AnalyzeFMRI: an R package to perform statistical analysis on fMRI

Cécile Bordier, Michel Dojat, Pierre Lafaye de Micheaux

use R 2009

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Inserm
Institut national
de la santé et de la recherche médicale

UNIVERSITE JOSEPH FOURIER
SCIENCES. TECHNOLOGIE. SANTÉ

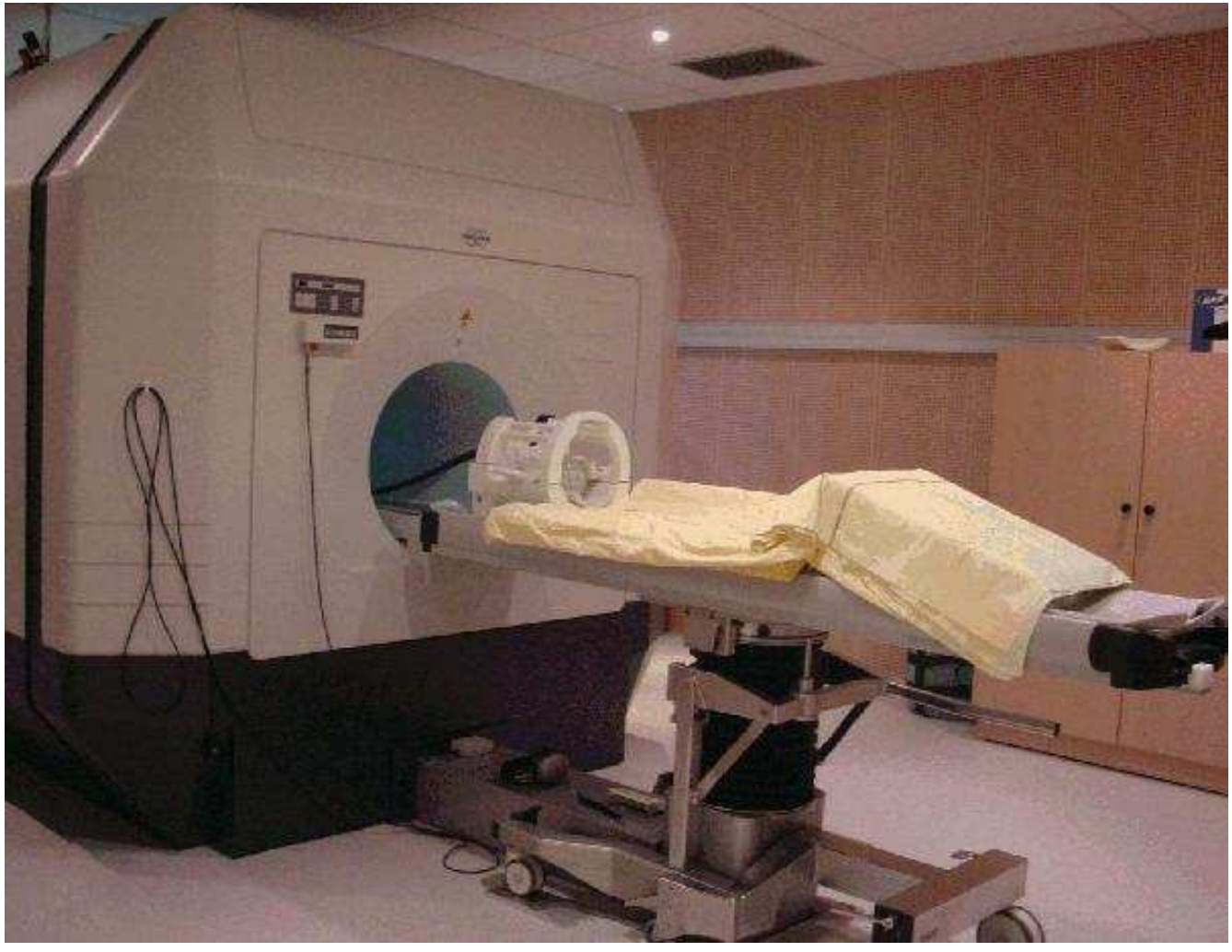
LABORATOIRE
JEAN KUNTZMANN
MATHÉMATIQUES APPLIQUÉES - INFORMATIQUE

Package R/C : AnalyzeFMRI

- 2001 J.Marchini
- 2007 AnalyzeFMRI extension

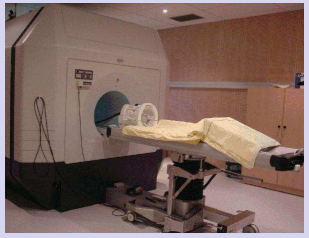
Processing and analysis of large structural Magnetic Resonance Imaging (MRI) and functional MRI (fMRI) datasets

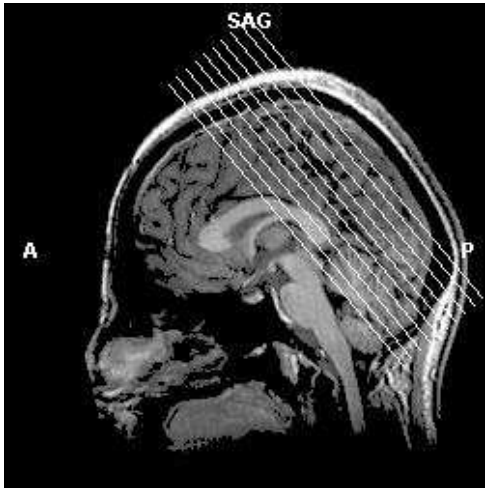
MRI & functional MRI



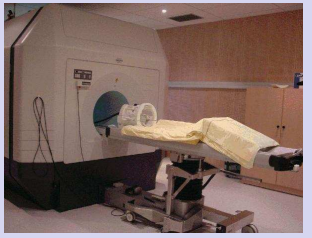
Non invasive procedure

MRI & functional MRI

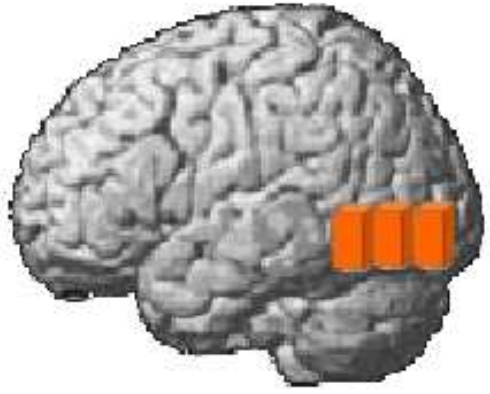


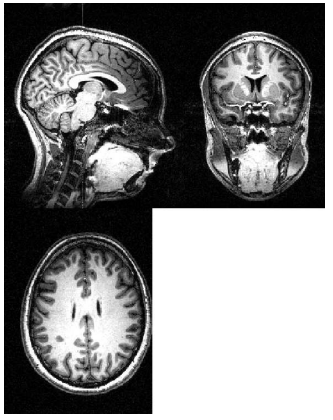


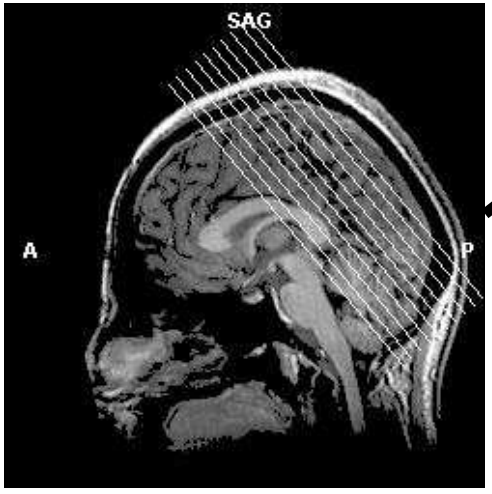
MRI & functional MRI



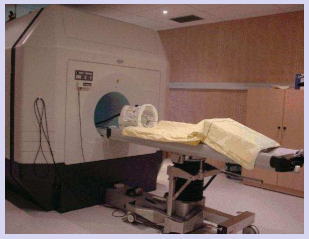
Anatomical

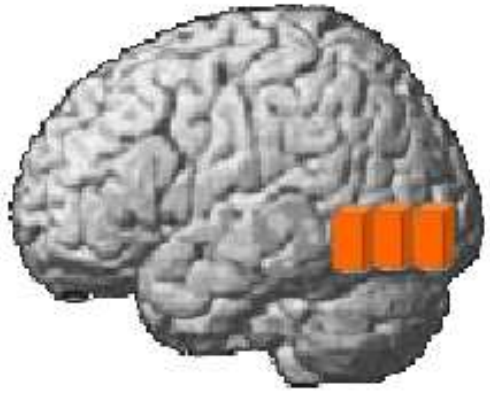


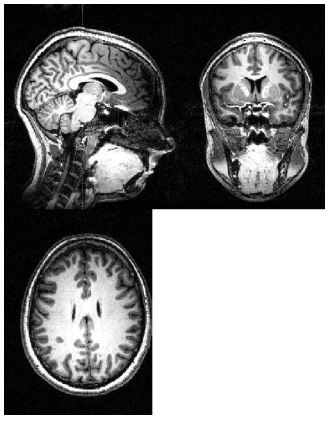




MRI & functional MRI







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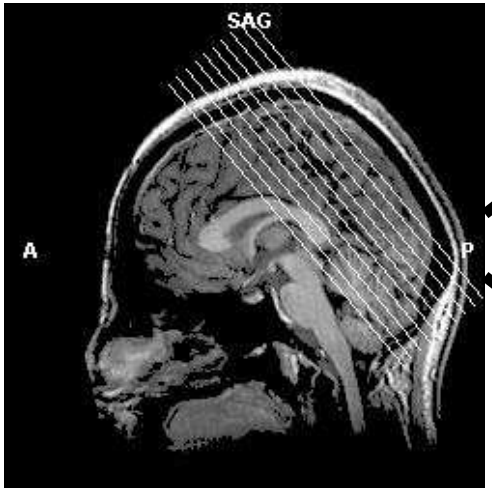
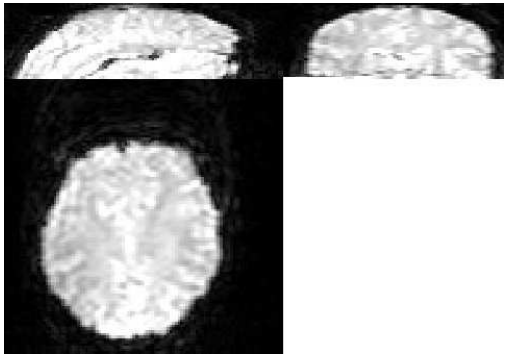


Functional
or EPI



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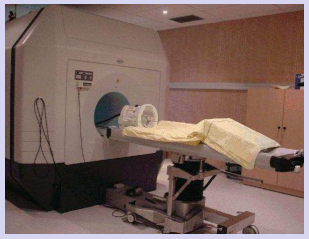

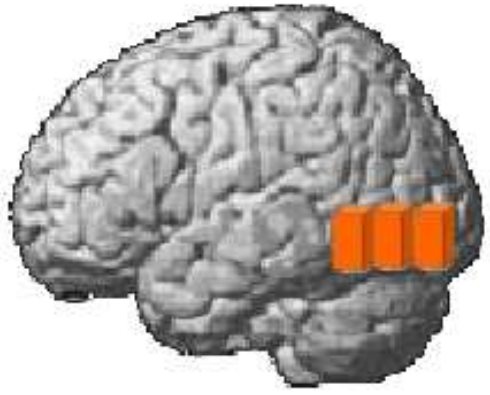

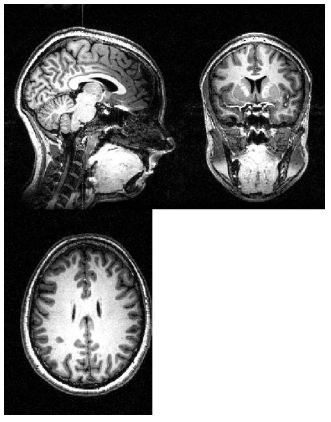

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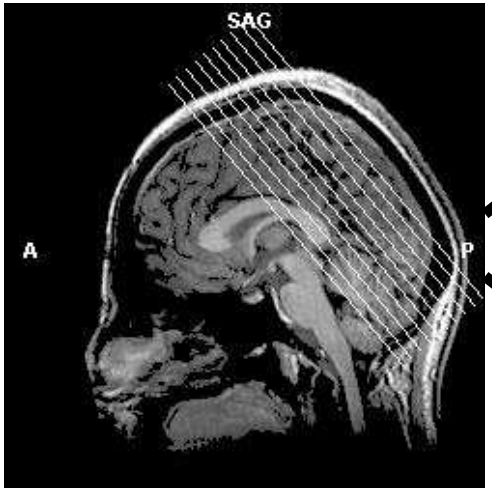

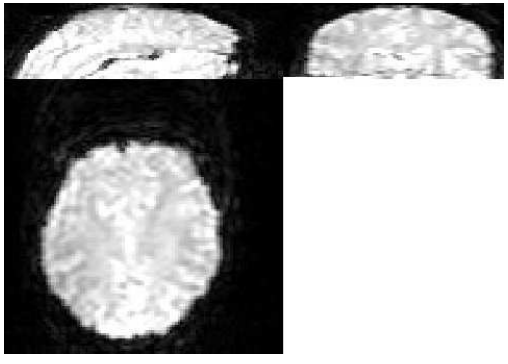

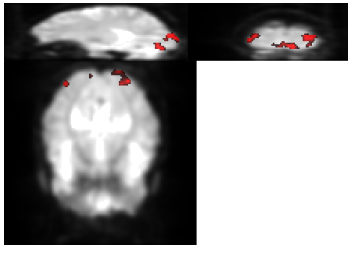

Functional
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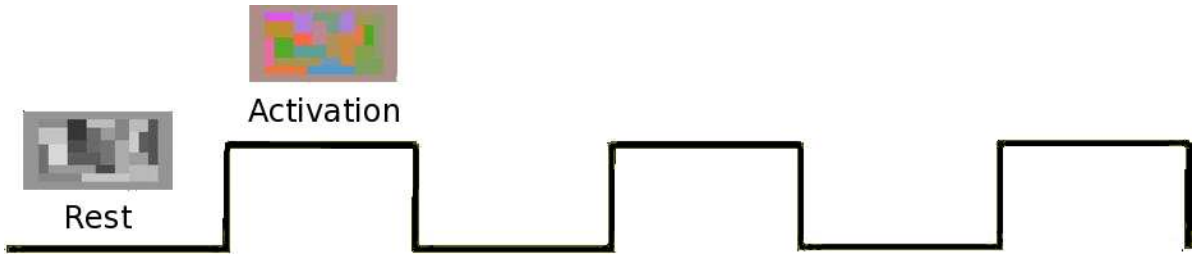
Example of Experiment

Paradigm



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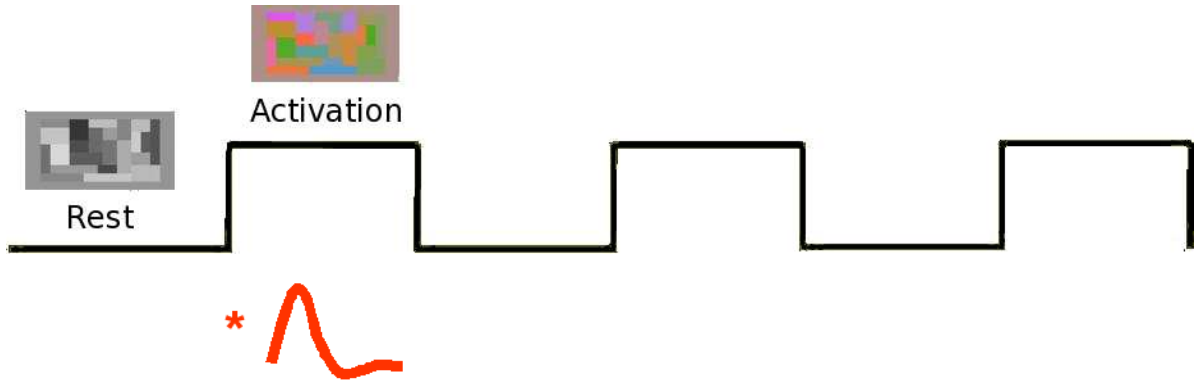

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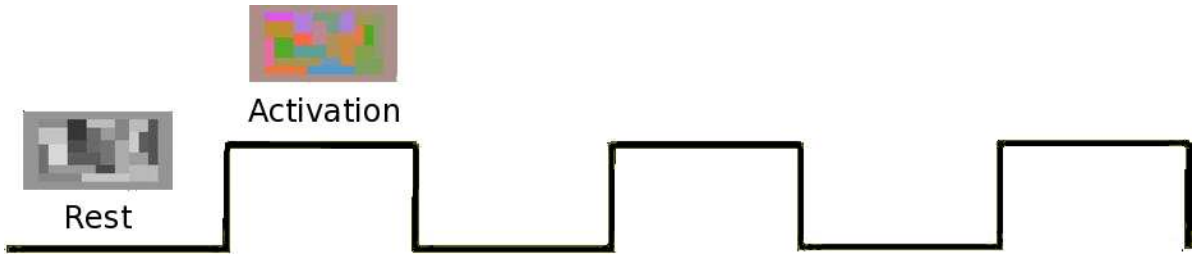

Expected Signal

Example of Experiment

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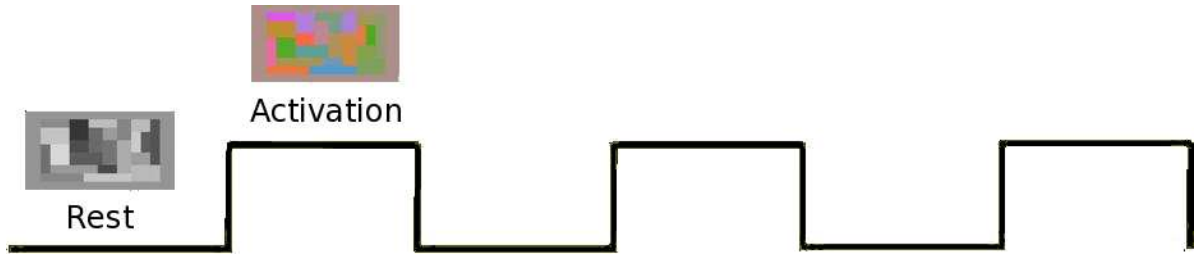
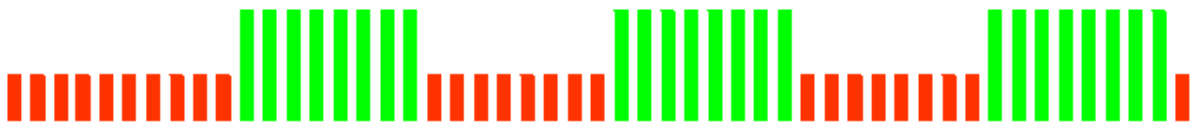
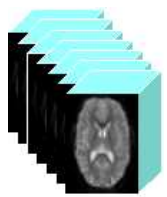


Expected Signal

Image Acquisition





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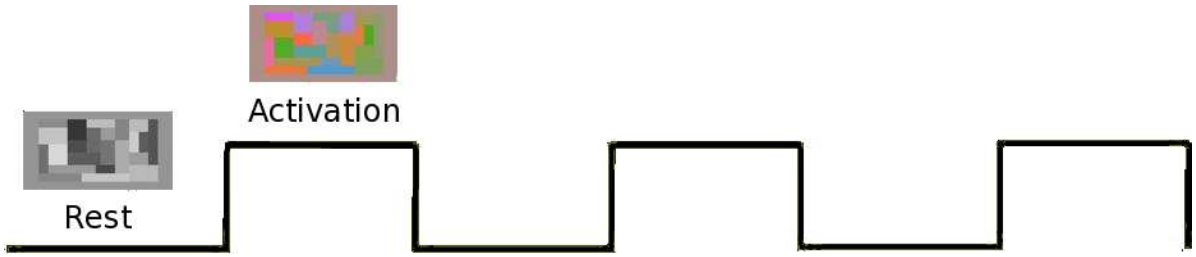

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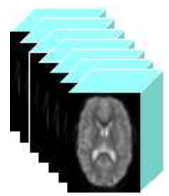

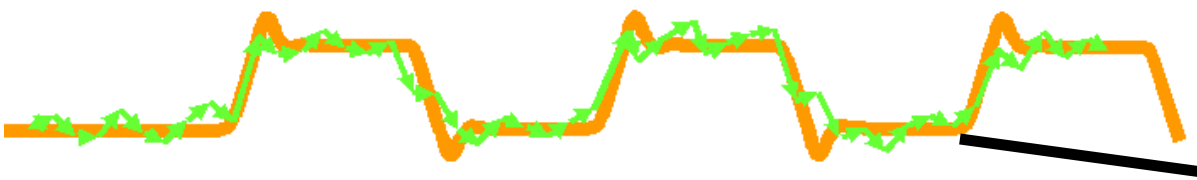

Correlation between voxels and paradigm

Problem & Solution

Problem: Each voxel is a mix of several original signals: occular movement, heart rate, respiratory cycle, noise...

Solutions: **GLM :** General Linear Model : Linear modelisation of the hemodynamic response during the paradigm

ICA: Independent Component Analysis : exploratory method

Is a computational method for separating a multivariate signal into additive subcomponents supposing the mutual statistical independence of the non-Gaussian source signals

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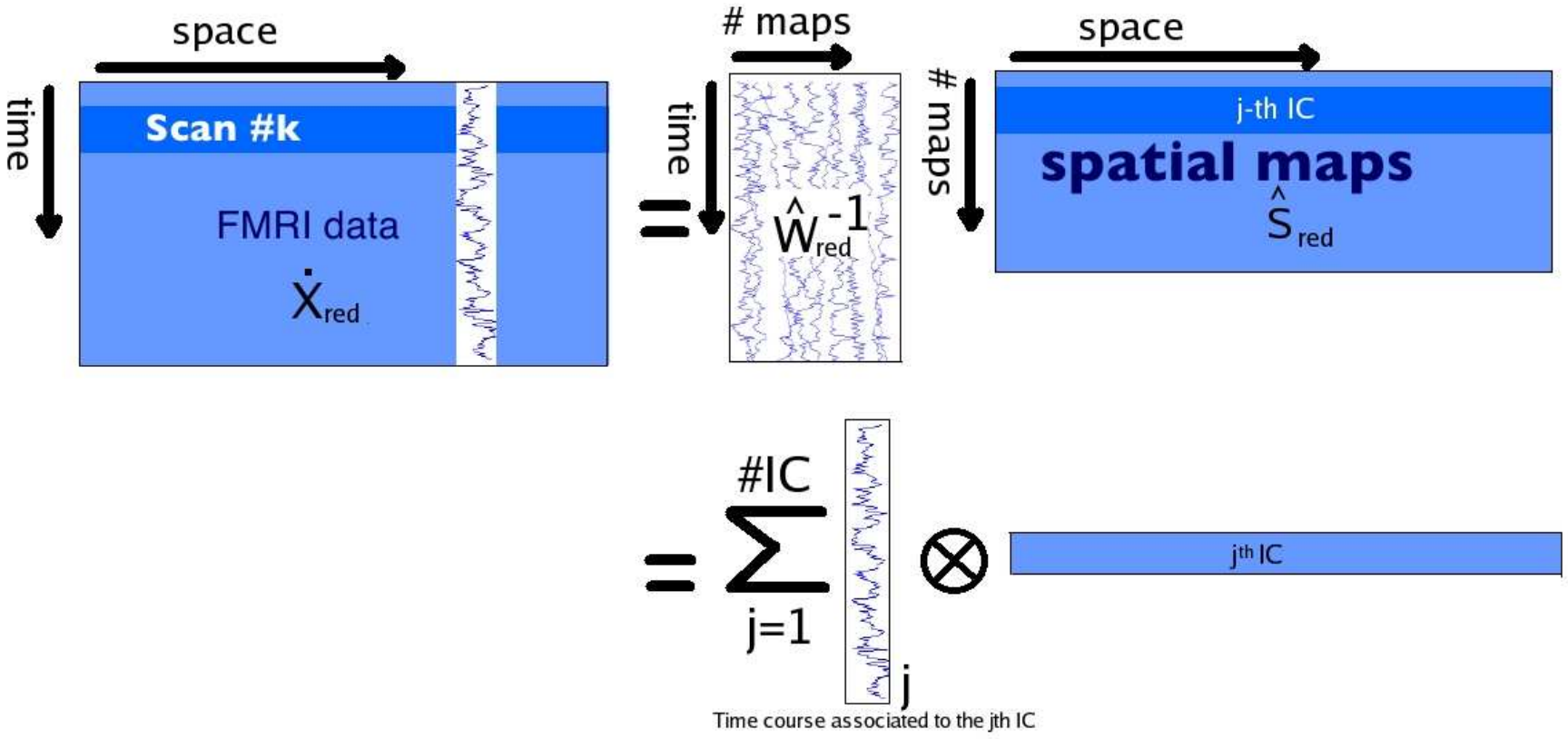
Spatial ICA

- Spatial decomposition



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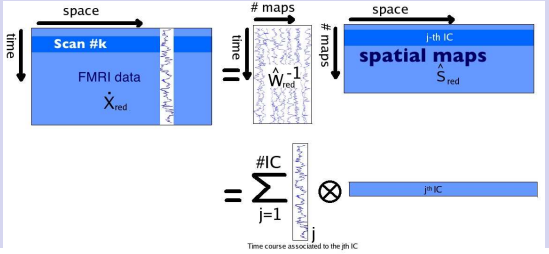
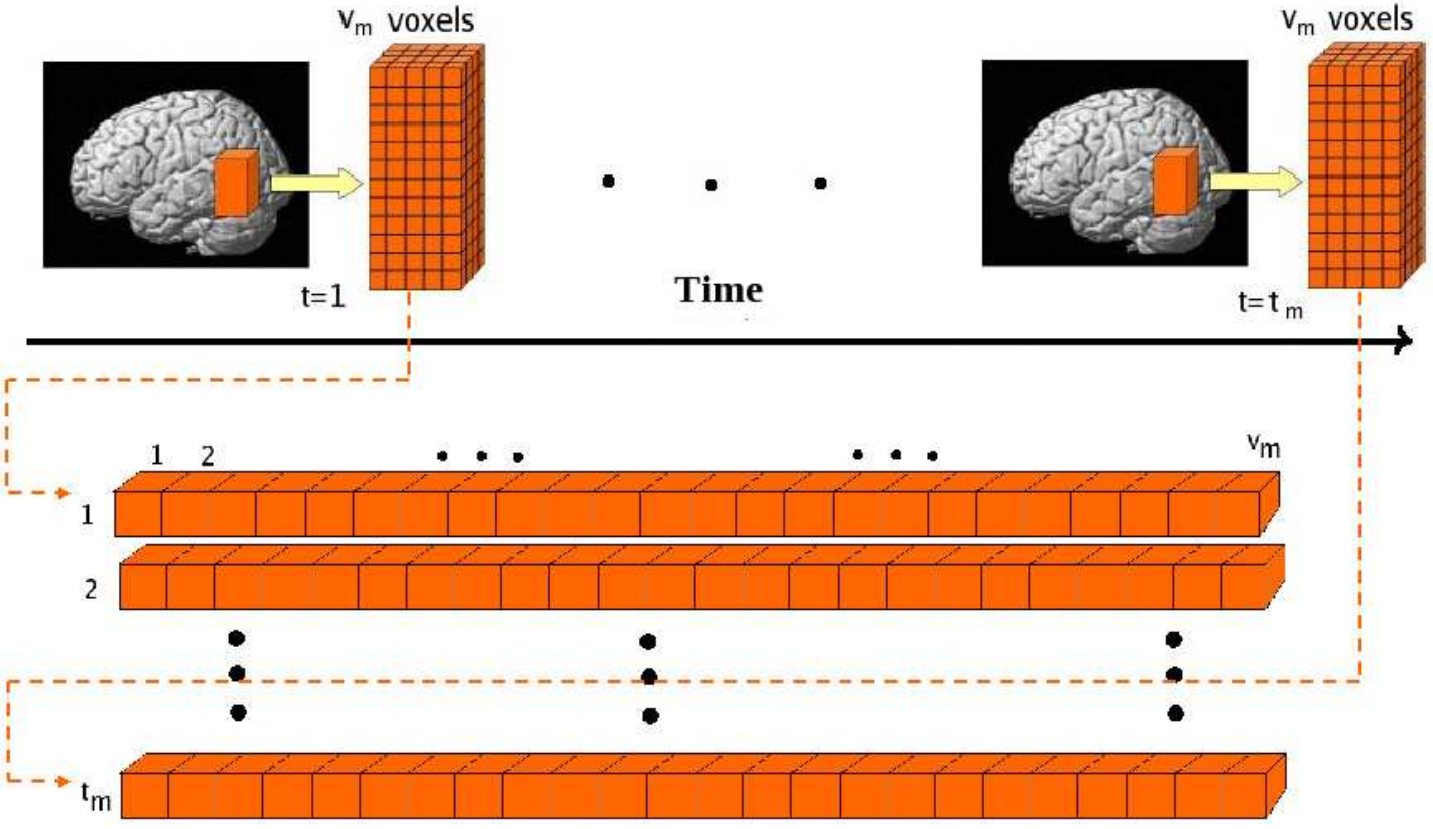
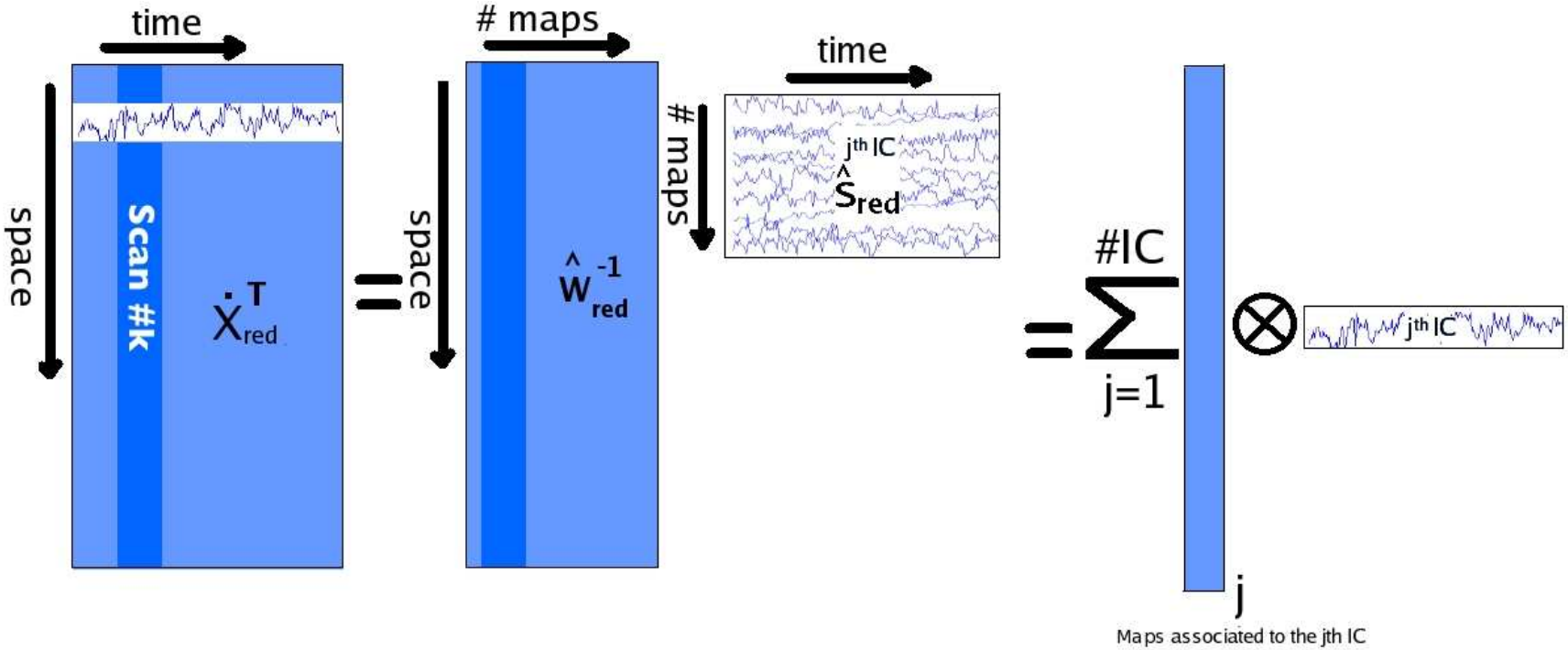

space
time
Scan #k
FMRI data
$\dot{X}_{red}$
maps
time
$\hat{W}^{-1}_{red}$
space
maps
j-th IC
spatial maps
$\hat{S}_{red}$
#IC
j=1
j
Time course associated to the jth IC
jth IC

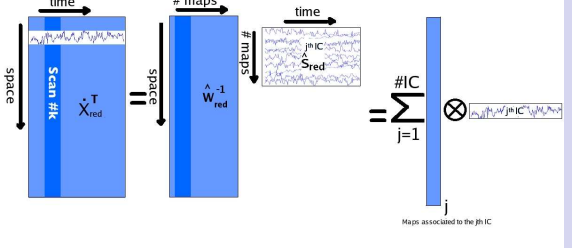

v_m voxels
t=1
Time
v_m voxels
$t=t_m$
1 2
v_m
1
2
t_m

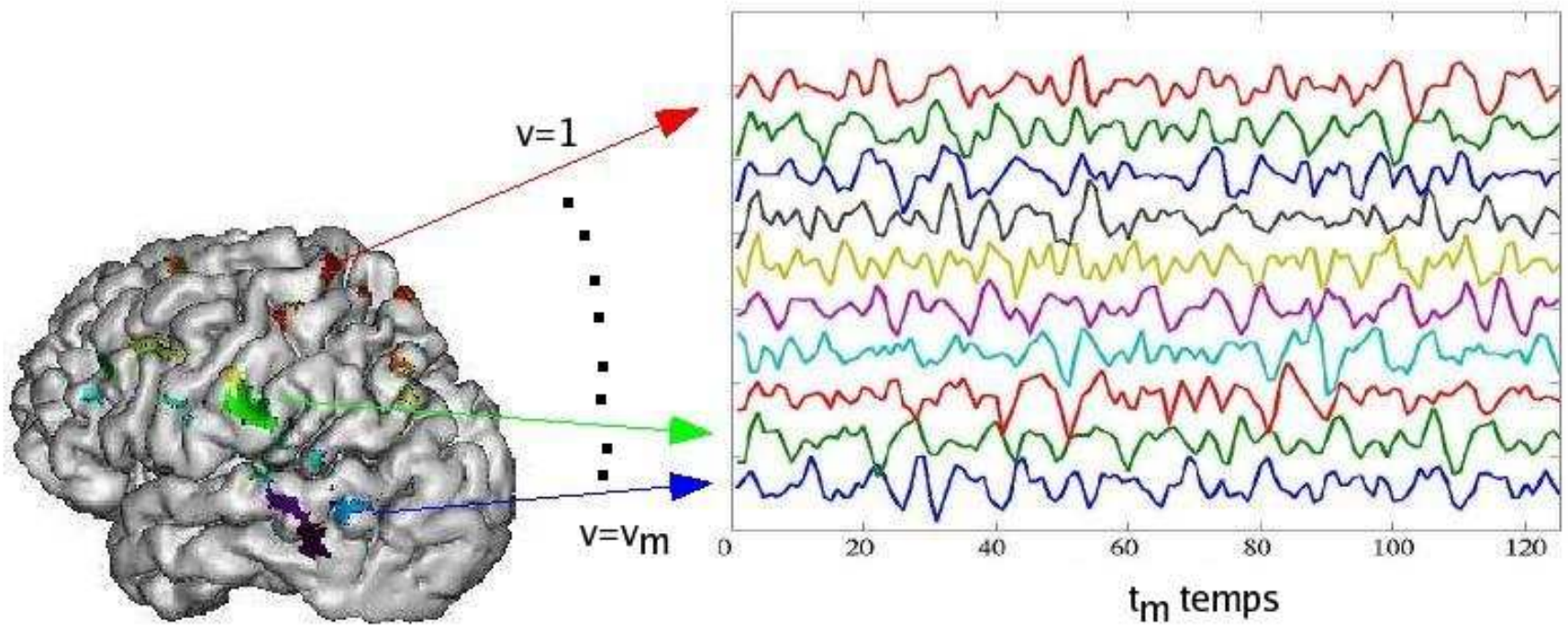
Temporal ICA

- Temporal decomposition



Temporal ICA





Temporal ICA

"...Note that TICA is typically much more computationally demanding than SICA for functional MRI applications because of a higher spatial than temporal dimension and can grow quickly beyond practical feasibility. Thus a covariance matrix on the order of N^2 (where N is the number of spatial voxels of interests) must be calculated. A combination of increased hardware capacity as well as more advanced methods for calculating and storing the covariance matrix may provide a solution in the future ..."

Calhoun, Human Brain Mapping, 2001

Volume= 128X128X30 voxels and Time= 240 volumes

Spatial ICA: covariance matrix $= 240^2 = 57600$

Temporal ICA: covariance matrix $\approx 500000^2 = 25 * 10^{11}$

Temporal ICA

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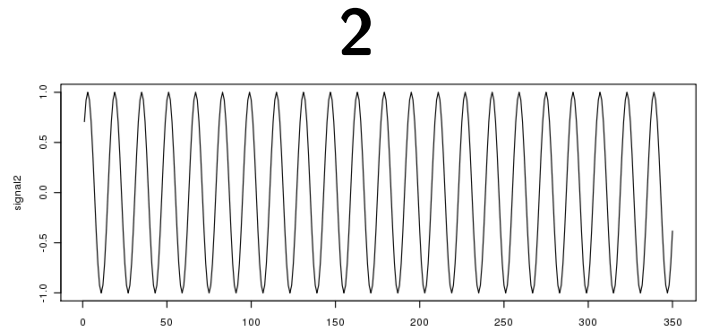
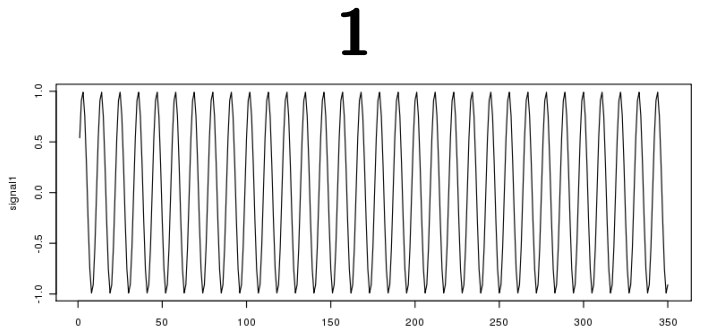
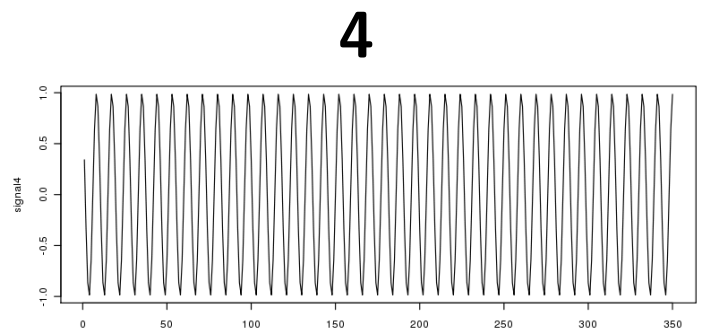
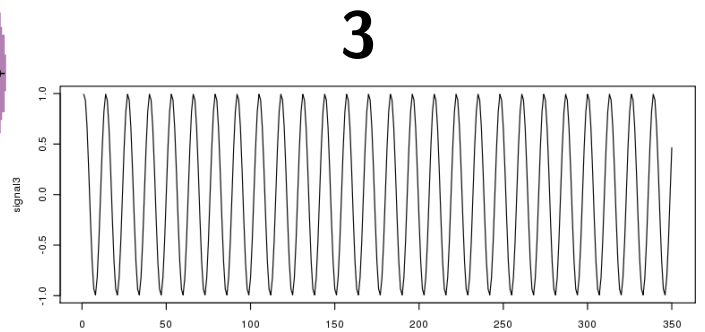
Possible with the singular value decomposition (svd)

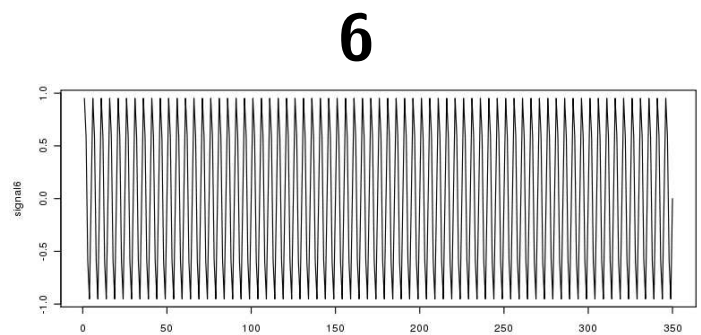
Simulation: sine wave with various frequency

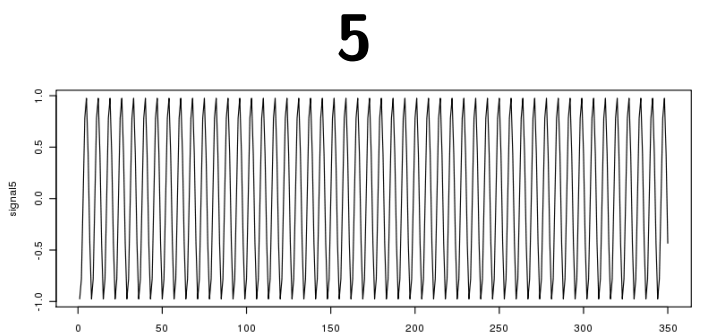


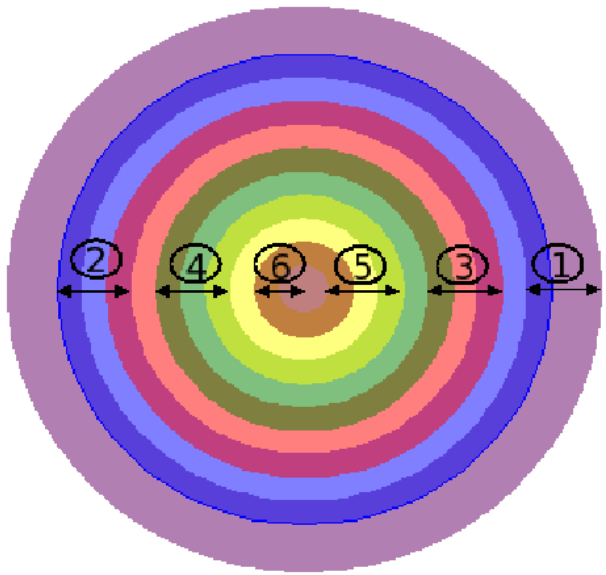








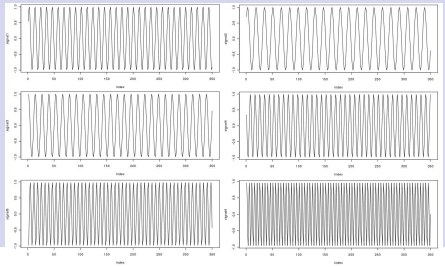




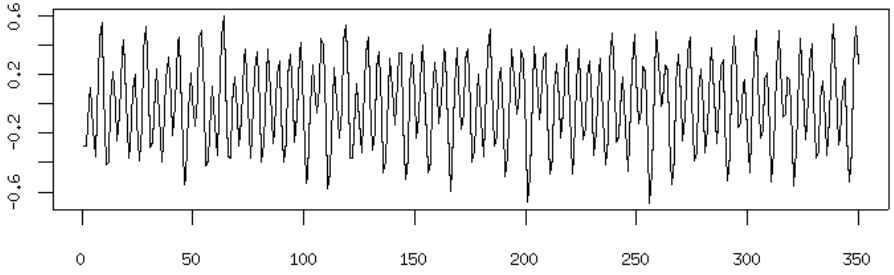
+Gaussian noise

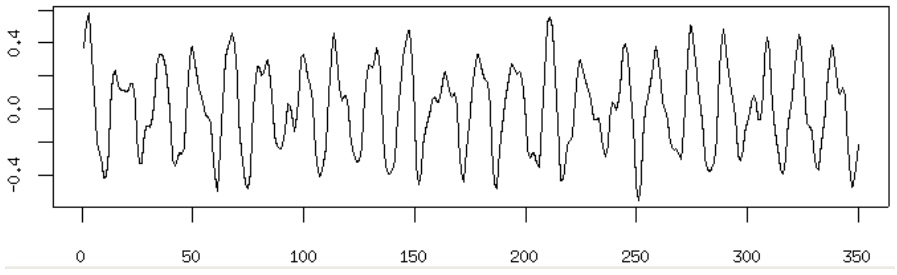
S/N=10%

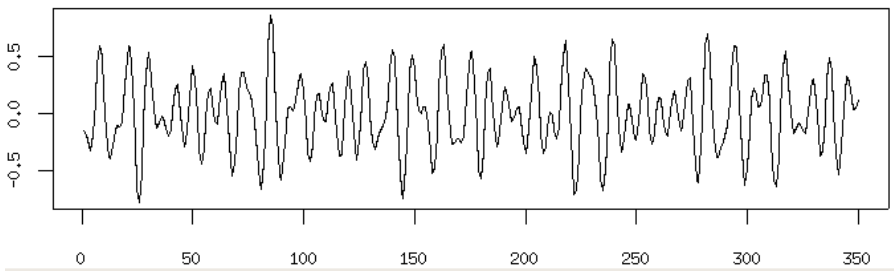
Spatial ICA simulation results

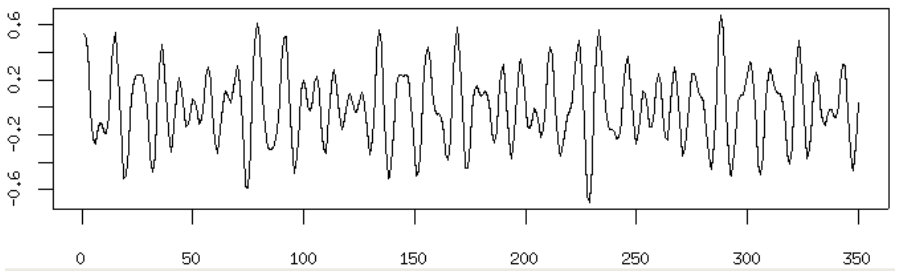


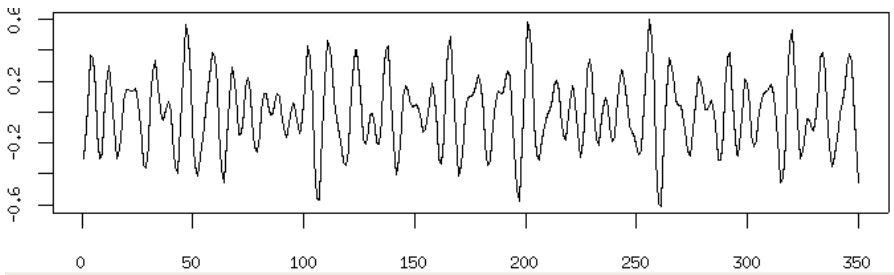
Poor Results

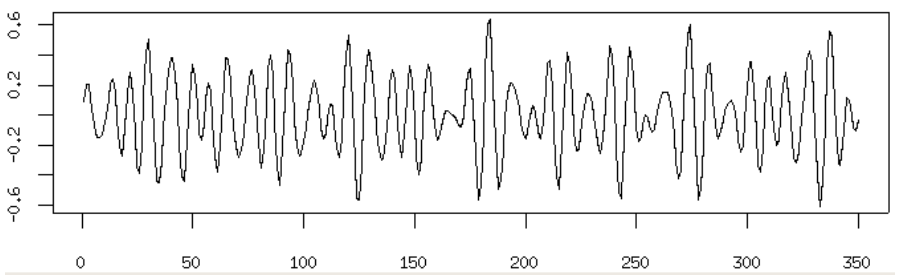




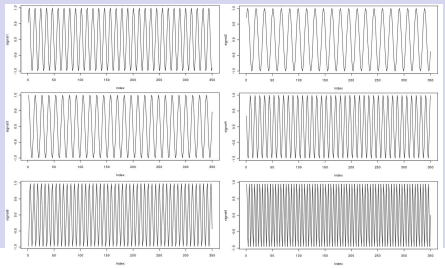




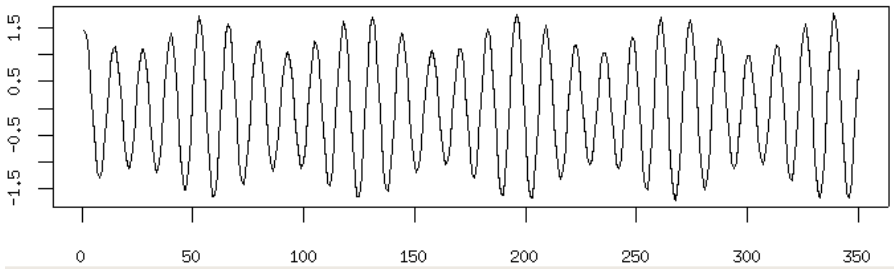


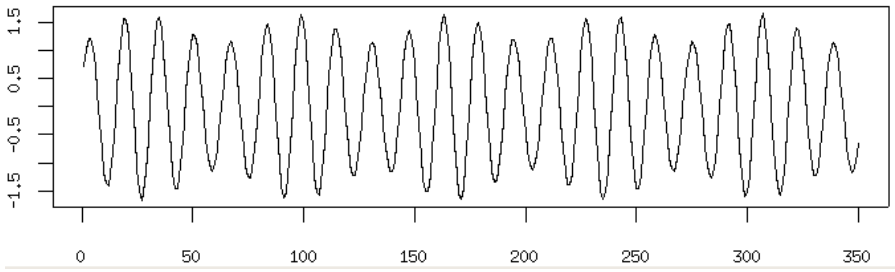


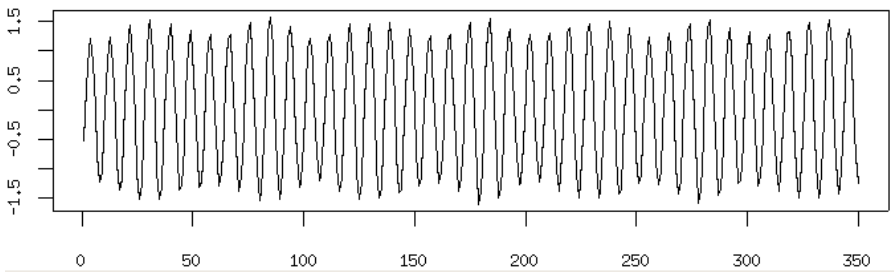
Temporal ICA simulation results

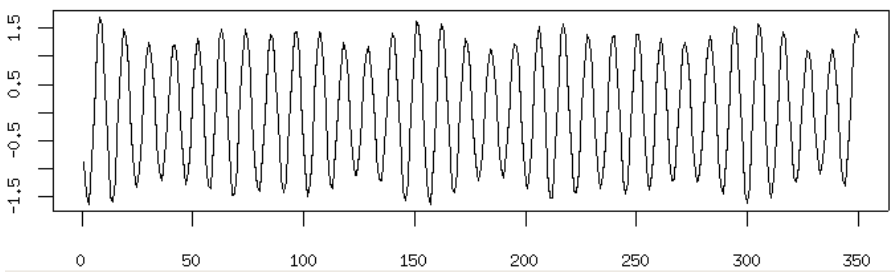


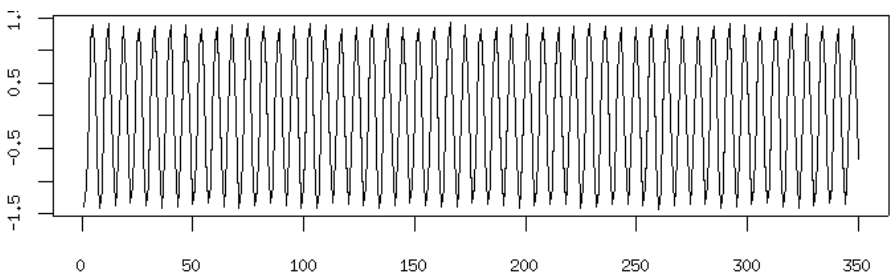
Better Results

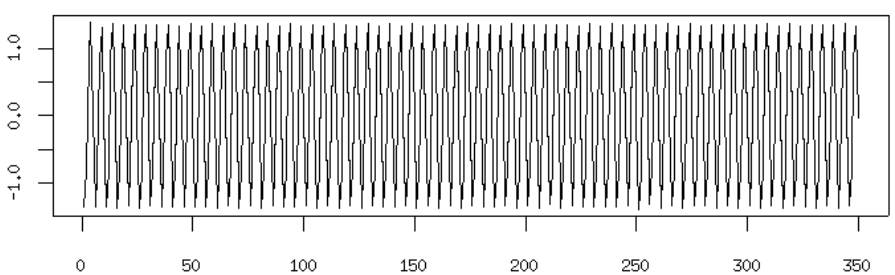






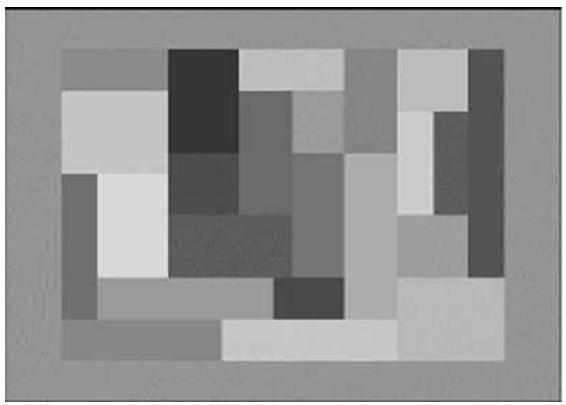






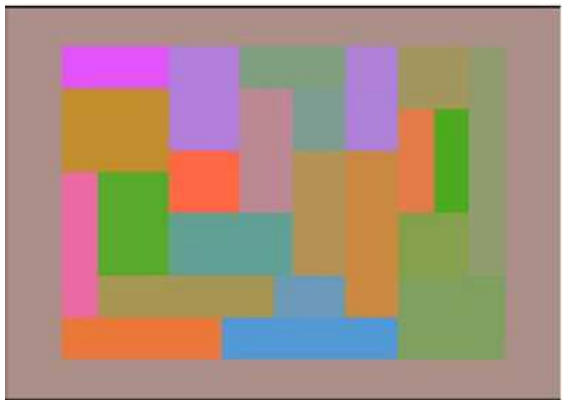
Real fMRI data with the AnalyzeFMRI package

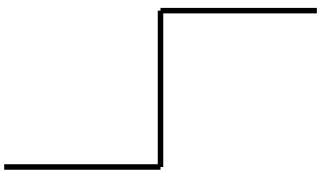
- Experimental Protocol



Real fMRI data with the AnalyzeFMRI package

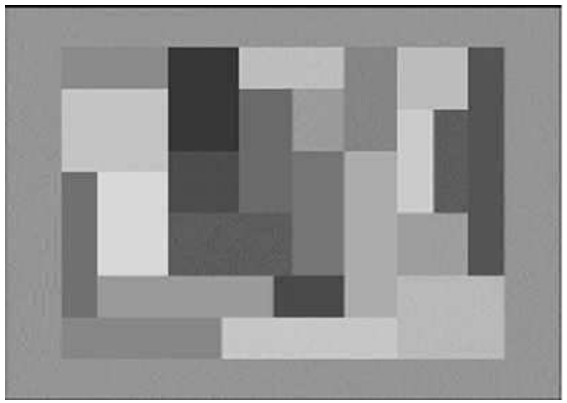
- Experimental Protocol

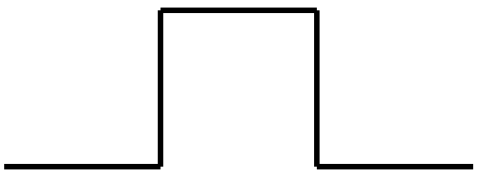




Real fMRI data with the AnalyzeFMRI package

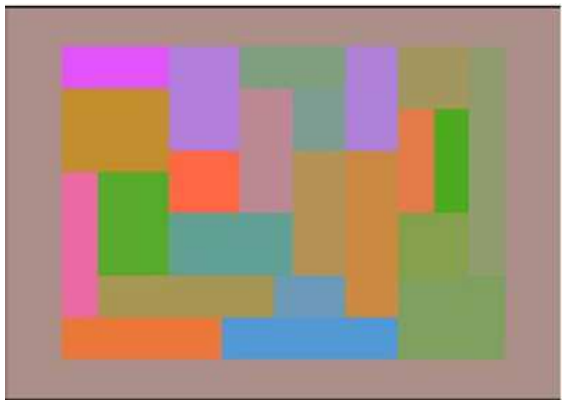
- Experimental Protocol

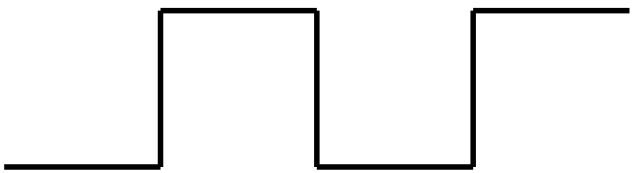




Real fMRI data with the AnalyzeFMRI package

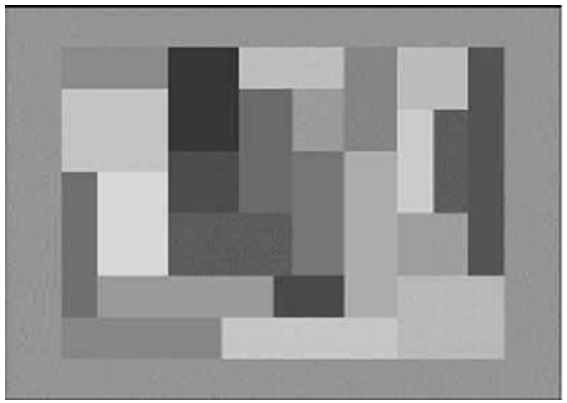
- Experimental Protocol

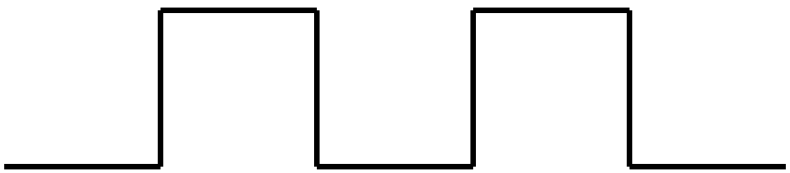




Real fMRI data with the AnalyzeFMRI package

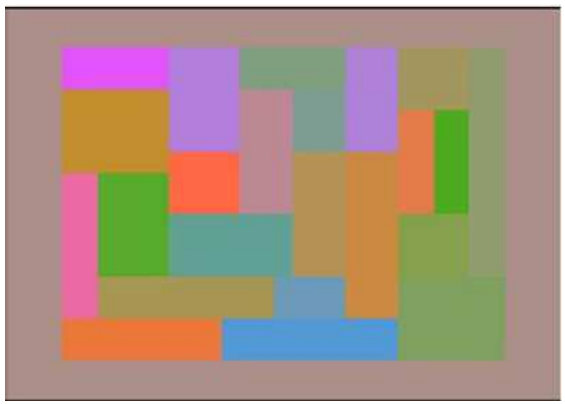
- Experimental Protocol

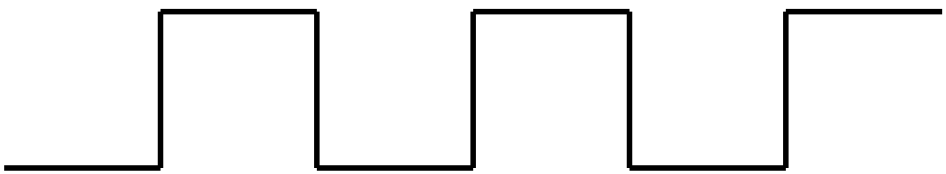




Real fMRI data with the AnalyzeFMRI package

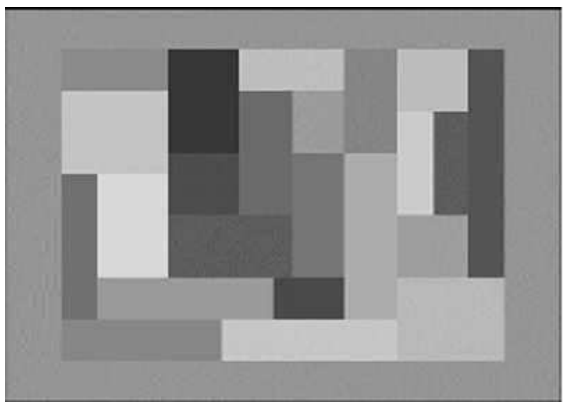
- Experimental Protocol

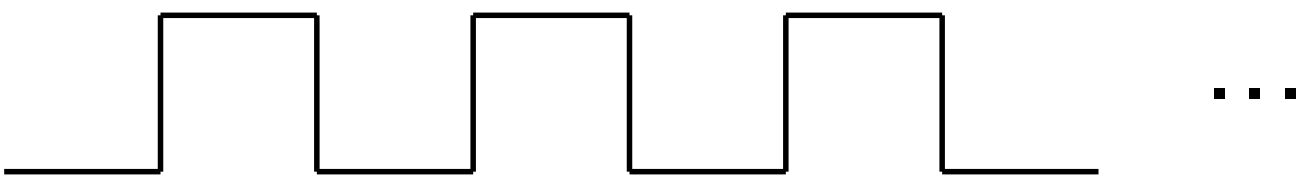




Real fMRI data with the AnalyzeFMRI package

- Experimental Protocol





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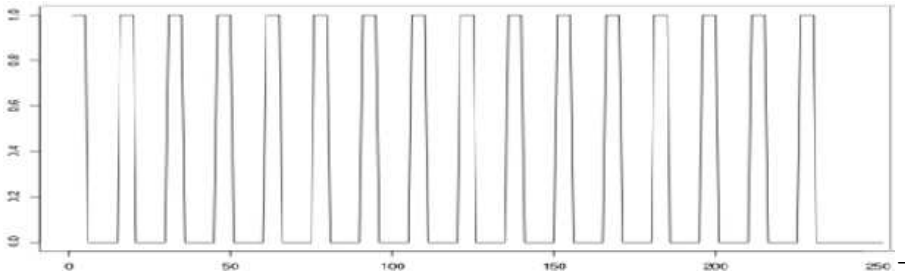
Real fMRI data results with the AnalyzeFMRI package

- Original



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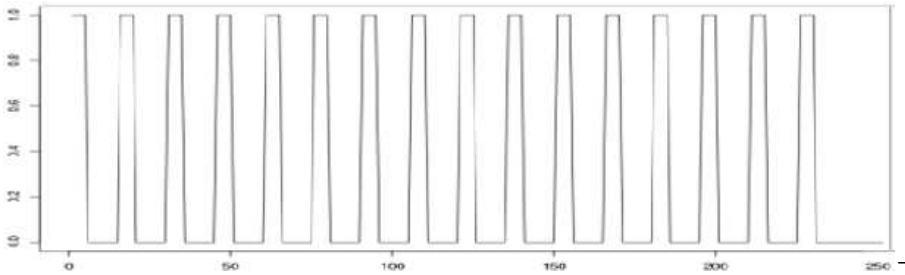
Real fMRI data results with the AnalyzeFMRI package

- Original



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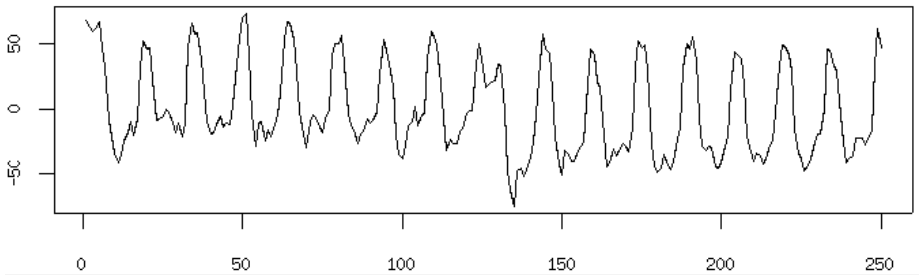
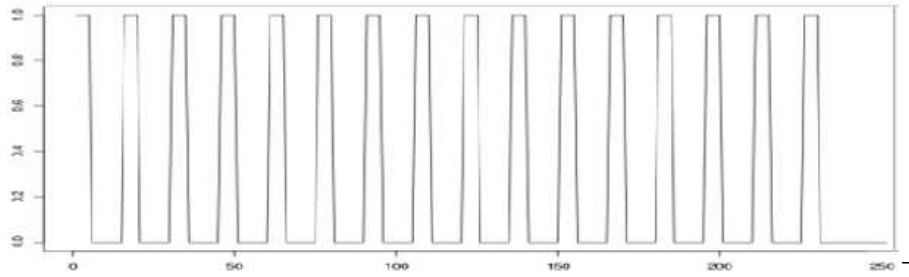
- Spatial ICA signal result



cor= -0.52

Real fMRI data results with the AnalyzeFMRI package

- Original



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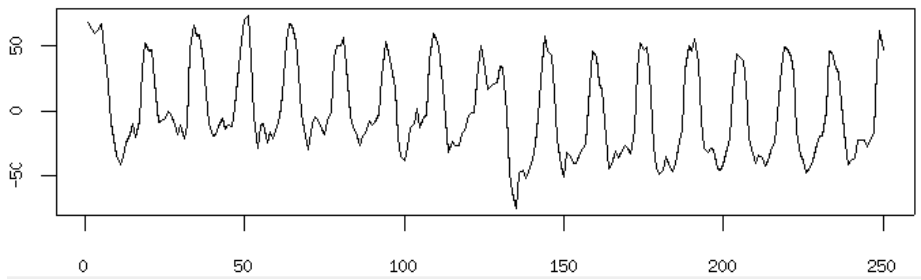
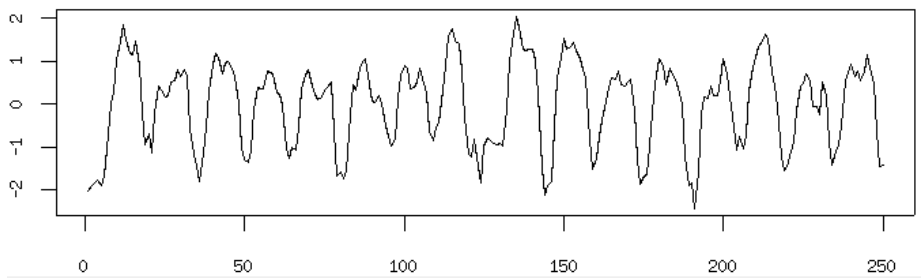
- Spatial ICA signal result



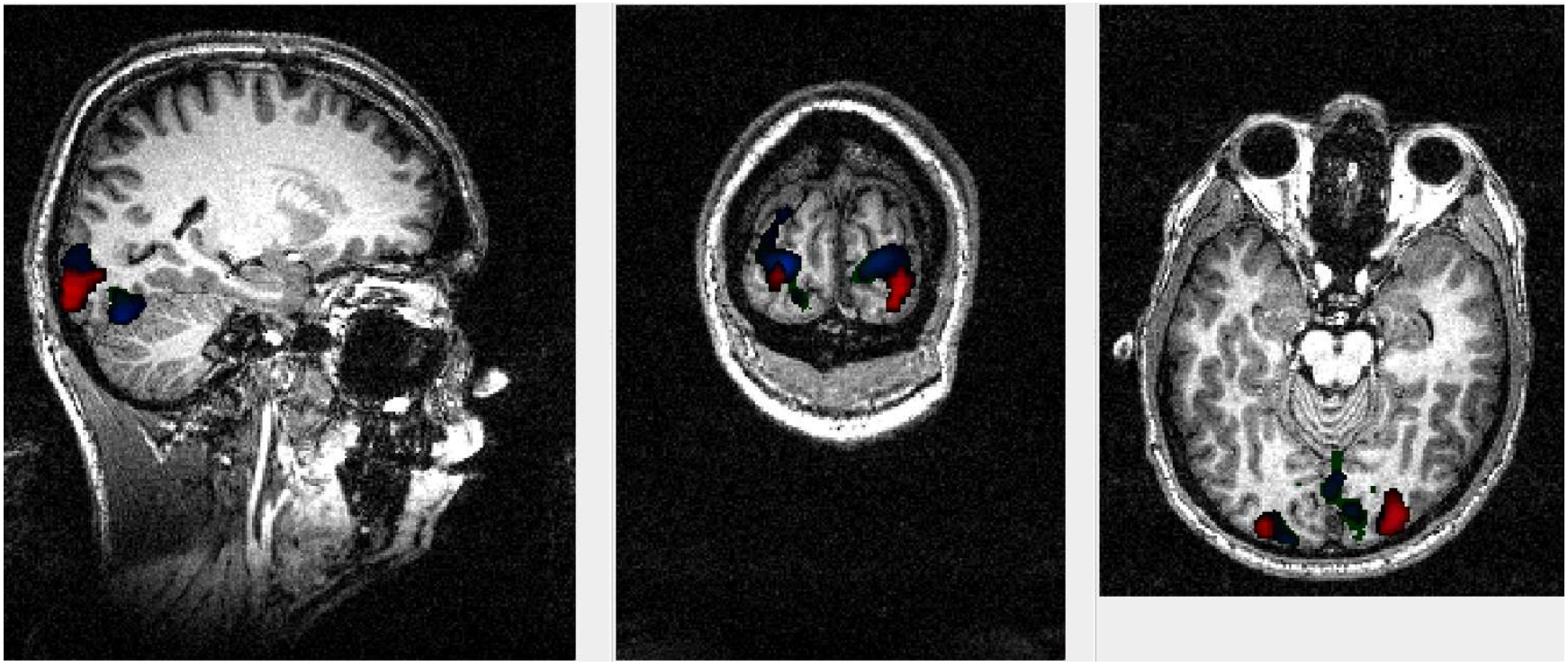
cor= -0.52

- Temporal ICA signal result



cor= 0.44

Comparison results



Temporal ICA results
Spatial ICA results

Results obtained with spm
general linear model

AnalyzeFMRI Package

Updates :

- Image Format in the package :

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti

AnalyzeFMRI Package

Updates :

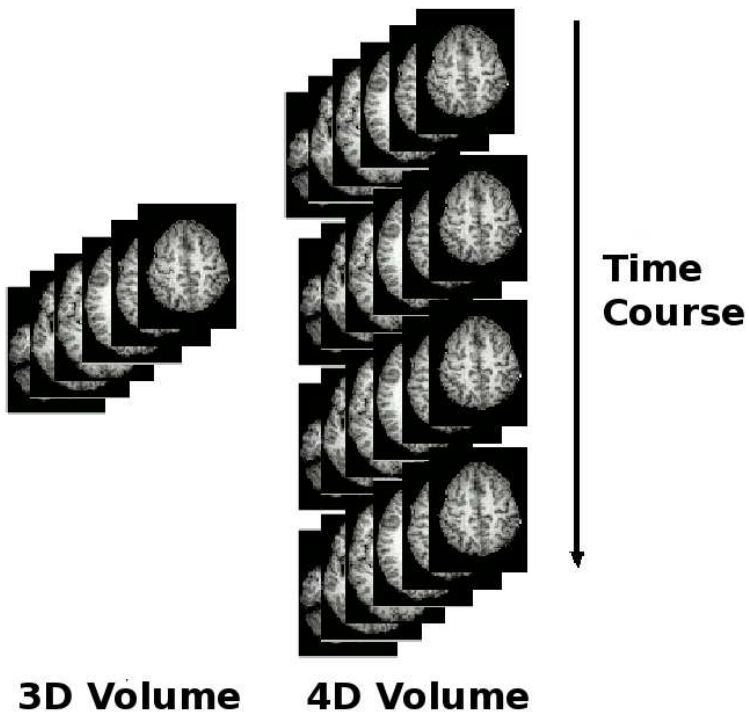
- Image Format in the package :
  - Existing : Analyze
  - New : nifti
    - Read, write, modify metada

More than 40 parameters: orientations, size, subject informations...

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti
    - Read, write, modify metada
    - Read, write, convert 3D and/to 4D



AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti
    - Read, write, modify metada
    - Read, write, convert 3D and/to 4D
    - Display nifti volume

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti
- ICA
  - Existing : Spatial ICA

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti
- ICA
  - Existing : Spatial ICA
  - New : Temporal ICA

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti
- ICA
  - Existing : Spatial ICA
  - New : Temporal ICA

Submission to CRAN very soon!

AnalyzeFMRI Package

Updates :

- Image Format in the package :
  - Existing : Analyze
  - New : nifti
- ICA
  - Existing : Spatial ICA
  - New : Temporal ICA

Submission to CRAN very soon!

Maintainers: Pierre Lafaye de Micheaux

Cécile Bordier

Thank you
for
your attention