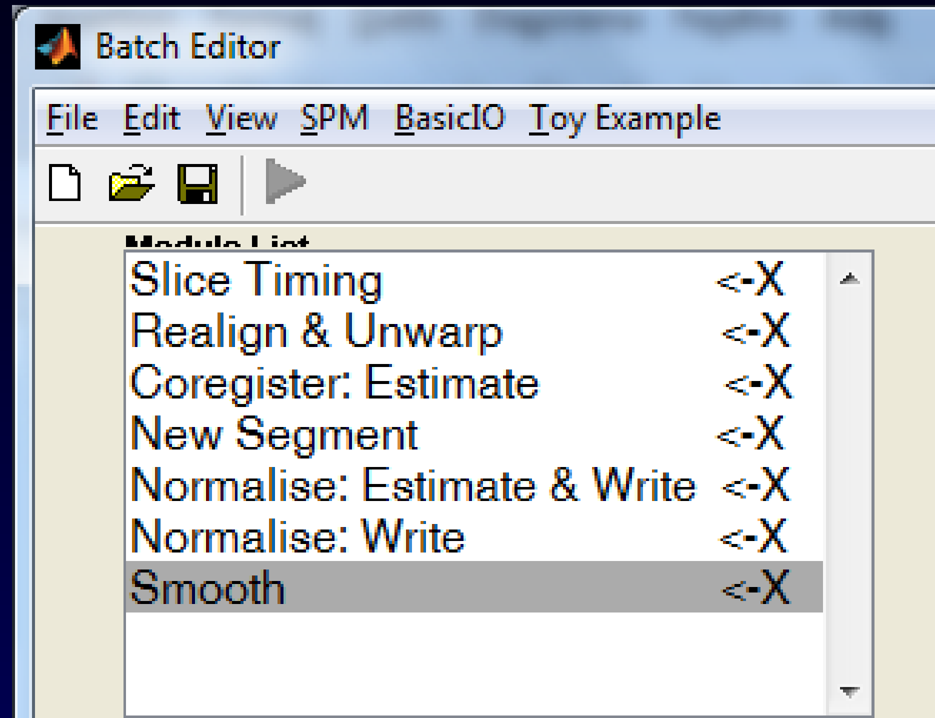
For activation studies, the risk of only partially removing BOLD signal noise sources is typically a potential decrease of sensitivity (increasing type II errors),
whereas for resting connectivity studies, the risk is a potential decrease of validity (increasing type I errors).

Importance des pré-traitements spatio-temporels (spm8)

Acquisition séquentielle



Acquisition entrelacée



Importance des pré-traitements temporels (Conn)

The main concern is that movement and physiological noise sources can potentially induce spurious correlations among distant voxels, increasing the chance of false positives and confounding the interpretation of fcMRI results.

→ Treatment of temporal confounding factors which can be defined :
1/ from indirect sources, as subject- and session-specific time series
(e.g., estimated subject movement parameters and artifacts,
cardiac or respiratory rates, and possible task effects)
2/ from BOLD signals obtained from subject-specific noise ROIs
(white matter and CSF masks, optionally additional user-defined ROIs).

The toolbox implements an anatomical aCompCor strategy (Behzadi et al., 2007) in which a userdefined number of orthogonal time series are estimated using principal component analysis (PCA) of the multivariate BOLD signal within each of these noise ROIs.

Effet des pré-traitements temporels (Conn)

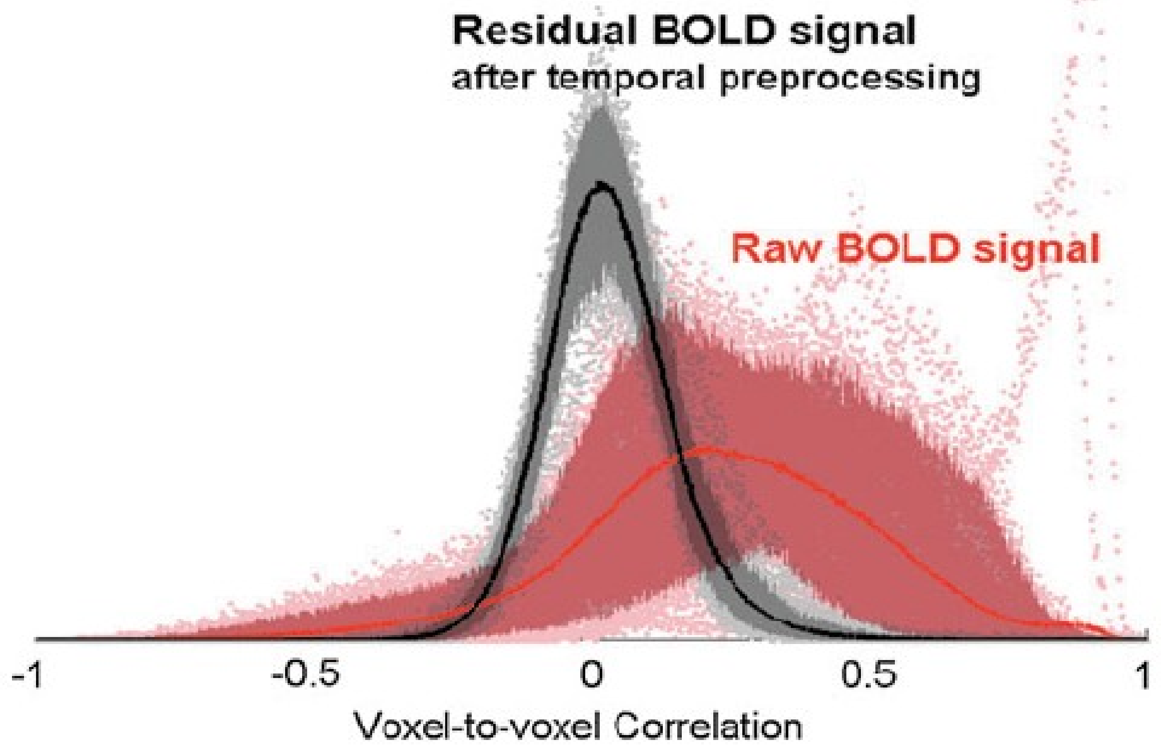


FIG. 2. Effect of temporal preprocessing steps on the distribution of voxel-to-voxel BOLD signal correlation values. The average distribution (across subjects and sessions) is shown as thick lines, and its 5% and 95% percentiles are shown as filled areas. After temporal preprocessing, voxel-to-voxel functional connectivity estimates show a reduction in bias and an associated increase in reliability across subjects and sessions (see text for details).

1er niveau : mesures de connectivité (ROI-to-ROI, Seed-to-voxel)

Linear measures of functional connectivity between two sources :
- zero-lagged bivariate correlation and bivariate-regression coefficients
- their associated multivariate measures, semipartial-correlation and multivariate-regression coefficients

TABLE 1. DEFINITION OF LINEAR MEASURES OF FUNCTIONAL CONNECTIVITY

Bivariate regression	$b = (x^t \cdot x)^{-1} \cdot (x^t \cdot y)$
Bivariate correlation	$r = (x^t \cdot x)^{1/2} \cdot b \cdot (y^t \cdot y)^{-1/2}$
Multivariate regression	$B = (X^t \cdot X)^{-1} \cdot (X^t \cdot Y)$
Semipartial correlation	$R = \left[(X^t \cdot X)^{-1}\right]^{-1/2} \cdot B \cdot \left[Y^t \cdot Y\right]^{-1/2}$

x and y represent two BOLD time series vectors (centered), X and Y represent matrices created by concatenating horizontally one or several x and y vectors, and the brackets [] represent the operation of zeroing all the nondiagonal elements in a matrix.

1er niveau : mesures de connectivité (ROI-to-ROI, Seed-to-voxel)

* Bivariate correlation and bivariate-regression coefficients measure the level of linear association of the BOLD time series between each pair of sources when considered in isolation.

* Semipartial-correlation and multivariate-regression : consider multiple sources simultaneously and estimate the unique contribution of each source using a general linear model.

* In bivariate and semipartial correlation analyses, effect sizes represent correlation coefficients (their values squared can be interpreted as the percentage of the target BOLD signal variance explained by each source BOLD signal).

* In bivariate and multivariate regression analyses, effect sizes represent % changes in BOLD activity at each target associated with a 1% change of BOLD activity at each source ROI.

1er niveau : mesures de connectivité (voxel-to-voxel)

* Connectome-MPVA: These analyses create, separately for each voxel, a low-dimensional multivariate representation characterizing the connectivity pattern between this voxel and the rest of the brain.

* Several voxel-level measures of functional connectivity directly from the original voxel-to-voxel correlation matrix ...

1er niveau : mesures de connectivité (voxel-to-voxel)

*** Several voxel-level measures of functional connectivity directly from the original voxel-to-voxel correlation matrix**

TABLE 2. VOXEL-LEVEL FUNCTIONAL CONNECTIVITY MRI MEASURES DERIVED FROM THE VOXEL-TO-VOXEL CONNECTIVITY MATRIX R(X,Y)

Integrated local correlation	$\sum_{y \in \Omega} h_\sigma(x - y) \cdot r(x, y)$
Radial correlation contrast	$\sum_{y \in \Omega} h_\sigma(x - y) \cdot \frac{\partial}{\partial_{x_k}} r(x, y)$
Global correlation strength	$\frac{1}{\lvert\Omega\rvert} \sum_{y \in \Omega} \lvert r(x, y) \rvert^2$
Radial similarity contrast	$\frac{1}{\lvert\Omega\rvert} \sum_{y \in \Omega} \left\lvert \frac{\partial}{\partial_x} r(x, y) \right\rvert^2$

Integrated local correlation and radial correlation contrast characterize properties of the local pattern of connectivity (between each voxel and its neighbors). Global correlation strength and radial similarity contrast characterize properties of the global pattern of connectivity (between each voxel and the entire brain).

x and y represent the spatial locations of two arbitrary voxels, h_σ represents a Gaussian convolution kernel of width σ, and Ω represents the set of all brain voxels.

1er niveau : mesures de connectivité (voxel-to-voxel)

- Integrated Local Correlation characterizes the average local connectivity between each voxel and its neighbors (a single number for each voxel)

- Radial Correlation Contrast (RCC, Goelman, 2004) characterizes the spatial asymmetry of the local connectivity pattern between each voxel and its neighbors (a 3d vector for each voxel)

- Intrinsic Connectivity Contrast characterizes the strength of the global connectivity pattern between each voxel and the rest of the brain (a single number for each voxel).

- Radial Similarity Contrast characterizes the global similarity between the connectivity patterns of neighboring voxels (a 3d vector for each voxel).

2nd niveau : ...

A SUIVRE ….

Remarque pour le resting-state : questionnaire sujet ...

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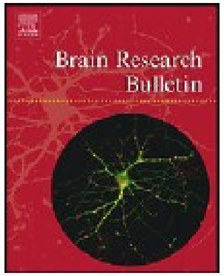

Research report

The resting state questionnaire: An introspective questionnaire for evaluation of inner experience during the conscious resting state

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