

The human brain resting state networks based on high time resolution EEG

R.D. Pascual-Marqui_{1,2}, D. Lehmann₁, M. Koukkou₁, M. Esslen₃, K. Nishida₂, M. Yoshimura₂, N. Saito₄, R. John₅, L. Prichep₅, P. Anderer₆, K. Kochi₁, T. Kinoshita₂

1: The KEY Institute for Brain-Mind Research, University Hospital of Psychiatry, Zurich

2: Department of Neuropsychiatry, Kansai Medical University Hospital, Osaka

3: Institute of Psychology, University of Zurich, Zurich

4:

5: Brain Research Laboratories, New York University School of Medicine, New York

6: Department of Psychiatry and Psychotherapy, Medical University of Vienna, Vienna

Part 1: Introduction

Part 2: Tutorial on using software

Part 1: Introduction

What is neuroimaging?

99% of the time

(example)

- Measure BOLD signals in two groups of subjects
- At each voxel in the brain, compare the BOLD signals by computing a *t*-test (millions of *t*-tests, one for each voxel)
- Set an appropriate threshold (correct for multiple tests), and report significant voxels (hot-spots or cold-spots)

Example: comparing Schizophrenic patients with normal control subjects

◆ Human Brain Mapping 25:60–69(2005)

Beyond Hypofrontality: A Quantitative Meta-Analysis of Functional Neuroimaging Studies of Working Memory in Schizophrenia

David C. Glahn,^{1,2*} J. Daniel Ragland,³ Adir Abramoff,⁴ Jennifer Barrett,¹
Angela R. Laird,² Carrie E. Bearden,⁵ and Dawn I. Velligan¹

Schizophrenic patients vs control subjects

◆ Human Brain Mapping 25:60–69(2005)

Activity: A Quantitative
Functional Neuroimaging
Study of Working Memory in Schizophrenia

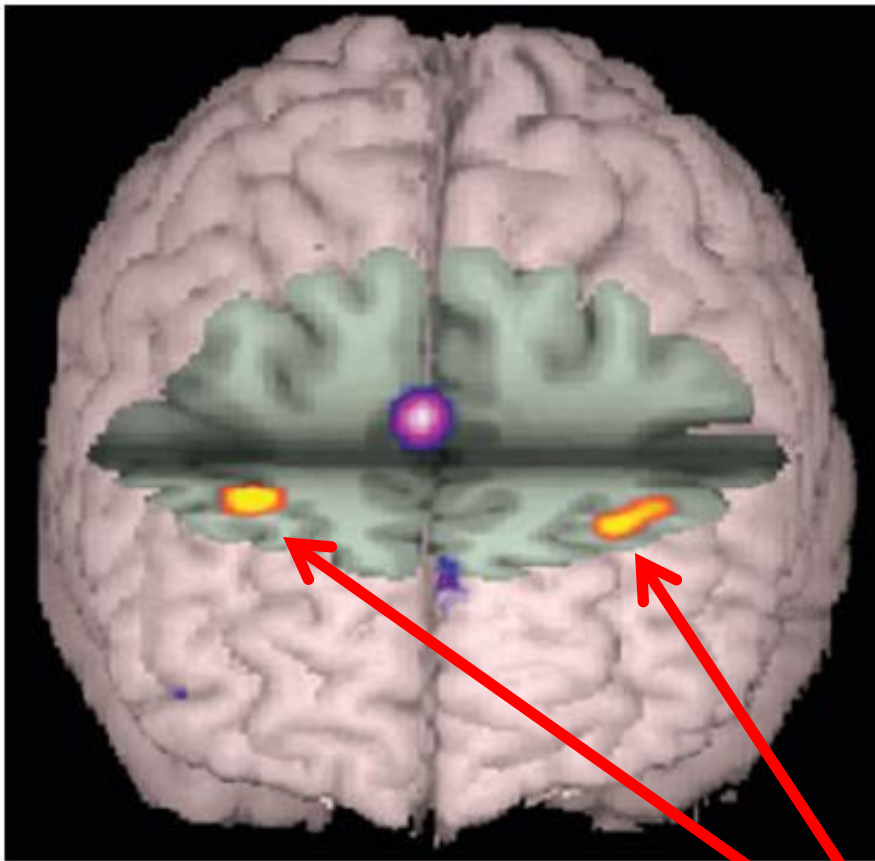


Figure 2.

Volume rendering of between-group contrasts where relative increased activity for healthy subjects is presented in red-yellow (DLPFC; BA9) and relative increased activity for patients with schizophrenia is shown in purple-pink (anterior cingulate; BA32). Although patients with schizophrenia engaged the DLPFC less than comparison subjects, they overactivated a portion of the anterior cingulate. Evidence of reduced DLPFC activation and increased activity in the anterior cingulate may be consistent with the notion that schizophrenia disrupts or reverses the normal functional connectivity of prefrontal and limbic structures.

Hypometabolism in schizophrenia: is it localized only here???

There is nothing wrong with classical neuroimaging

However, it gives very limited information

Can behavioral disorders, therapy effects, or cognition be assigned to some few hot-spots in the brain?

NO

Alternative approach: from hot-spots to distributions (networks)

Different parts of the brain work in a certain relationship to each other

Break the relations, and you have an emergent behavioral disorder

What is the “resting state”?

- **Wakeful rest**
- **Mind-wandering**
- **Spontaneous thoughts**
- **Daydreaming**
- **Retrieving memories**
- **Stimulus independent thoughts**
- **Absence of goal-directed neuronal action and external input**

- **REST = Random Episodic Spontaneous Thoughts**

- **EEG: resting, eyes closed, awake**

What is the “resting state”?

Resting brain \neq Inactive brain

NEUROSCIENCE

The Brain's Dark Energy

Marcus E. Raichle

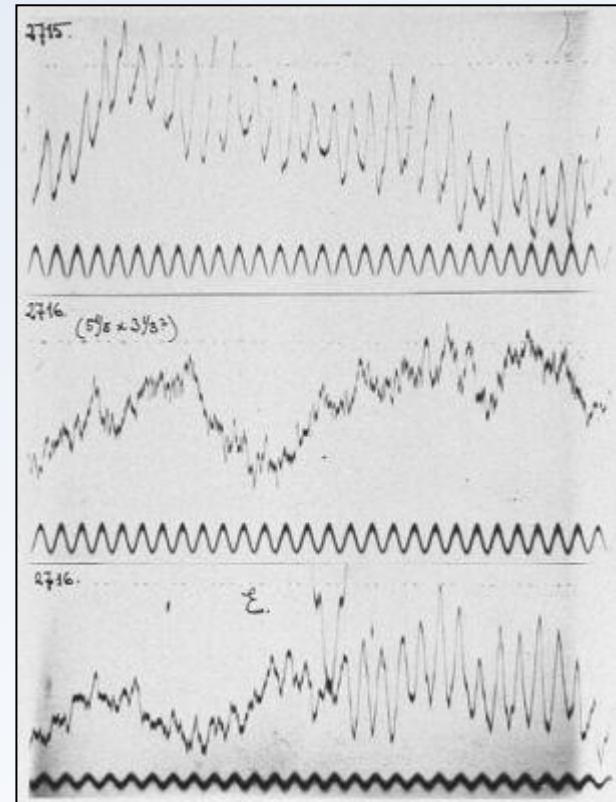
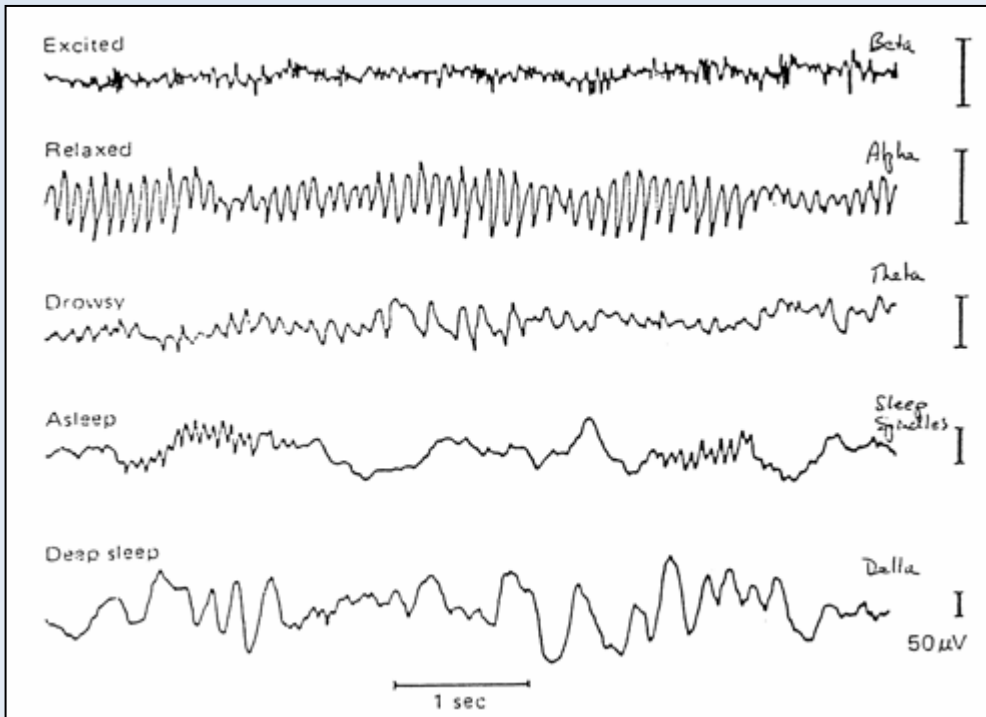
SCIENCE VOL 314 24 NOVEMBER 2006

it is estimated that 60 to 80% of the energy budget of the brain supports communication among neurons and their supporting cells (2). The additional energy burden associated with momentary demands of the environment may be as little as 0.5 to 1.0% of the total energy budget (2).

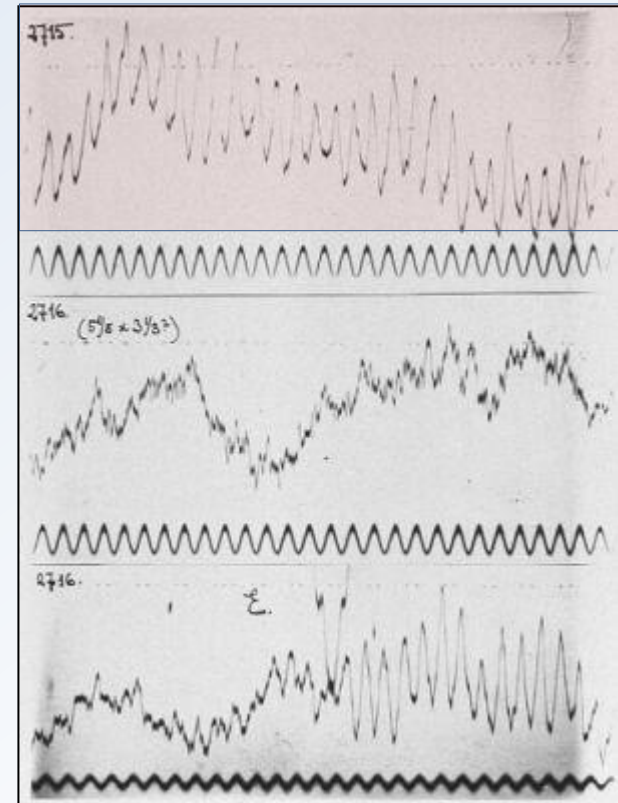
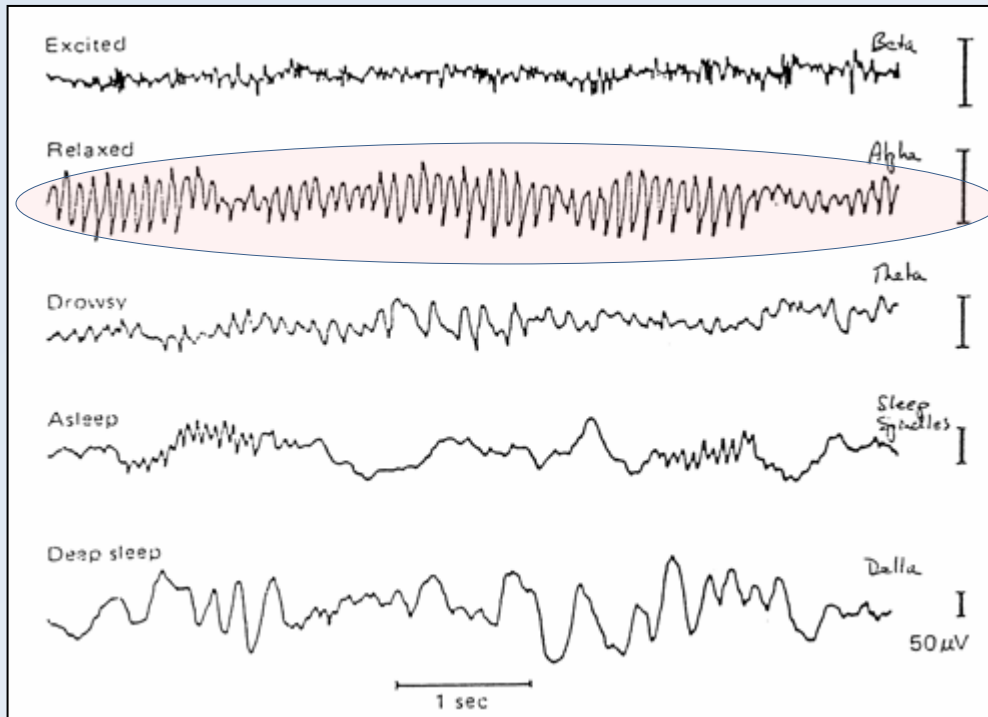
The resting state is important

**It is the dynamic substrate of the “present”,
momentary state of the brain, and determines
the fate of incoming information**

Resting state, first observations: EEG, Hans Berger, 1929

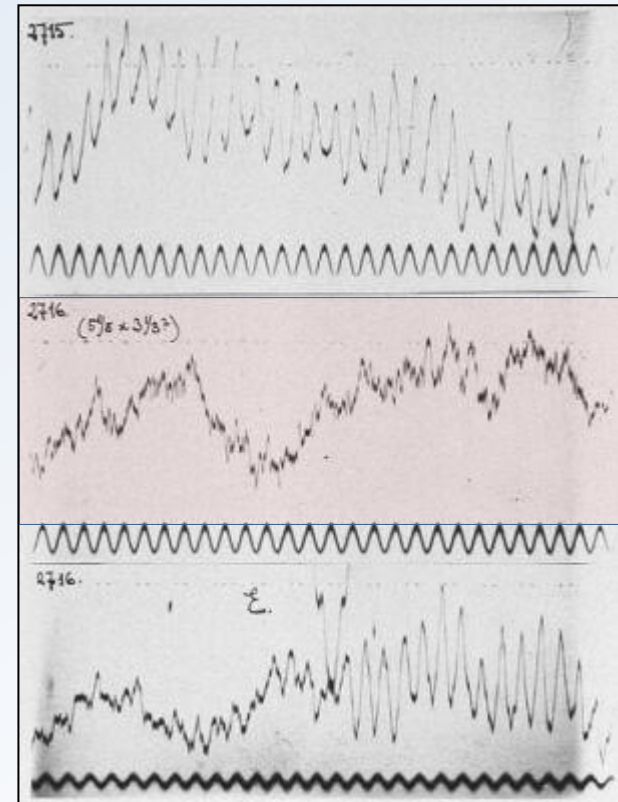
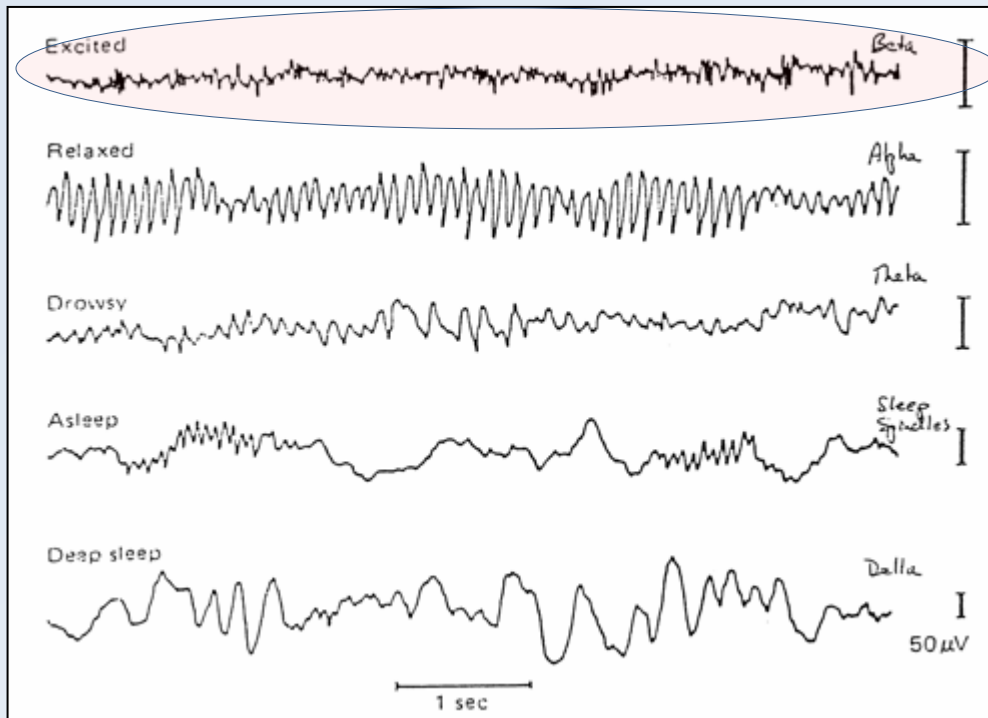


Resting state, first observations: EEG, Hans Berger, 1929



Rest (eyes closed)

Resting state, first observations: EEG, Hans Berger, 1929



Eyes-open

What are “resting state networks (RSN)”?

New definition (less than 10 years old), old ideas

First famous network: “default mode”, but it is just one of the many “resting state networks”

Default mode network (DMN): a set of brain regions that are jointly **active** during rest, and that jointly **deactivate** in any task.

Default mode network example

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REVIEW ARTICLES

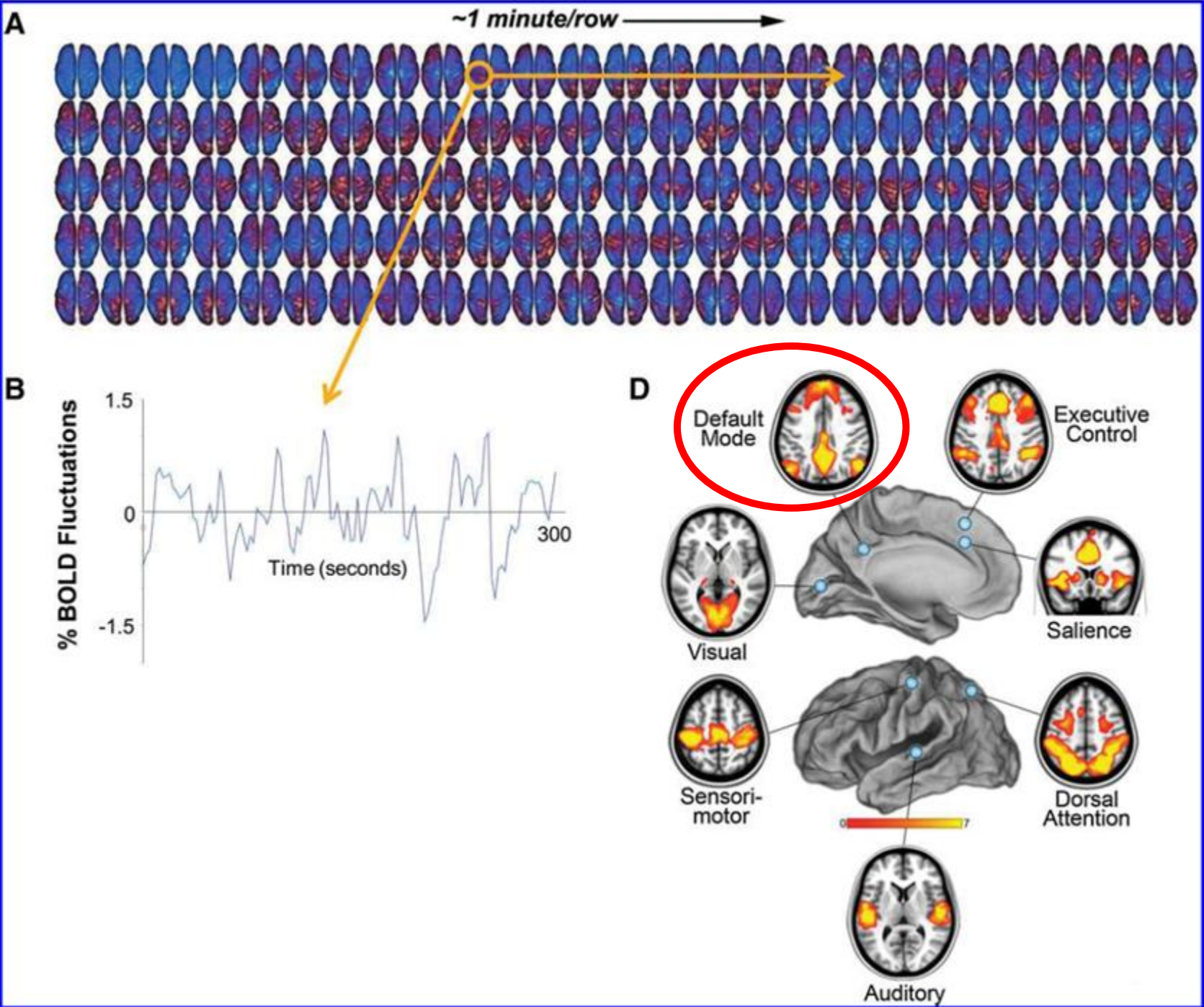
The Restless Brain

Marcus E. Raichle

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DOI:

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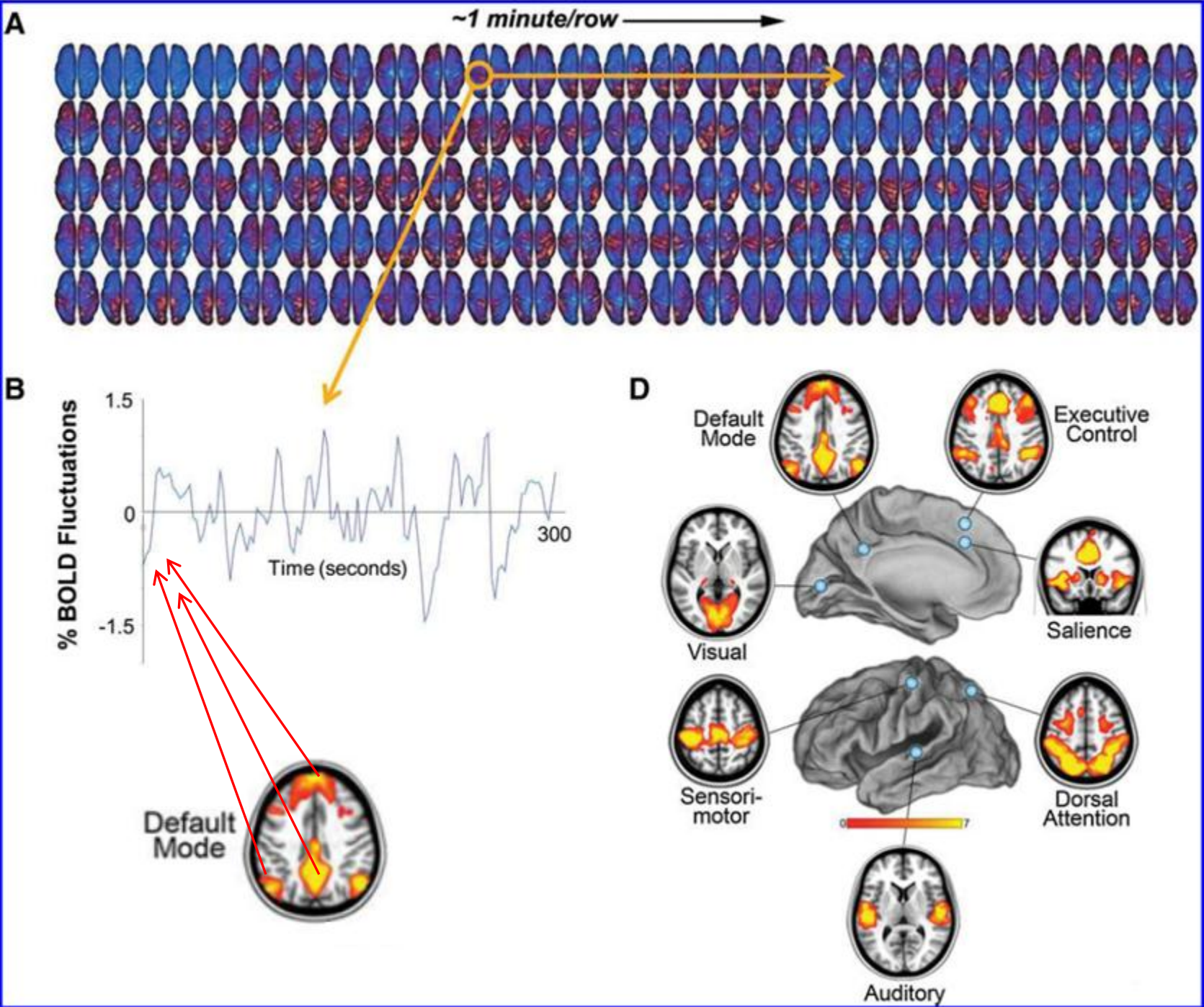
What are “resting state networks”?

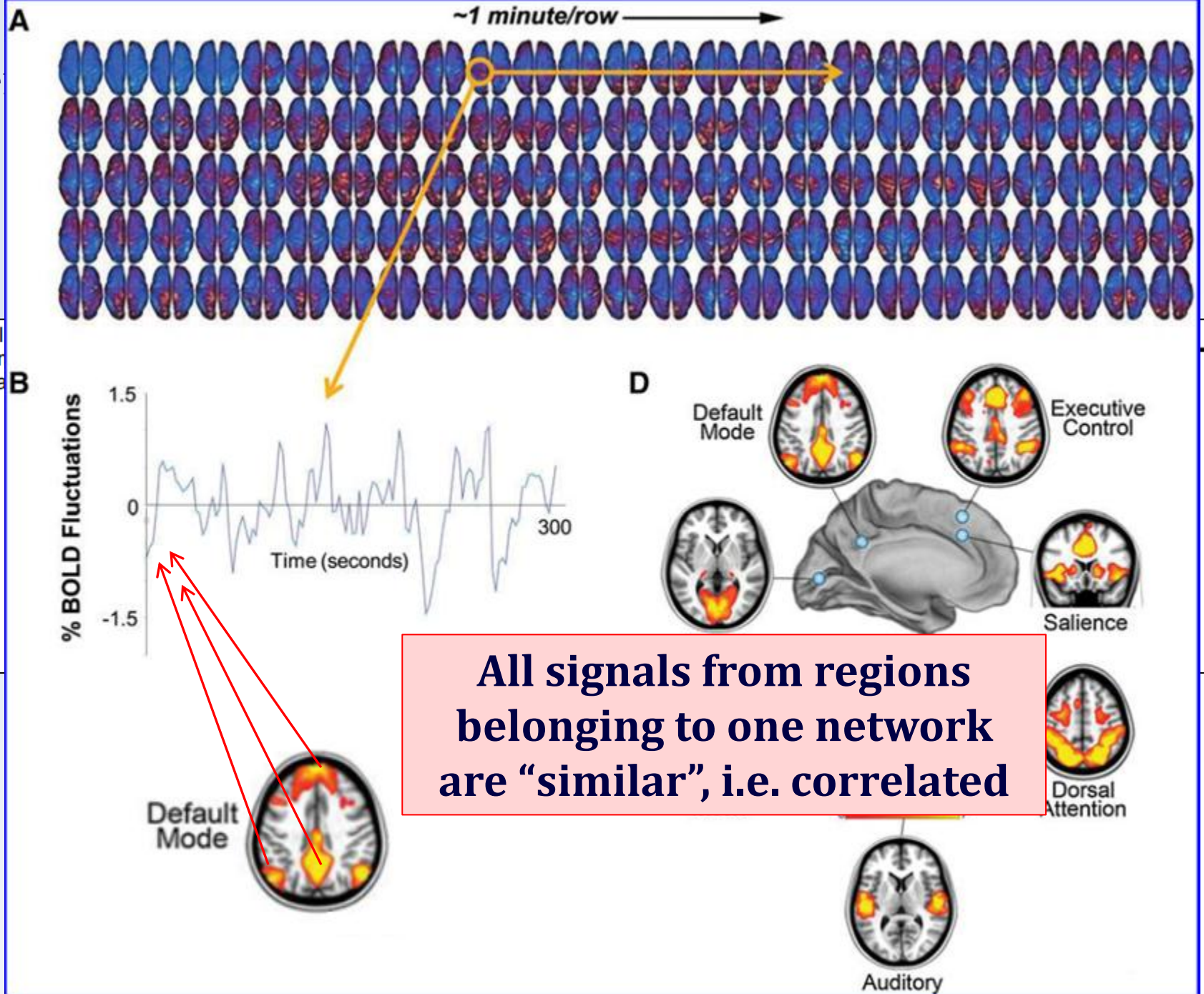
A network is composed of a group of brain regions, with “correlated” time varying activities.

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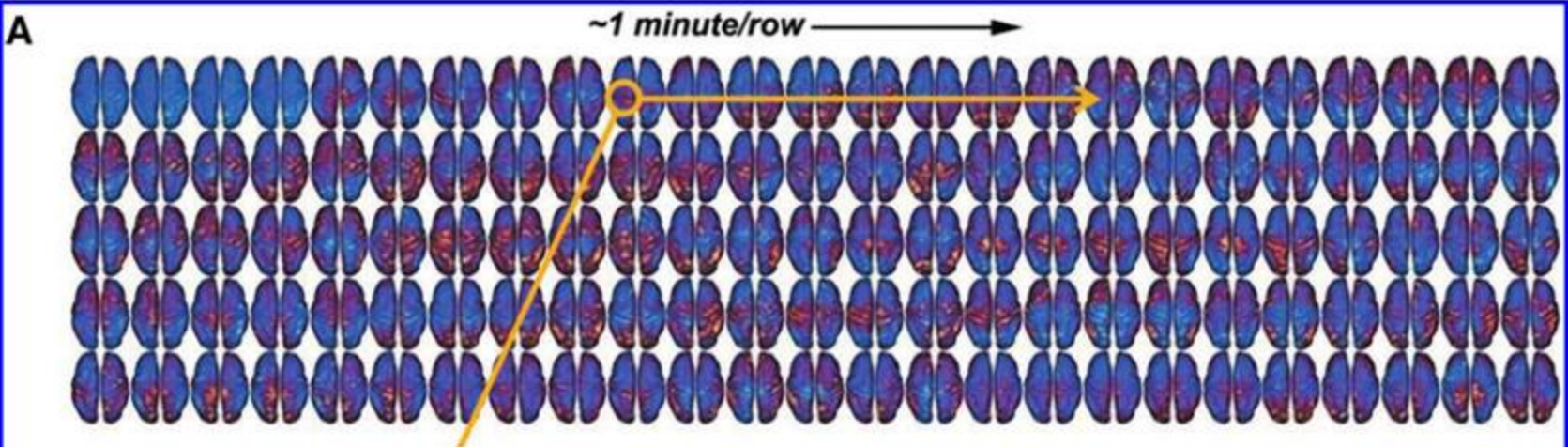


What are “resting state networks”?

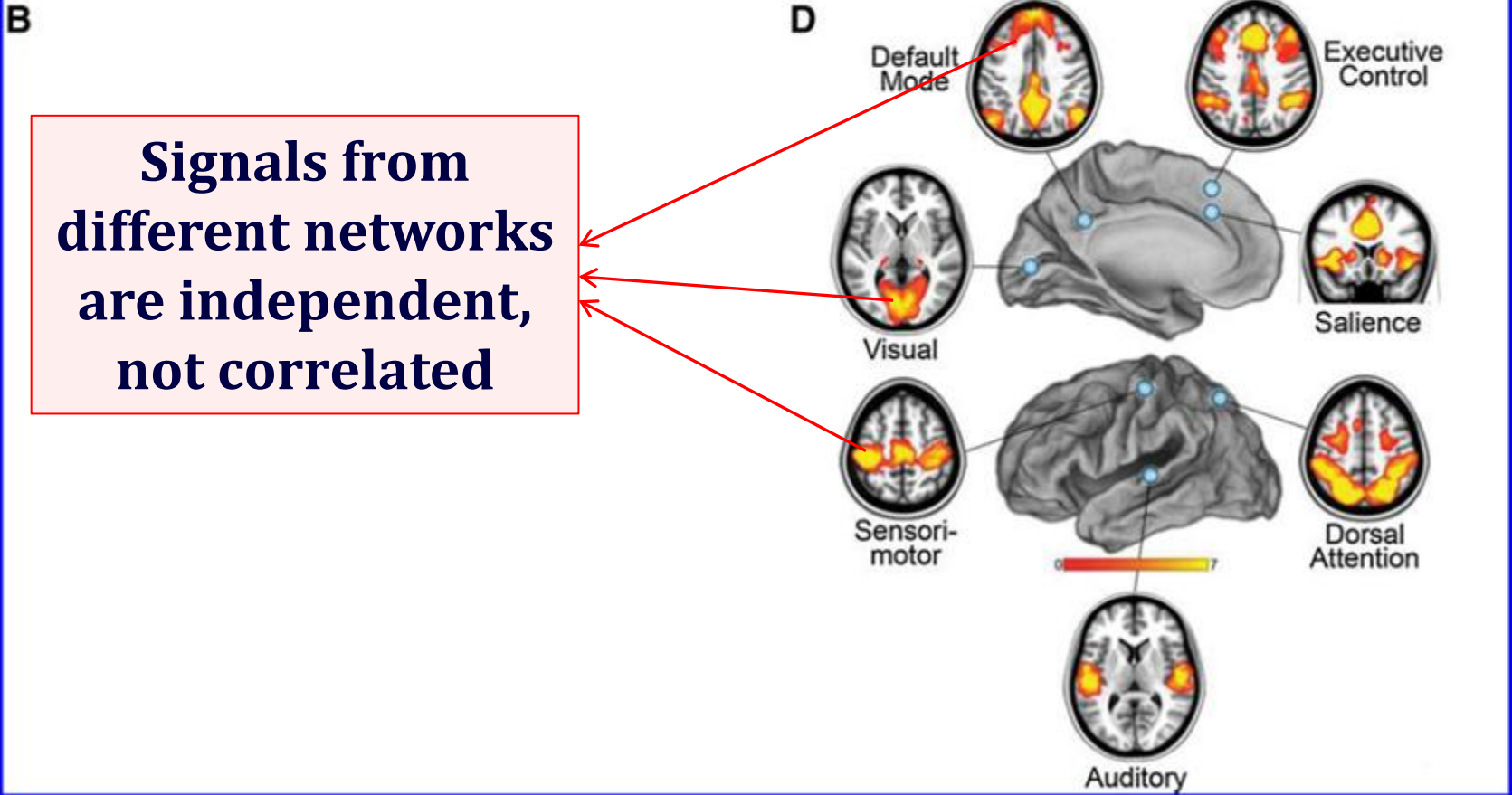
A network is composed of a group of brain regions, with “correlated” time varying activities.

Different networks work independently of each other.

De



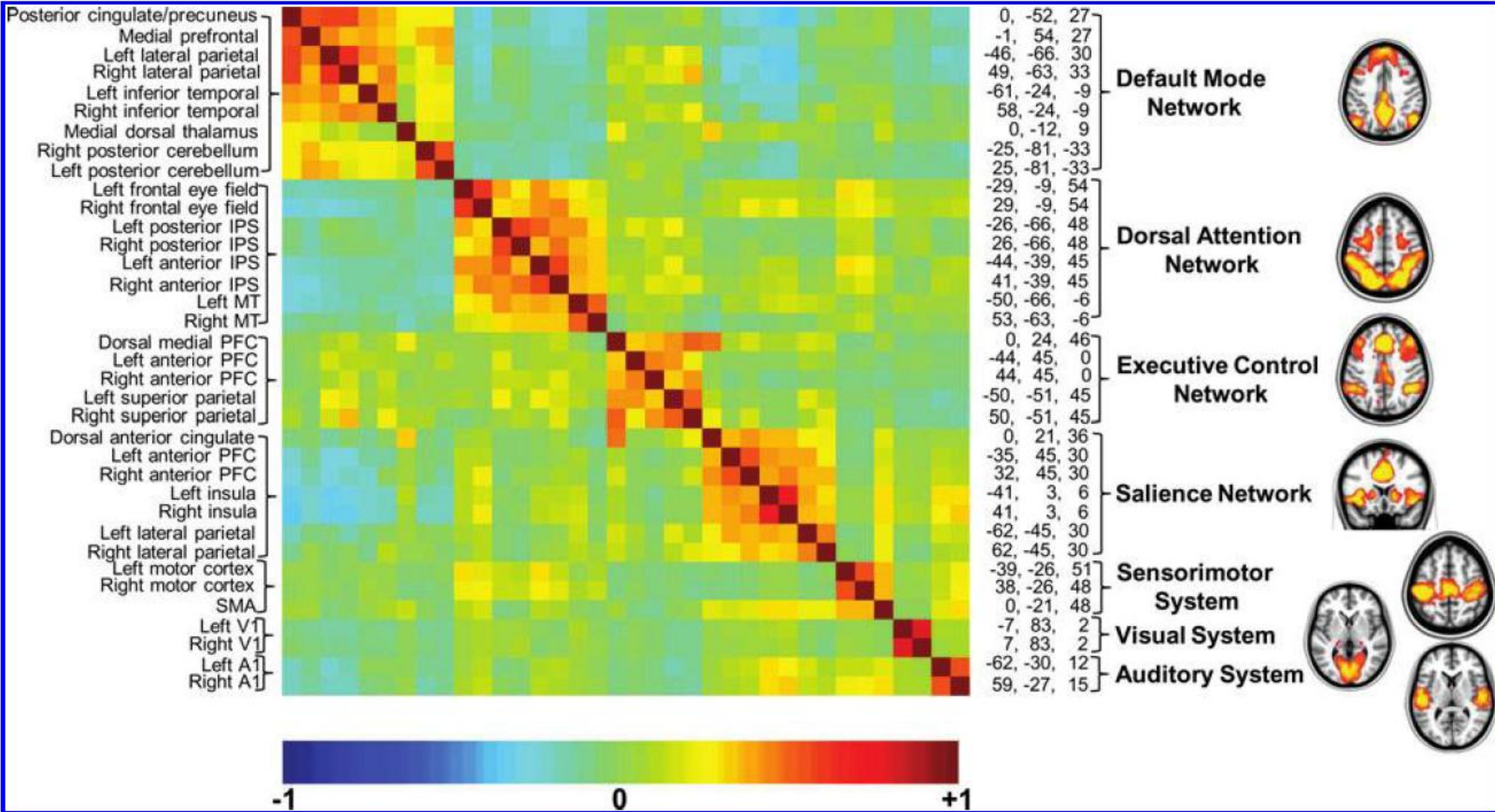
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Signals from different networks are independent, not correlated

Default mode network example



Resting state networks

Most of the recent literature, based on fMRI experiments, use many different methods of analysis such as ICA (independent components analysis), correlation analysis, clustering techniques, all with converging results



A baseline for the multivariate comparison of resting-state networks

Elena A. Allen^{1*}, Erik B. Erhardt¹, Eswar Damaraju¹, William Gruner^{1,2}, Judith M. Segall^{1,3}, Rogers F. Silva^{1,2}, Martin Havlicek^{1,2}, Srinivas Rachakonda¹, Jill Fries¹, Ravi Kalyanam^{1,2}, Andrew M. Michael¹, Arvind Caprihan¹, Jessica A. Turner^{1,4}, Tom Eichele⁵, Steven Adelsheim⁴, Angela D. Bryan^{1,6,7}, Juan Bustillo^{4,8}, Vincent P. Clark^{1,6,8}, Sarah W. Feldstein Ewing¹, Francesca Filbey^{1,9}, Corey C. Ford¹⁰, Kent Hutchison^{1,6,8}, Rex E. Jung^{1,11}, Kent A. Kiehl^{1,6,8}, Piyadasa Kodituwakku¹², Yuko M. Komesu¹³, Andrew R. Mayer^{1,10}, Godfrey D. Pearlson^{14,15,16}, John P. Phillips^{1,10}, Joseph R. Sadek^{4,17}, Michael Stevens^{14,15}, Ursina Teuscher^{1,6}, Robert J. Thoma^{1,4,6} and Vince D. Calhoun^{1,2,4,8,15}

¹ The Mind Research Network, Albuquerque, NM, USA

² Department of Electrical and Computer Engineering, University of New Mexico, Albuquerque, NM, USA

³ Department of Family and Community Medicine, University of New Mexico, Albuquerque, NM, USA

⁴ Department of Psychiatry, University of New Mexico, Albuquerque, NM, USA

⁵ Department of Biological and Medical Psychology, Faculty of Psychology, University of Bergen, Bergen, Norway

⁶ Department of Psychology, University of New Mexico, Albuquerque, NM, USA

⁷ Center on Alcoholism Substance Abuse and Addiction, University of New Mexico, Albuquerque, NM, USA

⁸ Department of Neuroscience, University of New Mexico, Albuquerque, NM, USA

⁹ Center for BrainHealth, School of Behavioral and Brain Sciences, University of Texas at Dallas, Dallas, TX, USA

¹⁰ Department of Neurology, University of New Mexico, Albuquerque, NM, USA

¹¹ Department of Neurosurgery, University of New Mexico, Albuquerque, NM, USA

¹² Center for Development and Disability, University of New Mexico, Albuquerque, NM, USA

¹³ Department Obstetrics and Gynecology, University of New Mexico, Albuquerque, NM, USA

¹⁴ Olin Neuropsychiatry Research Center, The Institute of Living, Hartford, CT, USA

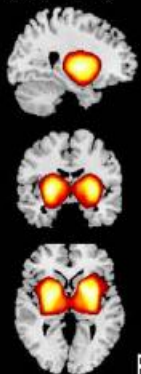
¹⁵ Department of Psychiatry, Yale University, New Haven, CT, USA

¹⁶ Department of Neurobiology, Yale University, New Haven, CT, USA

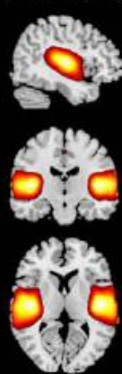
¹⁷ Behavioral Health Care Line, New Mexico VA Health Care System, Albuquerque, NM, USA

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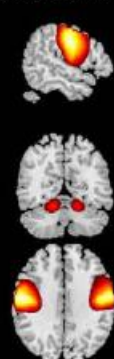
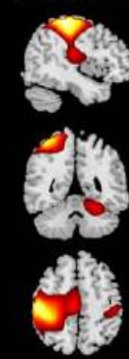
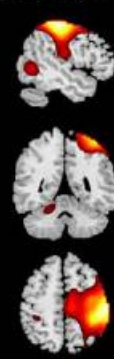
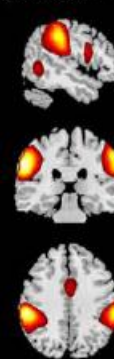
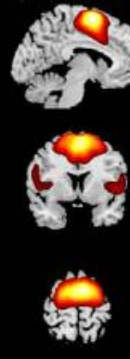
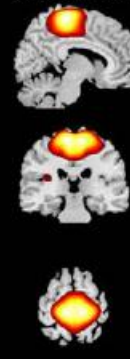
BASAL GANGLIA NETWORK

IC 21
(-28, -7, -1)

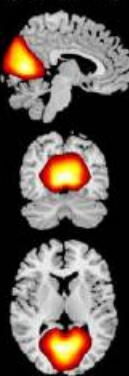
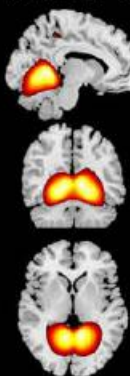
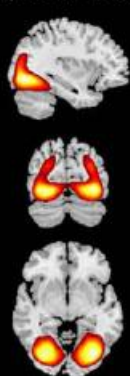
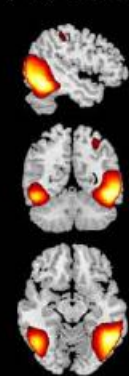
AUDITORY NETWORK

IC 17
(-46, -16, +6)

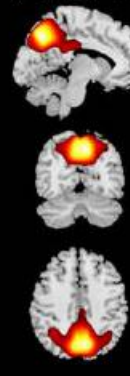
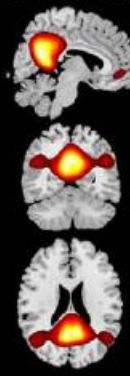
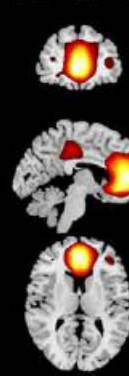
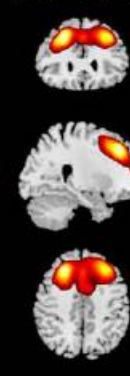
SENSORIMOTOR NETWORKS

IC 7
(-57, -63, +33)IC 23
(-46, -51, +51)IC 24
(-51, -51, +54)IC 38
(-52, -30, +40)IC 56
(+7, +7, +69)IC 29
(-9, -28, +67)

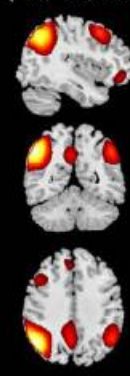
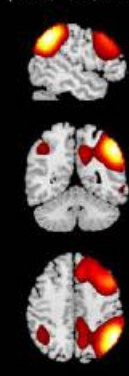
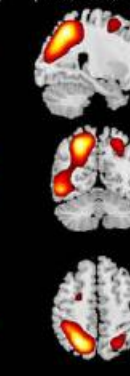
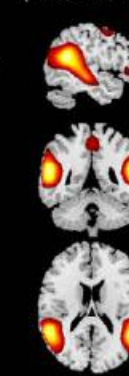
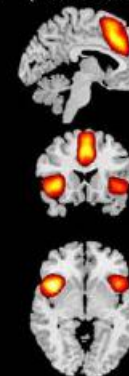
VISUAL NETWORKS

IC 46
(+5, -84, -10)IC 64
(-6, -70, +7)IC 67
(+10, -54, -1)IC 48
(+36, -78, -9)IC 39
(+49, -58, -16)IC 59
(+21, -93, +33)

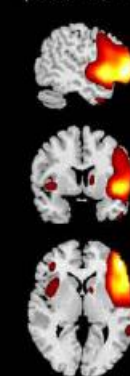
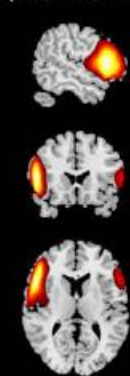
DEFAULT-MODE NETWORKS

IC 50
(+9, -70, +43)IC 53
(-7, -60, +22)IC 25
(+5, +45, +10)IC 68
(-27, +30, +45)

ATTENTIONAL NETWORKS

IC 34
(-42, -57, +37)IC 60
(+52, -54, +45)IC 52
(-26, -63, +51)IC 72
(+27, -55, +63)IC 71
(+51, -48, +18)IC 55
(+5, +21, -7)

FRONTAL NETWORKS

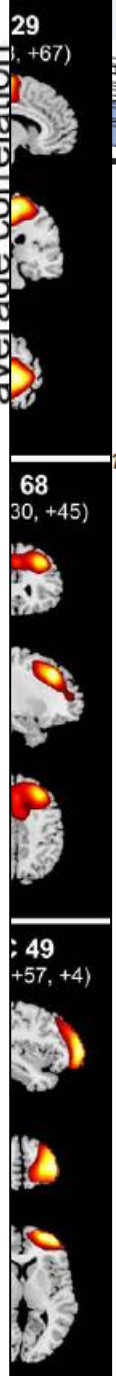
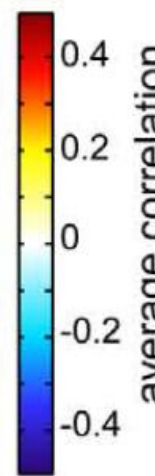
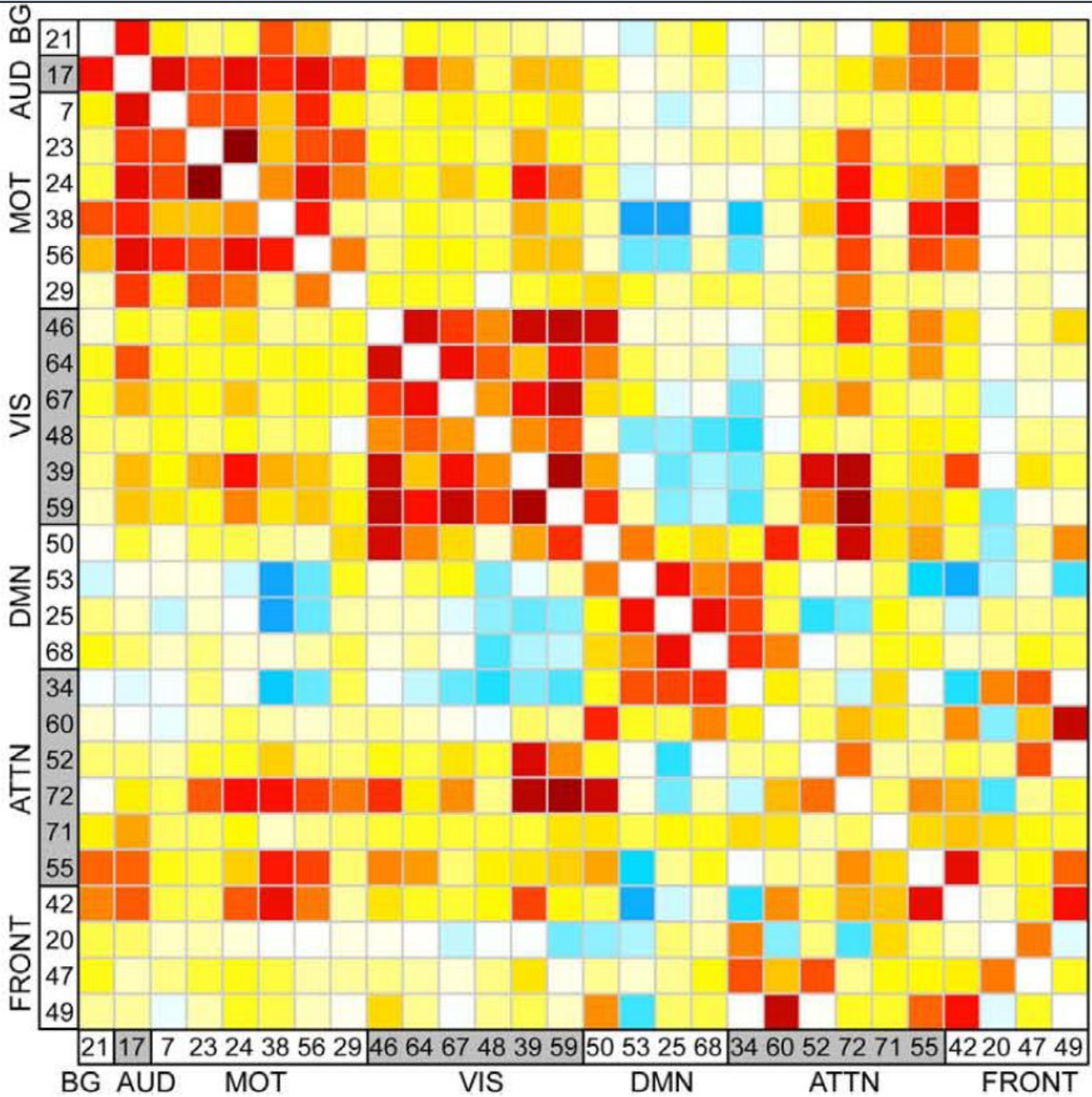
IC 42
(+51, +7, +1)IC 20
(-55, +22, +10)IC 47
(-49, +27, +24)IC 49
(+39, +57, +4)

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VISUAL NETWORKS

ATTENTIONAL NETWORKS

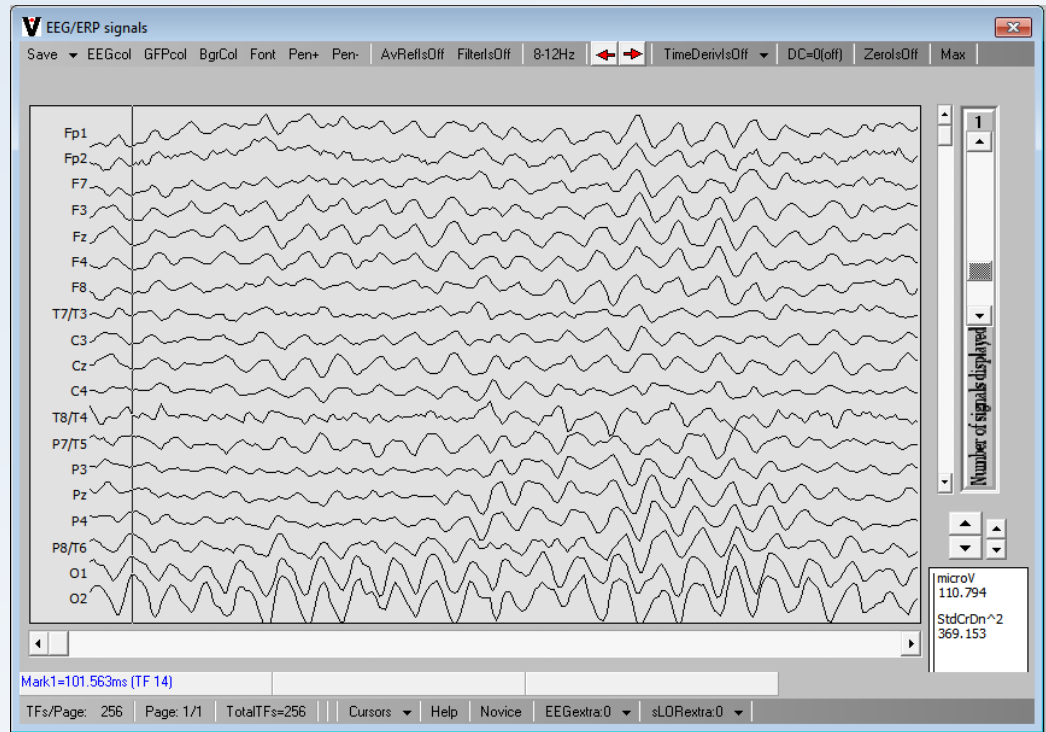


The resting state is important

It is the dynamic substrate of the “present”, momentary state of the brain, and determines the fate of incoming information

During rest, the brain goes through all working modes: sensory, **attention**, executive control, language, ... and rest

E.g.: Attention deficit = abnormal attention network, decreased time, weak interconnections, ...



LORETA explorer (EEG/ERP time domain)

Data Type: NumberOfElectrodes(19) SamplingRateHz(128) Offset(0) Jobs File ColorScales Tools Window ClearFiles Viewinfo [Exp(sLORETA):IsOff] Help

Data Type: slorCol ScalpCol AnatCol Slices AllSlices 3DCortex ScalpMap Signals FileExplorer DragDropUtil WindowsExplorer AdjustScreenSize

3D cortex/scalp/electrodes

Left Right Top Botm Front Back

Reset Rprnt BVws BVws

Save Cortex contrast

CtrlC ScpC ElctrC BgrC ScpDn Ctrlx0 Scp0 Elctr0 ElctrDn Max

Scalp map

ScpC BgrC Scp0 Save Reset Rprnt Max Help

EEG/ERP signals

Save EEGool GFPool BgrCol Font Pen+ Pen- AvRefsOff FiltersOff 8-12Hz TimeDerivsOff DC=0(off) ZerolsOff Max

Fp1 Fp2 F7 F3 Fz F4 F8 T7/T3 C3 Cz C4 T8/T4 P7/T5 P3 Pz P4 P8/T6 O1 O2

Number of signals displayed: 1

microV 110.794
StdCrDn^2 369.153

Mark1=101.563ms (TF 14)

TFs/Page: 256 Page: 1/1 TotalTFs=256 Cursors Help Novice EEGextra:0 sLORextra:0

SliceViewer

Save AnatColors InitialView JumpMax JumpMin JumpZero Jump to... Max Help CopyToClipBrd

[X,Y,Z]=[10;-70;15][mm] ; (3.11E+1) ; 14

Neuroanatomy (Talairach labels):

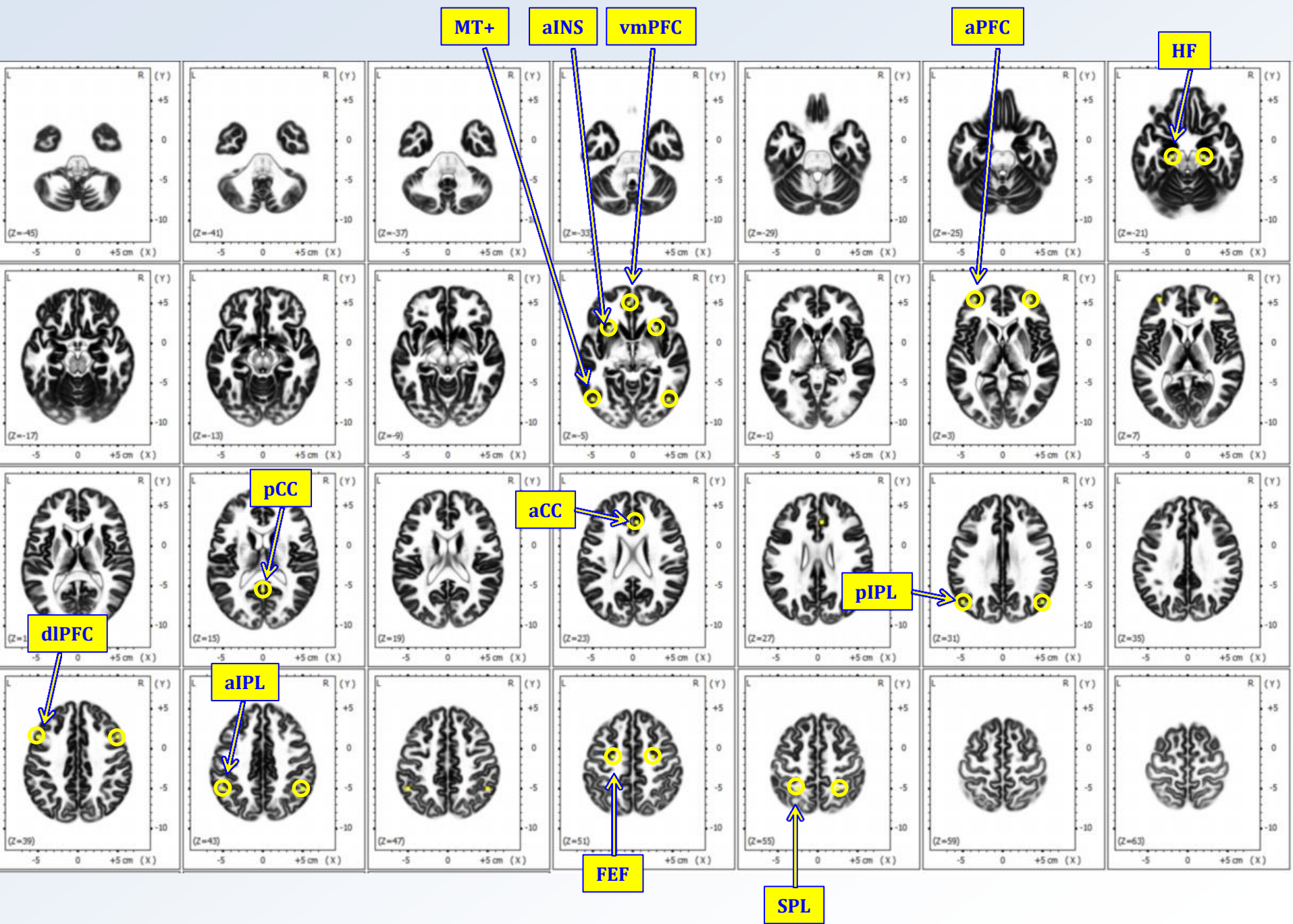
Track Append Hits: 1 Cpy2ClpBrd Save2File

Value= 3.11E+1
(X= 10 , Y= -70 , Z= 15) (MNI coords)

Best Match at 0 mm
Brodmann area 31
Posterior Cingulate
Limbic Lobe

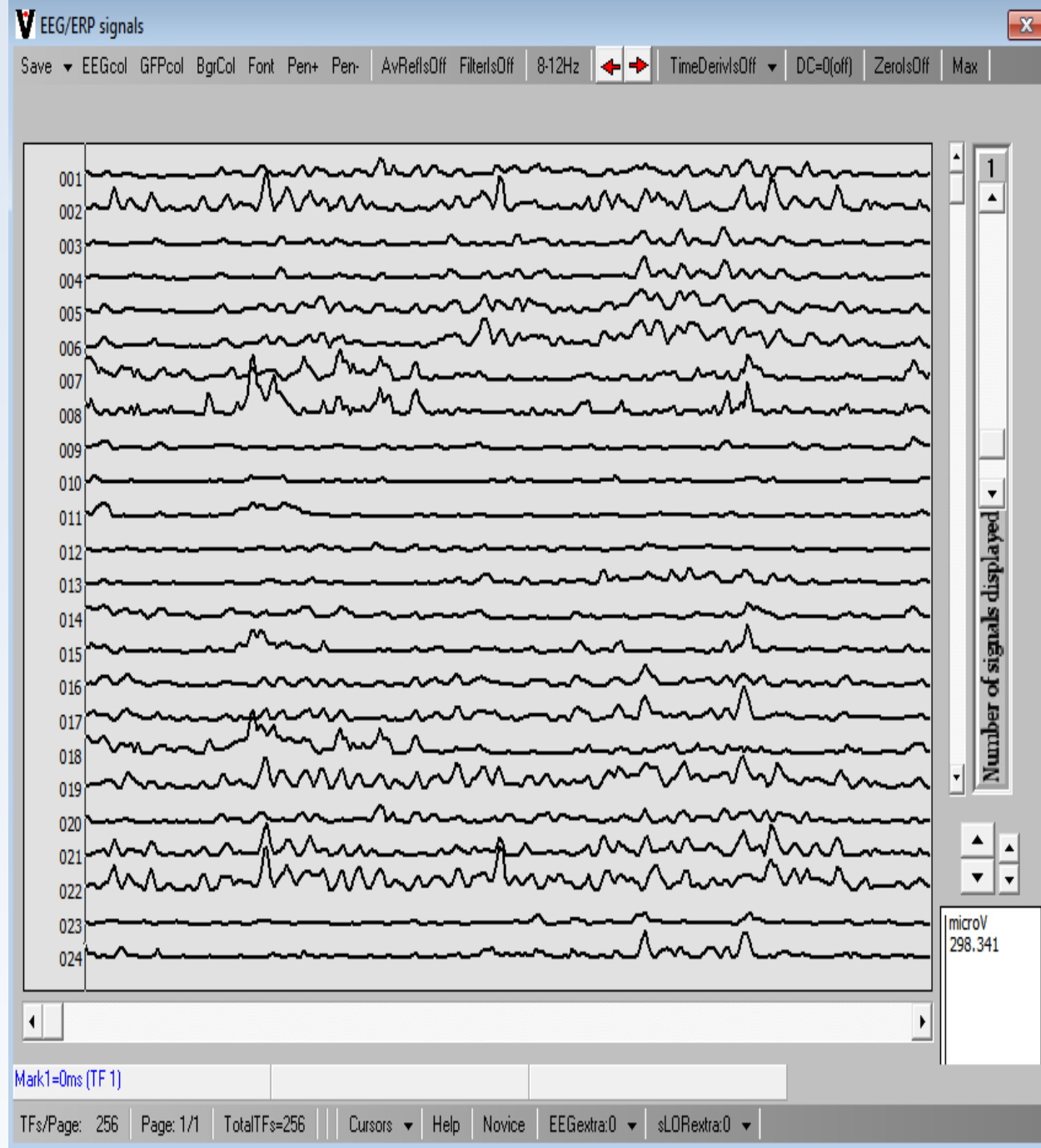
Find Max/Min

MRITemplate AllSlices Voxel0



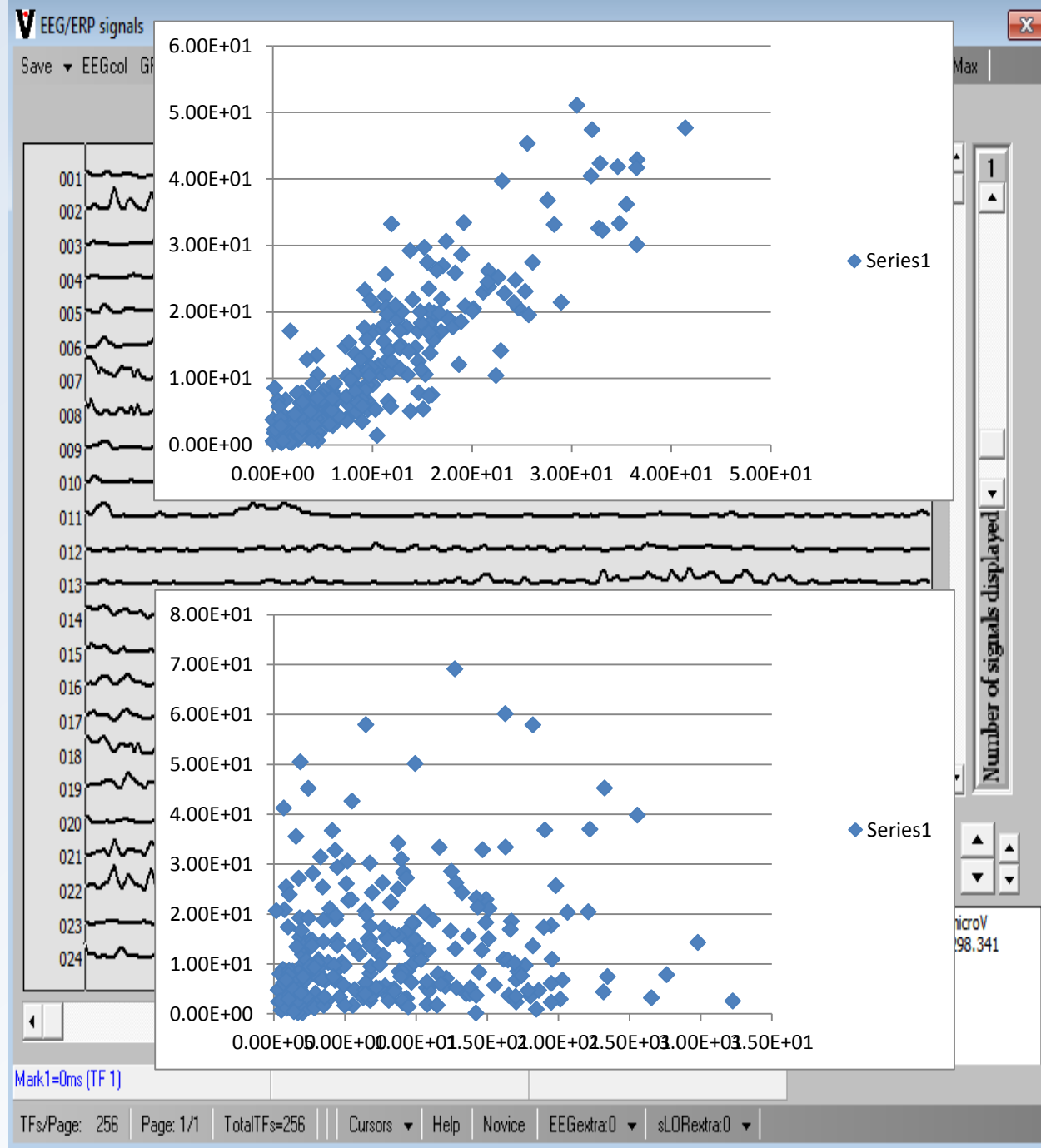
Intracranial electric neuronal activity

-47.5	-69	-2.5	IMT+
47.5	-69	-2.5	rMT+
-26	-8	50	IFEF
26	-8	50	rFEF
-25.5	-54	56	ISPL
25.5	-54	56	rSPL
-35	54.5	9.5	laPFC
35	54.5	9.5	raPFC
-48	17	38.5	ldIPFC
48	17	38.5	rdIPFC
3	31	27	aCC
-52	-47.5	47	laIPL
52	-47.5	46	raIPL
-31	21	-1	laINS
31	22	-2	raINS
-22.5	-22	-17.5	IHF
22.5	-22	-17.5	rHF
0	51	-7	vmPFC
1	-55	17	pCC
-48.5	-67.5	28	lpIPL
48.5	-67.5	28	rpIPL
2	-92	-6	Vis
-55	-25	10	IAud
55	-25	10	rAud



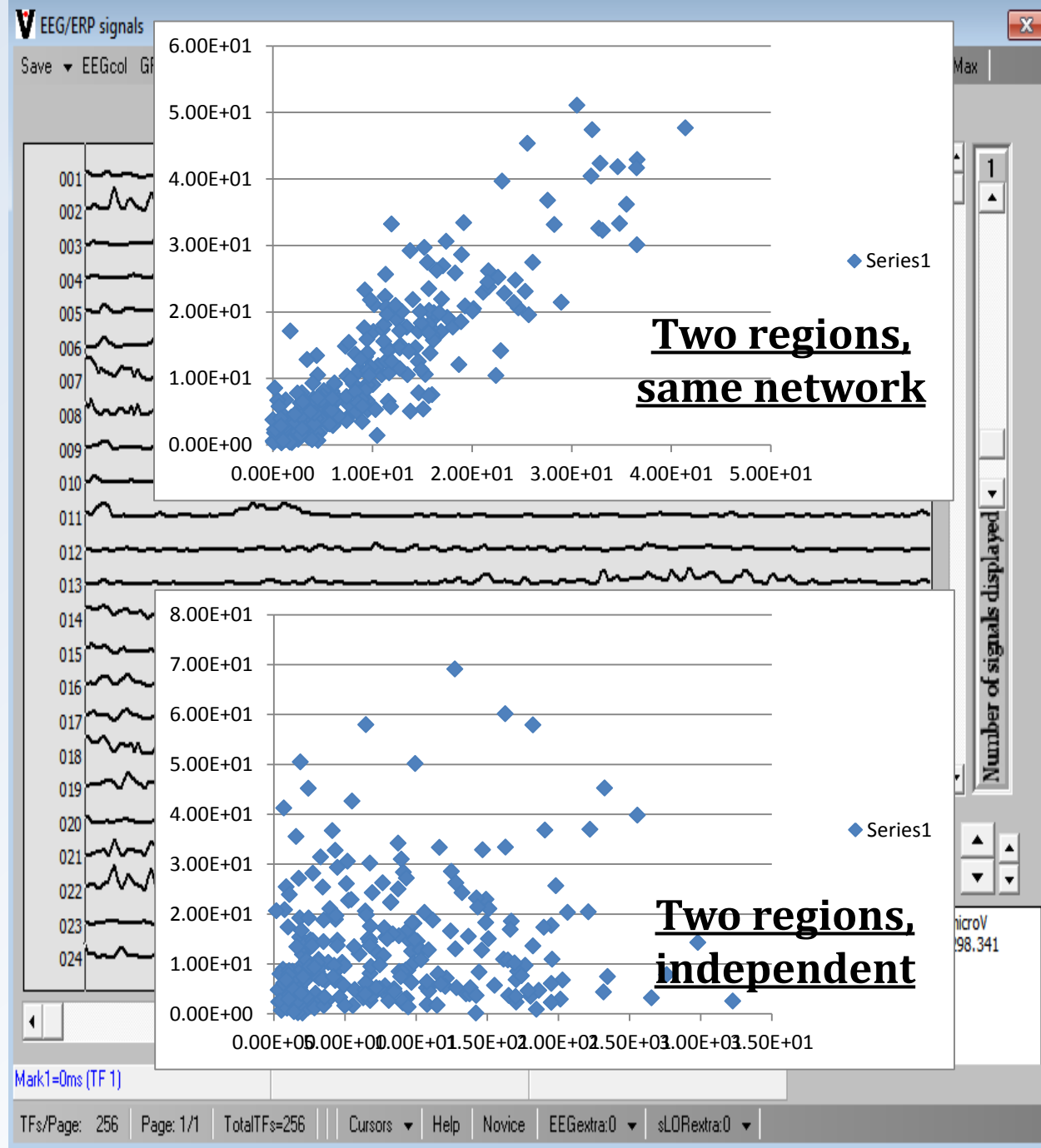
Intracranial electric neuronal activity

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-26	-8	50	IFEF
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2	-92	-6	Vis
-55	-25	10	lAud
55	-25	10	rAud



Intracranial electric neuronal activity

-47.5	-69	-2.5	IMT+
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48.5	-67.5	28	rpIPL
2	-92	-6	Vis
-55	-25	10	IAud
55	-25	10	rAud



In words, the procedure for the discovery of brain networks (intuitive, exploratory method):

- 1. Stick needles into the brain, cover the whole cortex (non-invasively, virtual electrodes, LORETA).**
- 2. Take each distinct pair of intracranial electrodes, and compute the “similarity” between the signals.**
- 3. If two signals are very similar, i.e. highly correlated – coherent – synchronized, then assign them into the same network.**
- 4. If two signals are very dissimilar, make sure they belong to different network.**
- 5. Scan all distinct pairs of intracranial signals.**

**Exploratory analysis using this intuitive method is
not feasible**

6239 cortical grey matter voxels

$6239 * 6238 / 2 = 19'459'441$ plots

For each EEG frequency band of interest, e.g.:

Delta: 1.5-6 Hz

Theta: 6.5-8.0 Hz

Alpha1: 8.5-10 Hz

Alpha2: 10.5-12.0 Hz

Beta1: 12.5-18.0 Hz

Beta2: 18.5-21.0 Hz

Beta3: 21.5-30.0 Hz

At least 40 seconds of EEG

ICA (independent components analysis)

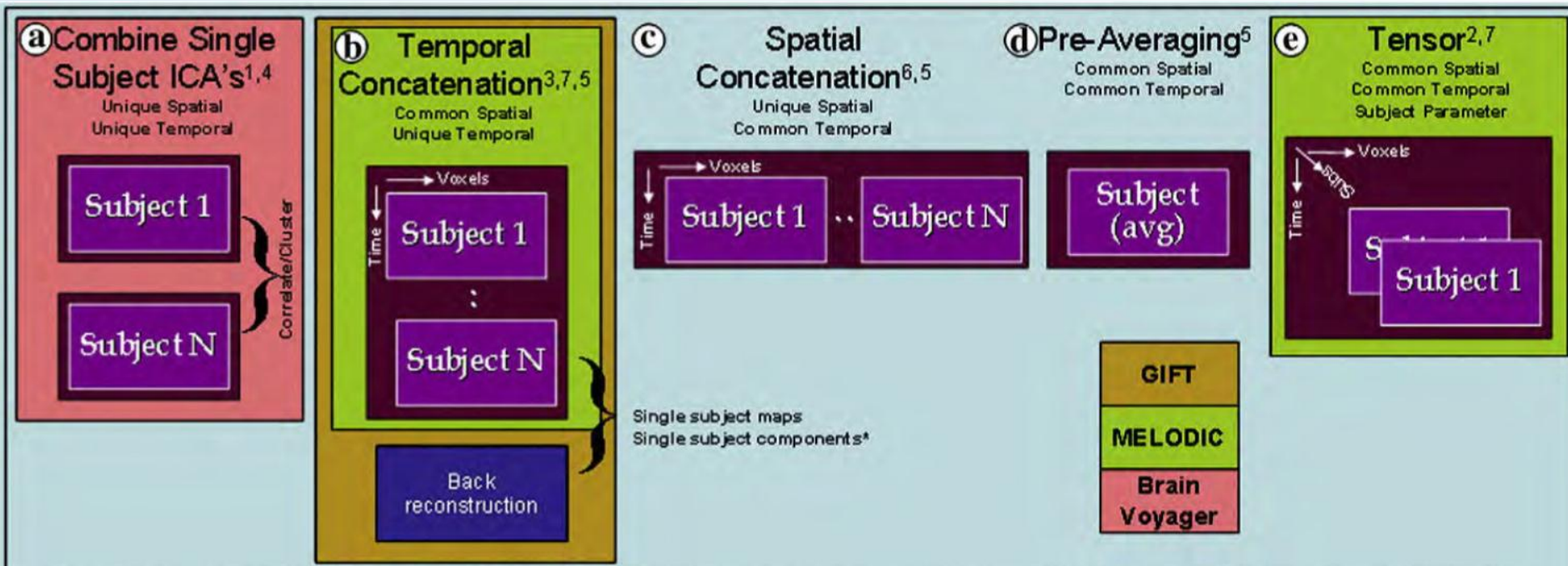
Published in final edited form as:

Neuroimage. 2009 March ; 45(1 Suppl): S163–S172. doi:10.1016/j.neuroimage.2008.10.057.

A review of group ICA for fMRI data and ICA for joint inference of imaging, genetic, and ERP data

$$X = AS$$

Vince D. Calhoun^{a,b,*}, Jingyu Liu^{a,b}, and Tülay Adalı^c



ICA (independent components analysis)

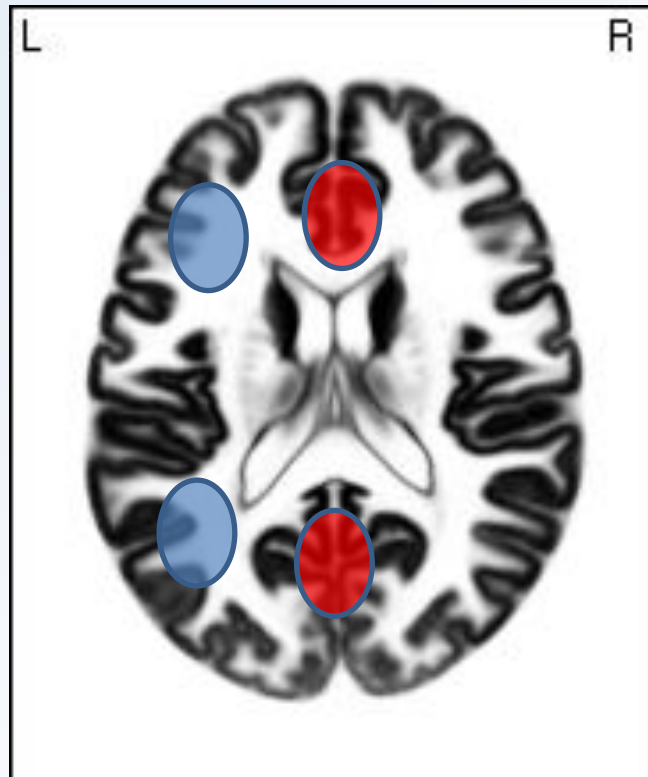
If brain activity is organized and structured in such a way that there are several different groupings (networks) of regions, where within a group (network) all activity is correlated, but between groups (networks) there is independence, then ICA should produce spatial “components” that correspond to the networks.

ICA (independent components analysis)

If brain activity is organized and structured in such a way that there are several different groupings (networks) of regions, where within a group (network) all activity is correlated, but between groups (networks) there is independence, then ICA should produce spatial “components” that correspond to the networks.

blue ↔ blue

red ↔ red



Part 2: Tutorial on using software

Run / open the main LORETA program

Open the Utilities module

Make electrode coordinates (skip if already made)

Compute transformation matrix (skip if already made)

Create frequency bands file

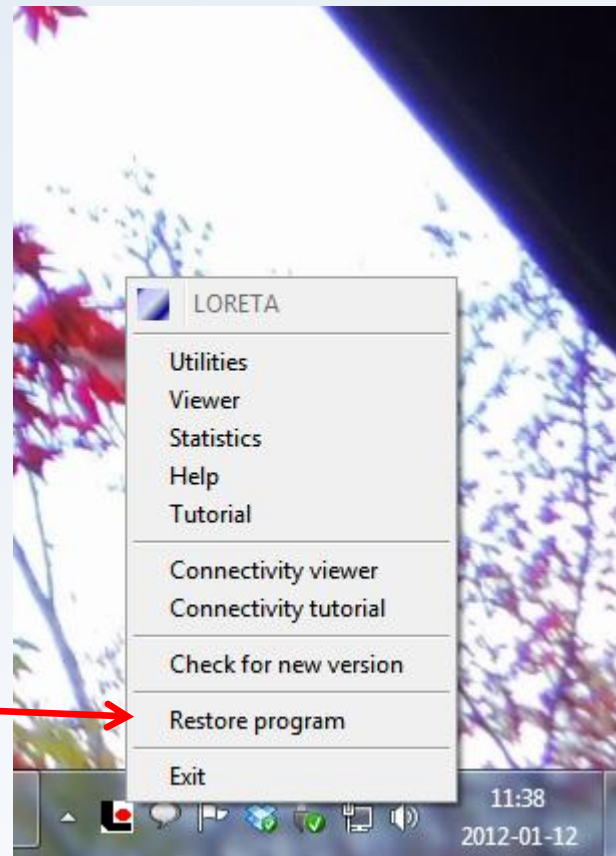
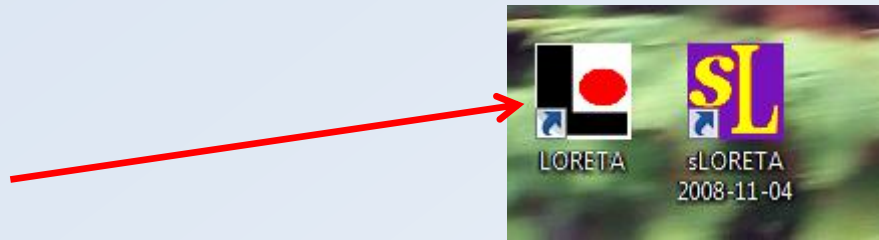
Compute cross-spectra (skip if already made)

Compute sLORETAs (skip if already made)

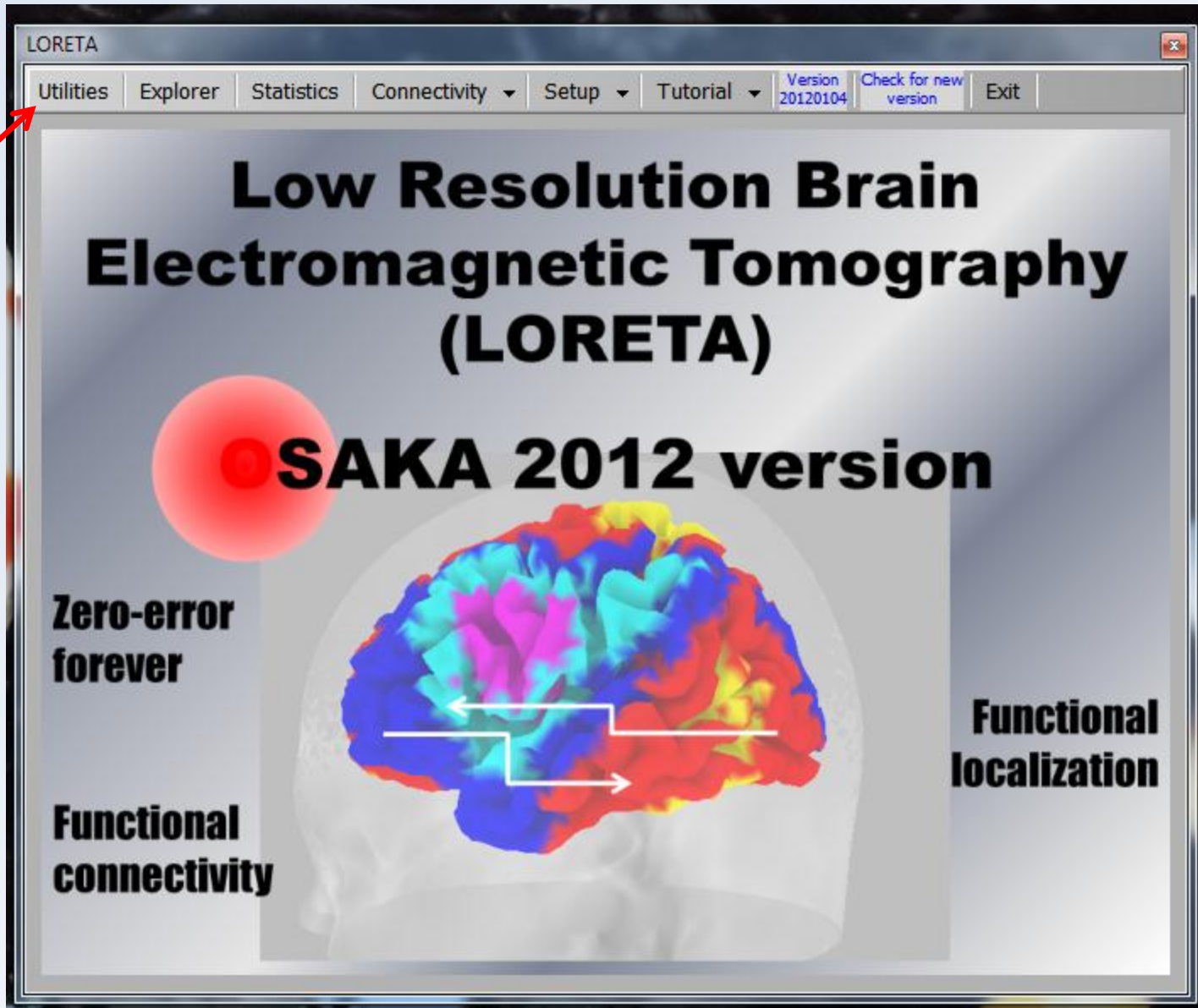
Compute Brain Networks

Statistical Analysis of Resting State Networks

Run / open the LORETA software



Open the Utilities



Make electrode coordinates for EEG data (skip next slides if already made!)

Utilities

Adjust for screen size Help DragDropUtil WindowsExplorer

Electrode names to coordinates

- Registering real electrodes
- Electrodes viewer
- Electrode coordinates to transformation matrix
- EEG/ERPs to sLORETA
- EEGs to cross spectrum
- Cross spectra to sLORETA
- Averager
- Merge files
- EEG to epochs
- Scaling and Baseline
- Filtering Time/Electrodes
- Format converter
- ROI maker 1
- ROI maker 2
- ROI maker 3
- sLORETA to ROIs
- Connectivity 1
- Time-varying cross-spectra
- View time-varying cross-spectrum
- Time-varying cross-spectra to sLORETA
- Connectivity2
- Microstate segmentation
- ICA for EEG/ERP
- BRL sLORETA norms
- Global connectivity
- fICA
- Scores for fICA
- Regression z-scores
- Conjunction
- Hilbert transform 1
- Microstates (BatchMode)
- Single trial covariance
- HilbTr single trial covariance

Electrode names to coordinates

Electrode names to coordinates

File with electrode names

Output file with electrode coordinates

Alternatively, you can open the "Electrode Maker" program, using as templates the 10/20, 10/10, or 10/5 % systems. Click this panel to execute the program. When you're finished, you can close it.

Make Talairach electrode coordinates from a list of electrode names

Make electrode coordinates for EEG data (skip next slides if already made!)

Drag and drop the text file with electrode names (List19e.txt), from the desktop folder with the example EEG data. Click “Go”. The file (List19e.sxyz) is created.

The image shows the LORETA software interface. The 'Utilities' window is open, displaying a list of tools on the left and the 'Electrode names to coordinates' tool selected. A red arrow points to the 'Go' button in the utility window. Another red arrow points to the 'File with electrode names' input field. A third red arrow points to the 'List19e.txt' file in the file explorer window.

The 'Electrode names to coordinates' utility window contains the following fields and buttons:

- File with electrode names:
- Clear names:
- Output file with electrode coordinates:
- Change output file name:
- View output file with electrodes:

The file explorer window shows the following table of files:

Name	Date modified	Type
01-VigCtrlEEG		File folder
02-VigCtrlEEG		File folder
03-CrssLor		File folder
04-fICA		File folder
05-Tfica		File folder
06-Tfica		File folder
Projections		File folder
tests		File folder
07-NetworksTutorial		File folder
BD-RE Drive (D:)		Removable Disk (E:)
RestEEG_Old	2012-01-06 07:54	File folder
RestEEG_Young	2011-12-17 11:49	File folder
VigCtrlEEG_Old	2011-12-17 11:49	File folder
VigCtrlEEG_Young	2011-12-17 11:49	File folder
Info.txt	2006-07-08 01:21	Text Document
List19e.txt	2006-03-04 05:14	Text Document
RoisHarrison.sxyz	2008-11-04 21:37	SXYZ File

The file name field at the bottom of the file explorer window is: 15-cum4-freqw-zScoresHyperIndpdntFICs-011.slor

Make the transformation matrix (skip next slides if already made!)

Drag and drop the file (List19e.sxyz) with electrode coordinates, from the desktop folder with the example EEG data. Click “Go”. The file (List19e.spinv) is created.

The screenshot displays the LORETA software interface. The main window is titled 'Utilities' and contains a list of functions on the left. The 'Electrode coordinates to transformation matrix' function is selected. The dialog box for this function is open, showing the following fields:

- File with electrode coordinates: C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)\List19e.sxyz
- Output file with transformation matrix: C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)\List19e.spinv

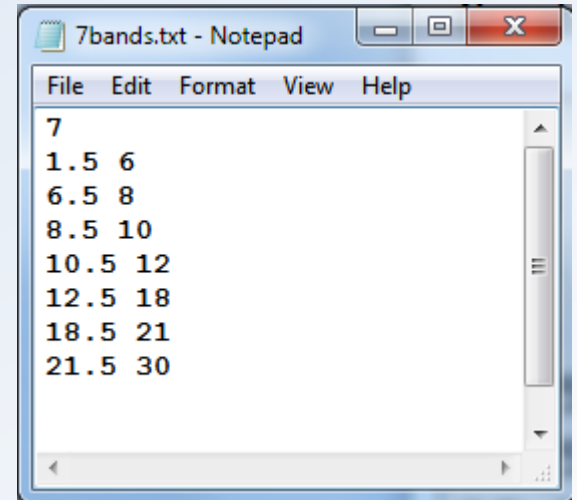
Buttons for 'Clear names' and 'Change output file name' are visible. Below these fields, there are radio buttons for 'Choose regularization method': None (selected), Automatic, Specify SNR (SignalPower/Noise), and Specify relative regularization.

A file explorer window titled 'Drag/Drop files/folders to LORETA' is open in the foreground, showing the directory 'sLORETA-ExampleDataSets > ExampleEEGdata(PeterAnderer)'. The file 'List19e.sxyz' is selected. A red dashed arrow points from the file name in the explorer to the input field in the dialog box.

Name	Date modified	Type
RestEEG_Old	2012-01-06 07:54	File folder
RestEEG_Young	2011-12-17 11:49	File folder
VigCtrlEEG_Old	2011-12-17 11:49	File folder
VigCtrlEEG_Young	2011-12-17 11:49	File folder
Info.txt	2006-07-08 01:21	Text Document
List19e.sxyz	2012-01-12 11:59	SXYZ File
List19e.txt	2006-03-04 05:14	Text Document
RoisHarrison.sxyz	2008-11-04 21:37	SXYZ File

Create a text file in the notepad with the following text:

```
7
1.5 6
6.5 8
8.5 10
10.5 12
12.5 18
18.5 21
21.5 30
```



This is a “User defined frequency band file”. You can make analysis with any bands of your interest. In this case, seven (7) bands are defined. The next seven lines have the “start” and “end” frequency, separated by space. These are the 7 classical bands, without the additional full band (1.5 30). Save this text file with name:

7bands.txt

Save to the EEG folder!

Compute the cross-spectra for vigilance controlled EEG, for old and young subjects. (skip next slides if already made!) Note every detail marked with arrows. Drag/drop “7bands.txt” to the box “File with user defined bands”

The image shows a screenshot of the 'Utilities' software interface, specifically the 'EEGs to cross spectrum' window. The interface is divided into several sections:

- Left Panel:** A list of utility functions. The 'EEGs to cross spectrum' option is highlighted in bold. A red arrow points to this option.
- Main Window:**
 - EEG folders/files:** An empty list box for specifying EEG data sources.
 - Folder/File mode:** A group box containing radio buttons for:
 - Each folder to 1 CRS
 - All files to 1 CRS
 - Each file to 1 CRS
 - Each BIG file to 1 CRS
 - Each BIG file to many CRSA red arrow points to this group box.
 - File mask:** A text box containing '*.asc'. A red arrow points to this field.
 - Number of lines:** A text box containing '0'.
 - Clear all items:** A button below the file mask and number of lines fields.
 - Number of electrodes:** A text box containing '19'. A red arrow points to this field.
 - Number of time frames per epoch:** A text box containing '512'. A red arrow points to this field.
 - Sampling rate [Hz]:** A text box containing '102.4'. A red arrow points to this field.
 - Force average reference:** A checked checkbox.
 - Frequencies:** A group box containing radio buttons for:
 - $\delta, \theta, \alpha 1, \alpha 2, \beta 1, \beta 2, \beta 3, \Omega$
 - $\delta, \theta, \alpha, \beta 1, \beta 2, \beta 3, \Omega$
 - Discrete frequency range
 - All discrete frequencies
 - User defined bandsA red arrow points to the 'User defined bands' option.
 - File with user defined bands:** A text box containing 'C:\Users\roberto\Desktop\LORETA'. A red arrow points to this field.
 - Go:** A button at the bottom of the main window.

In the foreground, a file explorer window titled 'Drag/ Drop files/folders to LORETA' is open, showing the directory 'sLORETA-ExampleDataSets > ExampleEEGdata(PeterAnderer)'. The file '7bands.txt' is selected. A red dashed arrow points from the '7bands.txt' file in the explorer to the 'File with user defined bands' field in the main window.

Compute the cross-spectra for vigilance controlled EEG, for old and young subjects. (skip next slides if already made!) Note every detail marked with arrows. Finally, drag/drop the 20 folders for old and 20 folders for young, vigilance controlled EEG. Note that there must be a total of 40 lines (blue arrow), indicating 40 folders. And click “Go”.

The image shows two overlapping windows. The left window is a Windows File Explorer titled "Drag/Drop files/folders to LORETA". It displays a directory structure under "ExampleEEGdata(PeterAnderer) > VigCtrlEEG_Young". The main pane lists 20 folders named VEEG01_Y through VEEG20_Y, all of type "File folder" and dated "2011-12-17 11:49". A red dashed arrow points from the "VEEG01_Y" folder to the software interface. The left sidebar shows a tree view with "VigCtrlEEG_Young" selected, and two red arrows pointing to it from the left. The bottom of the window shows a "File name:" field with "7bands.txt" and "Open" and "Cancel" buttons.

The right window is a software interface titled "LORETA" with a "Parameters" section. It has a "Folder/File mode" section with radio buttons for "Each folder to 1 CRS", "All files to 1 CRS", "Each file to 1 CRS", "Each BIG file to 1 CRS", and "Each BIG file to many CRS". Below this is a "File mask" field with "*.asc" and a "Number of lines" field with "40". A blue arrow points to the "Number of lines" field. There are also input fields for "Number of electrodes" (19), "Number of time frames per epoch" (512), and "Sampling rate (Hz)" (102.4). A "Force average reference" checkbox is checked. The "Frequencies" section has radio buttons for "8, θ , α 1, α 2, β 1, β 2, β 3, Ω ", "8, θ , α , β 1, β 2, β 3, Ω ", "Discrete frequency range", "All discrete frequencies", and "User defined bands". The "User defined bands" option is selected, and a text box below it contains the path "C:\Users\roberto\Desktop\LORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)\7bands.txt". A "Go" button is at the bottom.

Compute sLORETA from cross-spectra (skip next slides if already made!)
First drag and drop the transformation matrix (List19e.spinv) as indicated

The screenshot shows the 'Utilities' application window with the 'Cross spectra to sLORETA' workflow selected in the left-hand menu. The main window displays the 'Cross spectrum files' section, which is currently empty. A file selection dialog titled 'Drag/Drop files/folders to LORETA' is open, showing the contents of the folder 'C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)'. The file 'List19e.spinv' is selected in the dialog, and a red dashed arrow points from it to the 'File with transformation matrix' field in the main application window. The path in this field is 'C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)\List19e.spinv'. The 'Go' button is visible below the path field.

File with transformation matrix
C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)\List19e.spinv

Go

Name	Date modified	Type
RestEEG_Old	2012-01-06 07:54	File folder
RestEEG_Young	2011-12-17 11:49	File folder
VigCtrlEEG_Old	2012-01-12 12:37	File folder
VigCtrlEEG_Young	2012-01-12 12:37	File folder
7bands.txt	2011-05-13 15:56	Text Document
Info.txt	2006-07-08 01:21	Text Document
List19e.spinv	2012-01-12 12:06	SPINV File
List19e.sxyz	2012-01-12 11:59	SXYZ File
List19e.txt	2006-03-04 05:14	Text Document
List19e-El2SlorTM-RunInfo.txt	2012-01-12 12:05	Text Document

Compute sLORETA from cross-spectra (skip next slides if already made!)

Finally, drag and drop the folders VigCtrlEEG_Old and VigCtrlEEG_Young as indicated. These folders contain the cross-spectra. Note the “Number of lines = 40” cross-spectra. Click “Go”.

The screenshot displays the Brainstorm software interface. On the left is a vertical menu with various processing options. The main window shows the 'Cross spectra to sLORETA' dialog box. This dialog has a list of 'Cross spectrum files' and a 'Number of lines' field set to 40. A red dashed arrow points from the file list to a file explorer window. The file explorer shows the directory 'C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)'. A red arrow points to the 'ExampleEEGdata(PeterAnderer)' folder. Another red arrow points from the 'VigCtrlEEG_Old' folder in the file explorer to the 'Cross spectrum files' list in the dialog. A blue arrow points to the 'Number of lines' field.

Utilities

Adjust for screen size Help DragDropUtil WindowsExplorer

Electrode names to coordinates
Registering real electrodes
Electrodes viewer
Electrode coordinates to transformation matrix
EEG/ERPs to sLORETA
EEGs to cross spectrum
Cross spectra to sLORETA
Averager
Merge files
EEG to epochs
Scaling and Baseline
Filtering Time/Electrodes
Format converter
ROI maker 1
ROI maker 2
ROI maker 3
sLORETA to ROIs
Connectivity 1
Time-varying cross-spectra
View time-varying cross-spectrum
Time-varying cross-spectra to sLORETA
Connectivity2
Microstate segmentation
ICA for EEG/ERP
BRL sLORETA norms
Global connectivity
fICA
Scores for fICA
Regression z-scores
Conjunction
Hilbert transform 1
Microstates (BatchMode)
Single trial covariance

Cross spectra to sLORETA

Cross spectra to sLORETA

Cross spectrum files

Include subfolders

File mask
*.crss

Number of lines
40

Drag/Drop files/folders to LORETA

C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)

Search ExampleEEGdata(Peter...

Organize New folder

Name	Date modified	Type
Music stuff		File folder
SharePod_3.98		File folder
Xilisoft Audio Converter Pro v6.1.3.1026		File folder
SharePod_3.98.zip		File folder
Paint stuff		File folder
sLORETA-ExampleDataSets		File folder
ExampleEEGdata(PeterAnderer)		File folder
RestEEG_Old	2012-01-06 07:54	File folder
RestEEG_Young	2011-12-17 11:49	File folder
VigCtrlEEG_Old	2012-01-12 12:37	File folder
VigCtrlEEG_Young	2012-01-12 12:37	File folder
7bands.txt	2011-05-13 15:56	Text Document
Info.txt	2006-07-08 01:21	Text Document
List19e.spinv	2012-01-12 12:06	SPINV File
List19e.sxyz	2012-01-12 11:59	SXYZ File
List19e.txt	2006-03-04 05:14	Text Document
List19e-EI2SIorTM-RunInfo.txt	2012-01-12 12:05	Text Document

File name: \VigCtrlEEG_Old

Open Cancel

Compute sLORETA from cross-spectra

Computing brain networks

Computing brain networks

Resting state networks in EEG are computed in a very similar way to fMRI, using independent components analysis (ICA). An excellent review paper on fMRI-ICA is: [Calhoun VD, Liu J, Adali T. Neuroimage. A review of group ICA for fMRI data and ICA for joint inference of imaging, genetic, and ERP data. 2009 Mar;45\(1 Suppl\):S163-72.](#)

The papers describing LORETA-ICA are:

[Pascual-Marqui RD and Biscay-Lirio RJ. Interaction patterns of brain activity across space, time and frequency. Part I: methods. arXiv:1103.2852v2 \[stat.ME\], 2011-March-15, <http://arxiv.org/abs/1103.2852>](#)

[RD. Pascual-Marqui, K Kochi, D Lehmann, M Koukkou, T Kinoshita. Functional independent components: revealing cortico-cortical, cross-frequency interactions. Japanese Journal of Pharmacology-EEG 2011, Vol 12 : 53-58](#)

Computing brain networks

In fMRI, the basic material are images of metabolic brain activity that change with time.

In EEG, the basic material are images of electric cortical activity for each frequency band (sLORETA files, with 7 images, one for each band: delta, theta, alpha1, alpha2, beta1, beta2, beta3).

An fMRI resting state network is a single static image of metabolic brain activity. The brain areas in a network activate together, but different networks do not activate together.

An sLORETA resting state network consists of many images of electric cortical activity, one for each frequency (e.g. 7 images). The “brain areas *AND* frequencies” in a network always activate together, but different networks do not activate together.

Select "Transposed fICA" in the "Utilities" module. Drag/drop indicated folders with sLORETA files. Select all parameters as indicated.

The screenshot displays the sLORETA software interface with the 'Utilities' module selected. The 'Transposed fICA' window is open, showing various configuration options. A file selection dialog is also open, showing a list of folders and files. Red arrows point to specific settings in the software, and a blue arrow points to the 'Number of files' field in the dialog.

Software Settings:

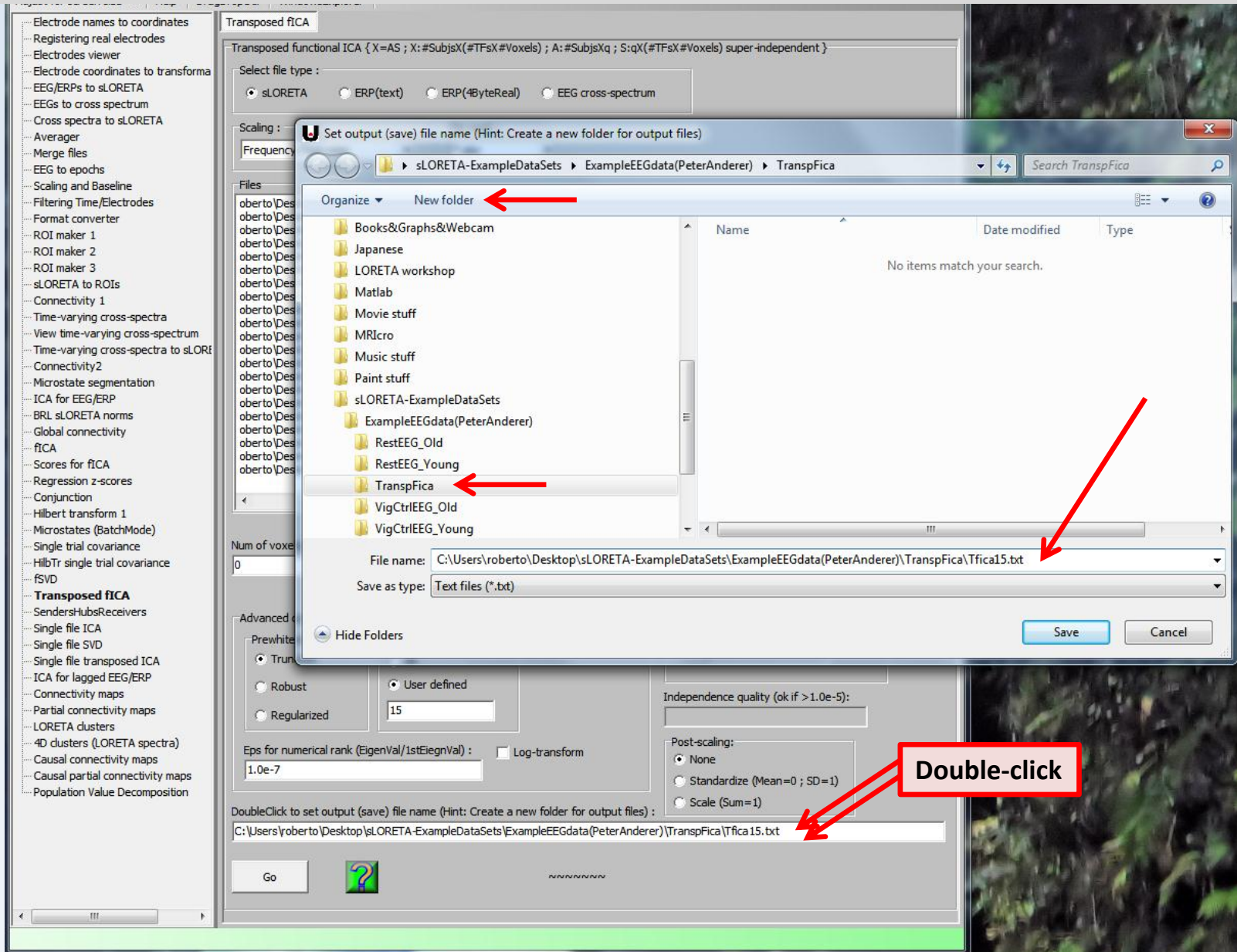
- Module: **Transposed fICA**
- Transposed functional ICA { X=AS; X:#SubjsX(#TFsX#Voxels); A:#SubjsXq; S;qX(#TFsX#Voxels) super-independent }
- Select file type: **sLORETA**
- Scaling: **Frequency/Time-wise**
- File mask: ***.slor**
- Files: (List of folders and files)
- Number of files: **40**
- Advanced options:
 - Prewhitening method: **Truncate**
 - Number of components: **User defined** (value: **15**)
 - Eps for numerical rank (EigenVal/1stEiegnVal): **1.0e-7**
 - Post-scaling: **None**

File Selection Dialog:

- Path: **C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)**
- File name: **\VigCtrlEEG_Old**
- Files listed:

Name	Date modified	Type
RestEEG_Old	2012-01-06 07:54	File folder
RestEEG_Young	2011-12-17 11:49	File folder
VigCtrlEEG_Old	2012-01-12 12:50	File folder
VigCtrlEEG_Young	2012-01-12 12:50	File folder
7bands.txt	2011-05-13 15:56	Text Document
Info.txt	2006-07-08 01:21	Text Document
List19e.spiniv	2012-01-12 12:06	SPINIV File
List19e.sxyz	2012-01-12 11:59	SKYZ File
List19e.txt	2006-03-04 05:14	Text Document
List19e-EI2SlorTM-RunInfo.txt	2012-01-12 12:05	Text Document

Double-click as indicated, and create a “New Folder” within the EEG folder (any name, e.g. “TranspFica”), and within the new folder, define a file name for the results of the ICA analysis (e.g. Tfica15). Click “Save”, then click “Go”.



Open the windows explorer, e.g. click as indicated. Navigate to the folder with the ICA results.

The screenshot shows the 'Utilities' software interface with the 'Transposed fICA' settings window open. A red arrow points to the 'WindowsExplorer' tab in the top menu bar. The window title is 'Transposed fICA' and the subtitle is 'Transposed functional ICA { X=#AS ; X:#SubjsX(#TFsX#Voxels) ; A:#SubjsXq ; S;qX(#TFsX#Voxels) super-independent }'. The 'Select file type' section has 'sLORETA' selected. The 'Scaling' dropdown is set to 'Frequency/Time-wise' and the 'File mask' is '*.slor'. The 'Files' list contains a long list of files from the 'oberto' user's desktop. The 'Advanced options' section includes 'Prewhitening method' (Truncate selected), 'Number of components' (User defined, 15), 'Eps for numerical rank' (1.0e-7), and 'Log-transform' (unchecked). The 'Estimators for dimension' section shows AIC: 40, BIC: 40, and Numerical rank: 40. The 'Independence quality' is 0.0196208991110325. The 'Post-scaling' section has 'None' selected. The 'DoubleClick to set output (save) file name' field contains the path 'C:\Users\oberto\Desktop\slORETA-ExampleDataSets\ExampleEEGdata(Peter Anderer)\TranspFica\Tfica 15.txt'. A 'Go' button is at the bottom left.

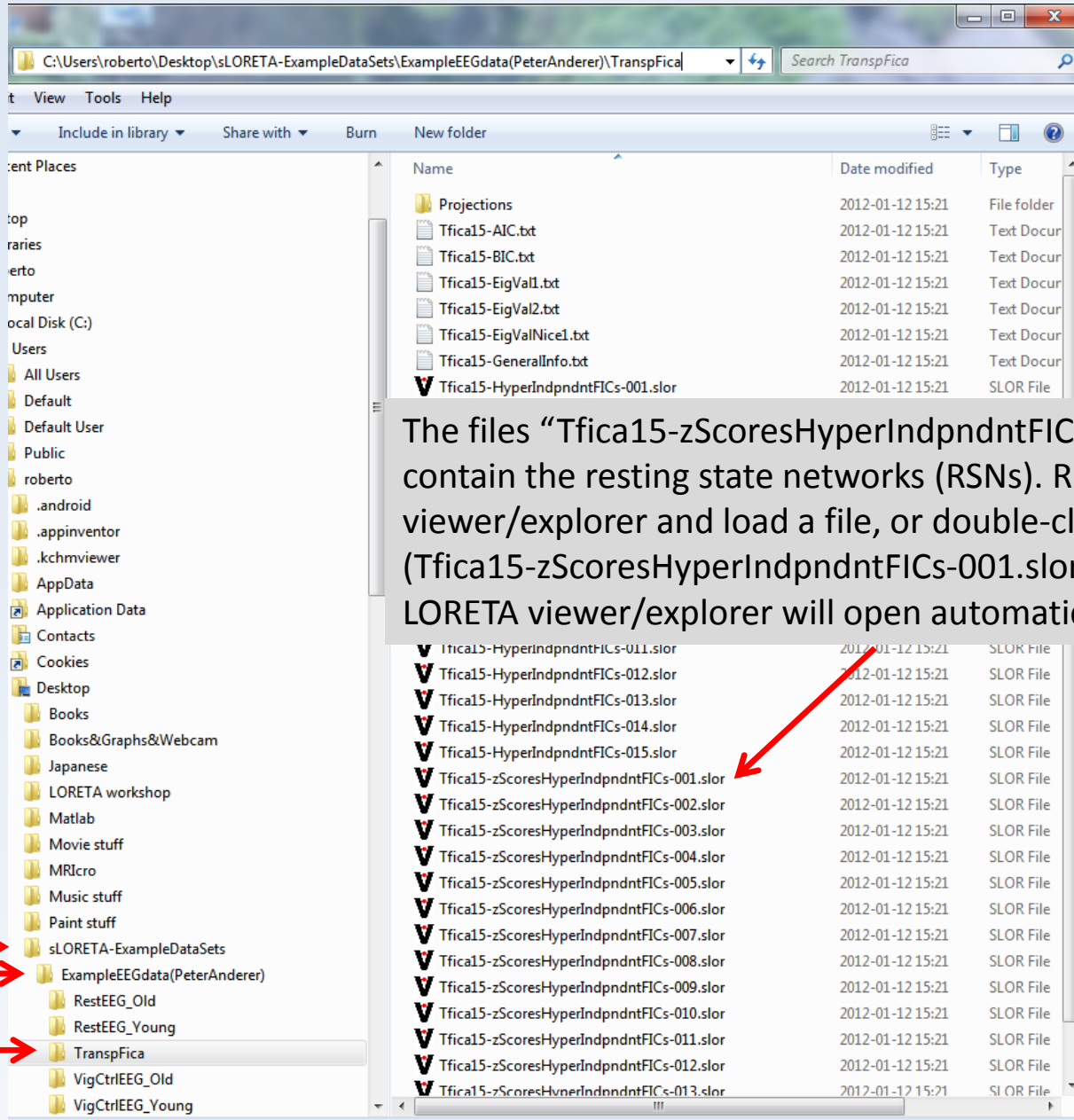
The results for the Transposed fICA analysis:

The screenshot displays a Windows File Explorer window with the following details:

- Address Bar:** C:\Users\roberto\Desktop\sLORETA-ExampleDataSets\ExampleEEGdata(PeterAnderer)\TranspFica
- Left Pane (Navigation):** Shows the folder hierarchy. Red arrows point to Desktop, sLORETA-ExampleDataSets, ExampleEEGdata(PeterAnderer), and TranspFica.
- Right Pane (File List):** A table of files with columns for Name, Date modified, and Type.

Name	Date modified	Type
Projections	2012-01-12 15:21	File folder
Tfica15-AIC.txt	2012-01-12 15:21	Text Docur
Tfica15-BIC.txt	2012-01-12 15:21	Text Docur
Tfica15-EigVal1.txt	2012-01-12 15:21	Text Docur
Tfica15-EigVal2.txt	2012-01-12 15:21	Text Docur
Tfica15-EigValNice1.txt	2012-01-12 15:21	Text Docur
Tfica15-GeneralInfo.txt	2012-01-12 15:21	Text Docur
Tfica15-HyperIndpndntFICs-001.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-002.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-003.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-004.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-005.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-006.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-007.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-008.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-009.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-010.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-011.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-012.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-013.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-014.slor	2012-01-12 15:21	SLOR File
Tfica15-HyperIndpndntFICs-015.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-001.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-002.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-003.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-004.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-005.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-006.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-007.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-008.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-009.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-010.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-011.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-012.slor	2012-01-12 15:21	SLOR File
Tfica15-zScoresHyperIndpndntFICs-013.slor	2012-01-12 15:21	SLOR File

The results for the Transposed fICA analysis:

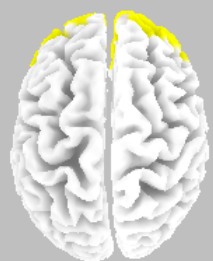


The files “Tflica15-zScoresHyperIndpndntFICs-0XX.slor” contain the resting state networks (RSNs). Run the LORETA viewer/explorer and load a file, or double-click the first file (Tflica15-zScoresHyperIndpndntFICs-001.slor), and the LORETA viewer/explorer will open automatically.

The next slide shows the preferred display layout.

3D cortex/scalp/electrodes

Left Right Top Bottom Front Back



Reset Rprint 5Vws 6Vws

Save Cortex contrast [] Rst

Cortex transparency [] Rst

Scalp contrast [] Rst

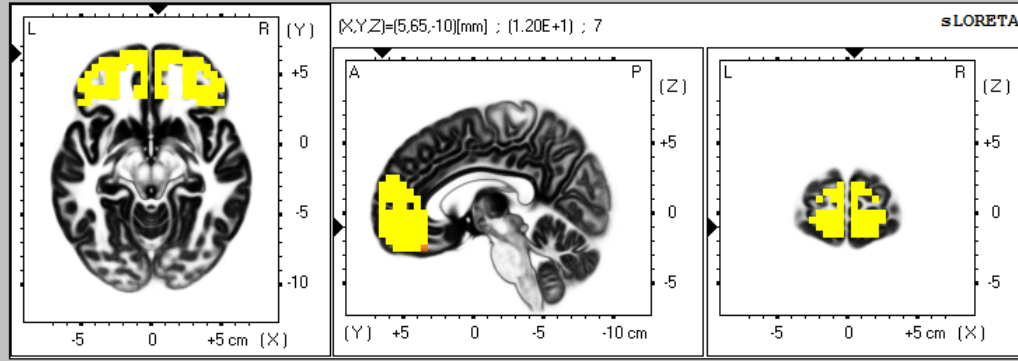
Scalp transparency [] Rst

Cortex Help

SliceViewer

Save AnatColors InitialView JumpMax JumpMin JumpZero Jump to... Max Help CopyToClipBrd TalMNIconvert

[X,Y,Z]=[5,65,-10][mm] ; (1.20E+1) ; 7



Neuroanatomy (Talairach labels):

Track Append Hits: 1 Cpy2ClpBrd Save2File

Value = 1.20E+1
(X = 5, Y = 65, Z = -10) (MNI coords)

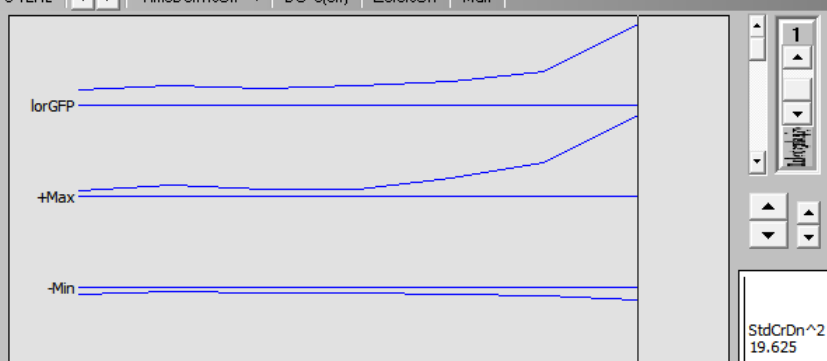
Best Match at 0 mm
Brodmann area 11
Superior Frontal Gyrus
Frontal Lobe

Find Max/Min

EEG/ERP signals

Save EEGcol GFPcol BgrCol Font Pen+ Pen- AvReflsOff FiltersOff

8-12Hz TimeDerivsOff DC=0(off) ZerolsOn Max




StdCrDn^2
19.625

8.82056ms

Current density related color scale

SaveImg SavePal LodSPal LodAPal DefltPal NewPal Ticks: 9 Font +Pos/-Neg Patch Help



Scale exponent 148.41 Reset Scale Max 3.000E+00

SelfMax SelfMax% 50 FixedMax GlobalMax

Select all windows and parameters as indicated by the arrows. In the next slide.

3D cortex/scalp/electrodes

Left Right Top Bottom Front Back

Reset Rprint

5Vws 6Vws

Save Cortex contrast Rst

Cortex transparency Rst

Scalp contrast Rst

Scalp transparency Rst

Cortex Help

SliceViewer

Save AnatColors InitialView JumpMax JumpMin JumpZero Jump to... Max Help CopyToClipBrd TalMNIconvert

[X,Y,Z]=[5,65,-10][mm]; (1.20E+1); 7

sLORETA

Neuroanatomy (Talairach labels):

- Track
- Append
- Hits: 1
- Cpy2ClpBrd
- Save2File

Value = 1.20E+1
(X = 5, Y = 65, Z = -10) (MNI coords)

Best Match at 0 mm
Brodmann area 11
Superior Frontal Gyrus
Frontal Lobe

Find Max/Min

EEG/ERP signals

Save EEGcol GFPcol BgrCol Font Pen+ Pen- AvReflsOff FiltersOff

8-12Hz TimeDerivsOff DC=0(off) ZerosOn Max

lorGFP

+Max

-Min

StdCrDn^2
19.625

8.82056ms

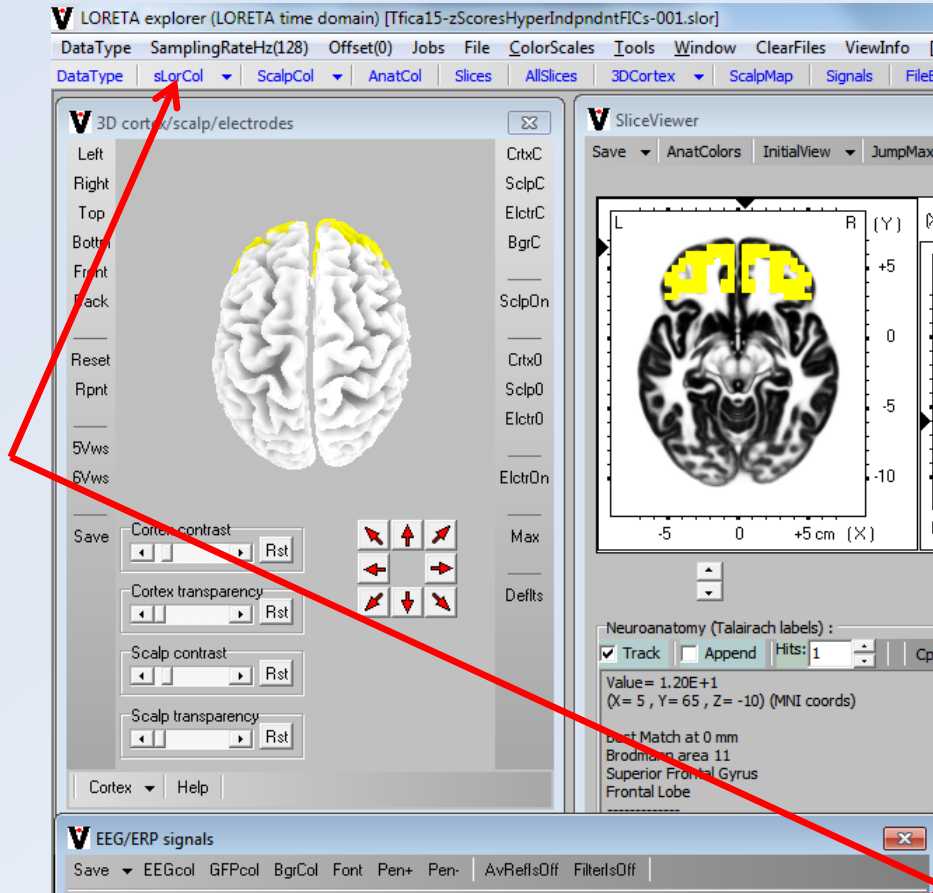
Current density related color scale

SaveImg SavePal LodSPal LodAPal DefltPal NewPal Ticks: 9 Font +Pos/-Neg Patch Help

Scale exponent 148.41 **Reset** Scale Max 3.000E+00

SelfMax SelfMax% 50

FixedMax GlobalMax

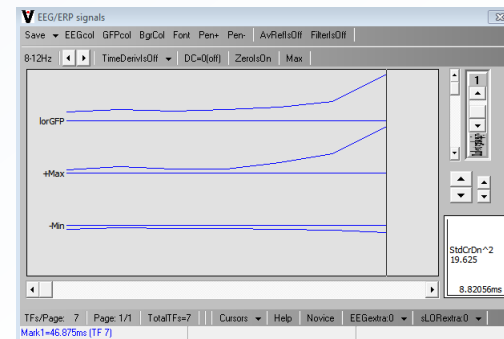
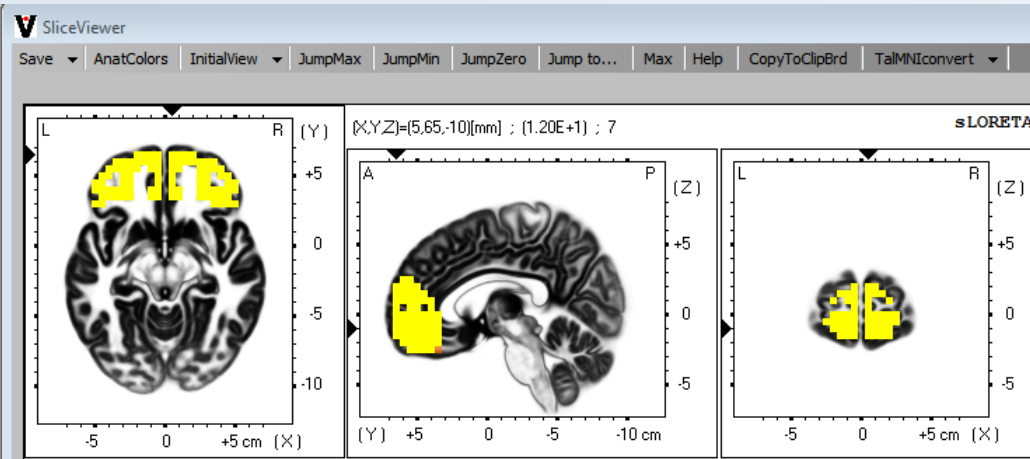
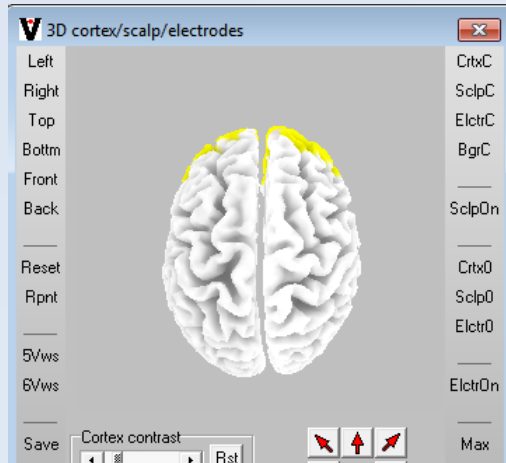


How to interpret what you see:

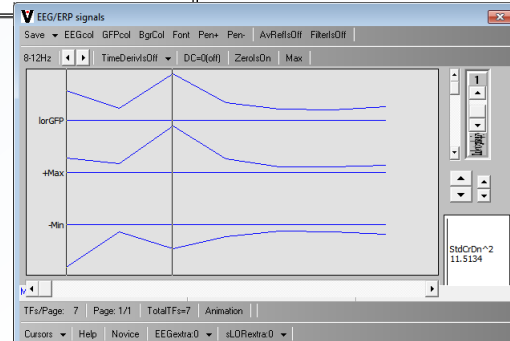
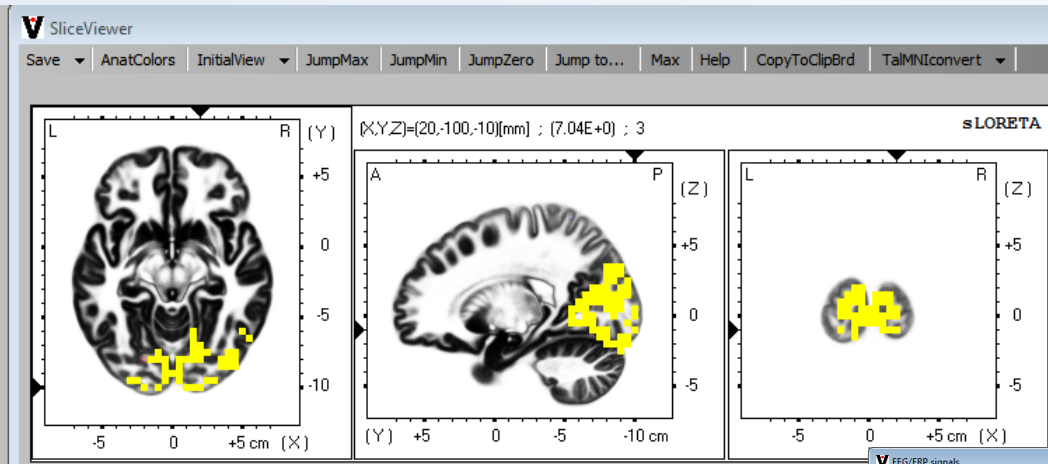
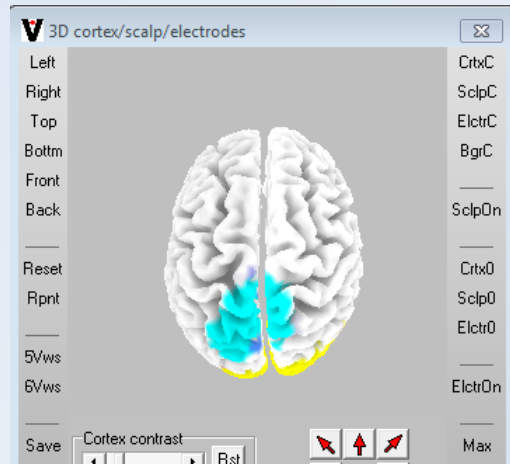
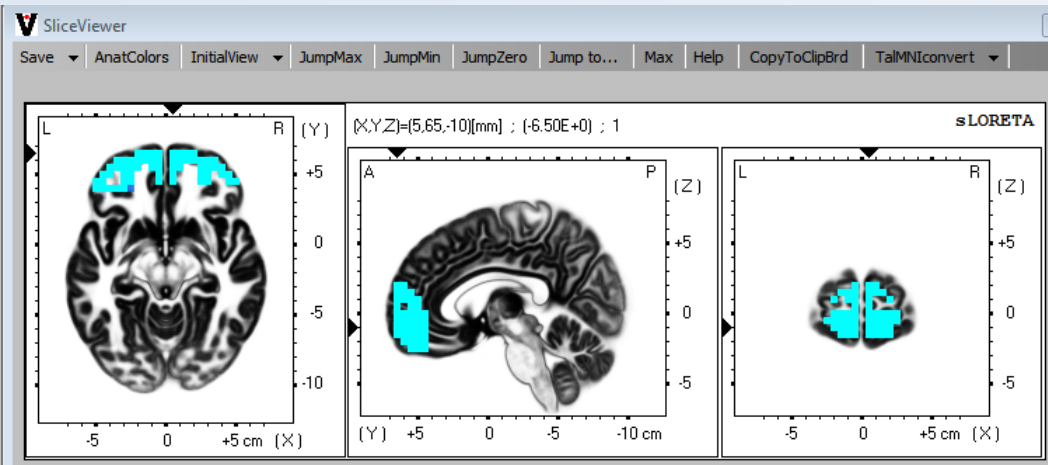
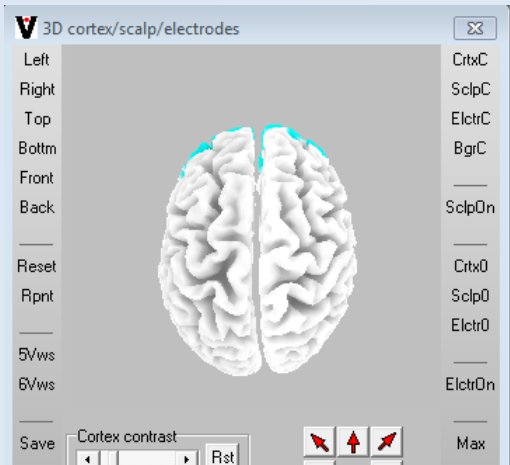
1. The color scale is set to display activation only if it has a z-score higher than 3, which is significant.
2. In the “EEG/ERP signals” window, the two lower curves correspond to positive maximum, and minimum negative activation, for each frequency band (there are 7 bands along the x-axis).
3. In the previous slide, the results show maximum activation in frontal cortex for high frequency Beta3 band.
4. This is a simple case, with only one dominant frequency (Beta3). For other brain networks, if there is more than one dominant frequency, it is necessary to check each of those frequencies individually.

The next slides summarize some of the main networks

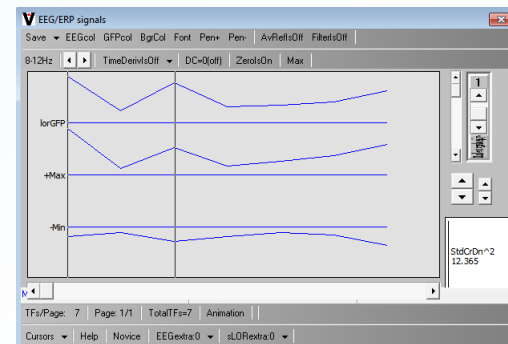
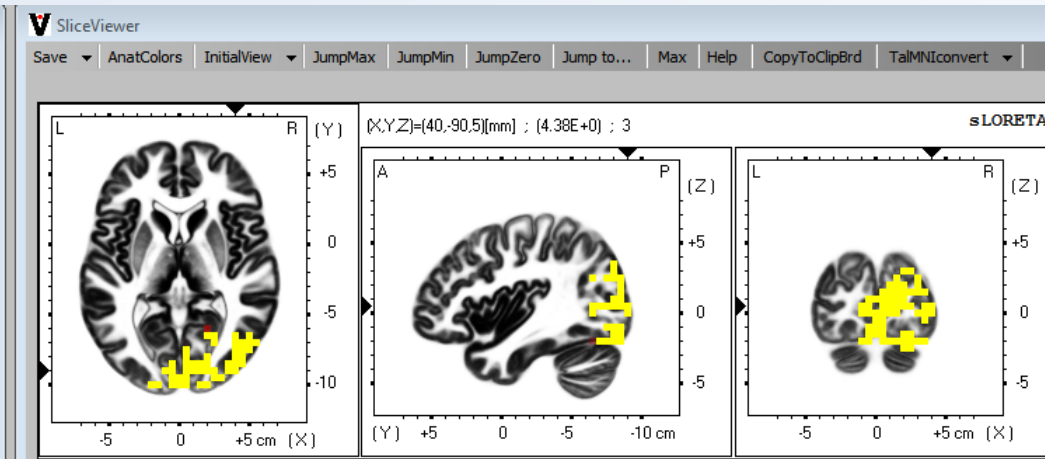
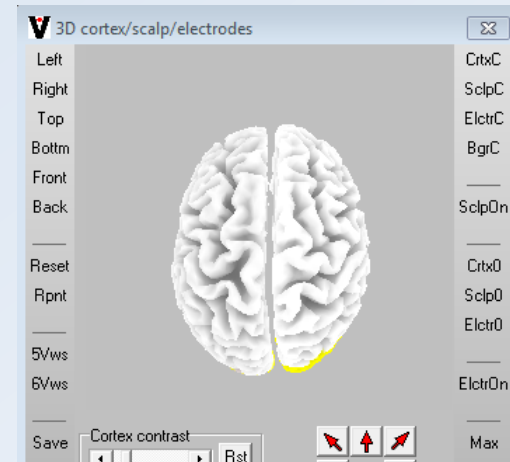
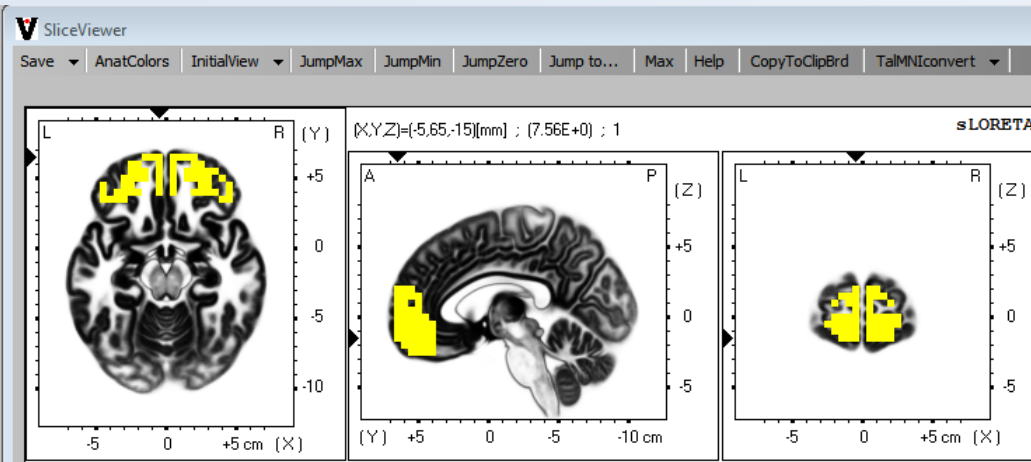
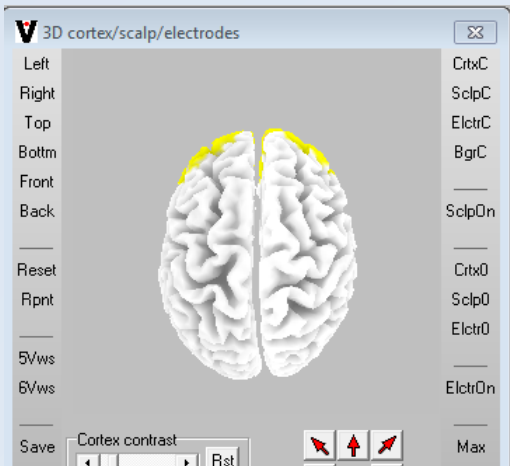
LORETA resting state network 1: Frontal Beta3



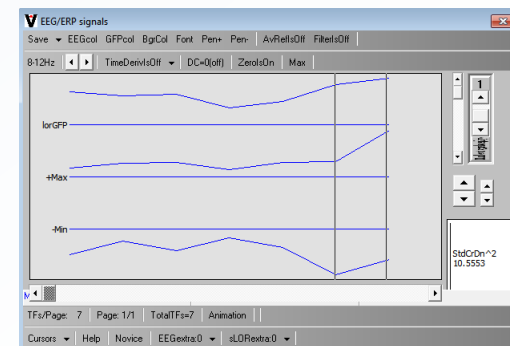
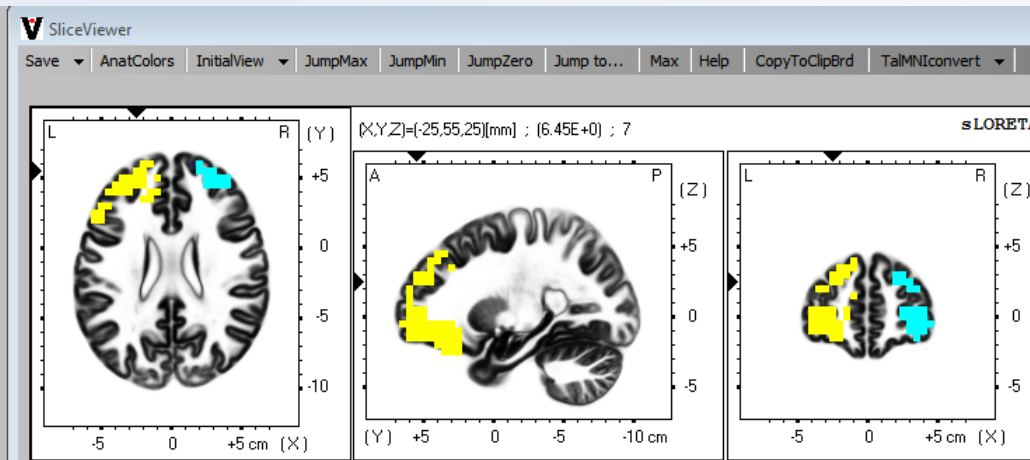
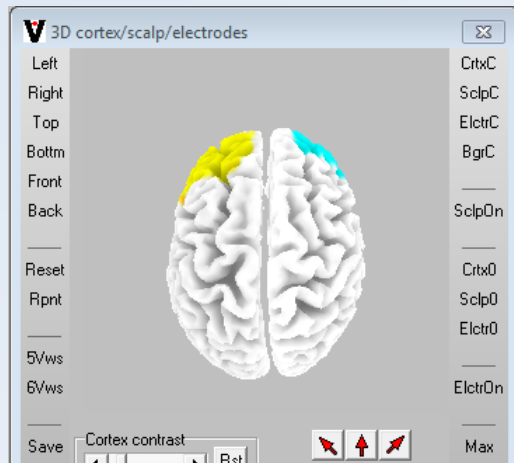
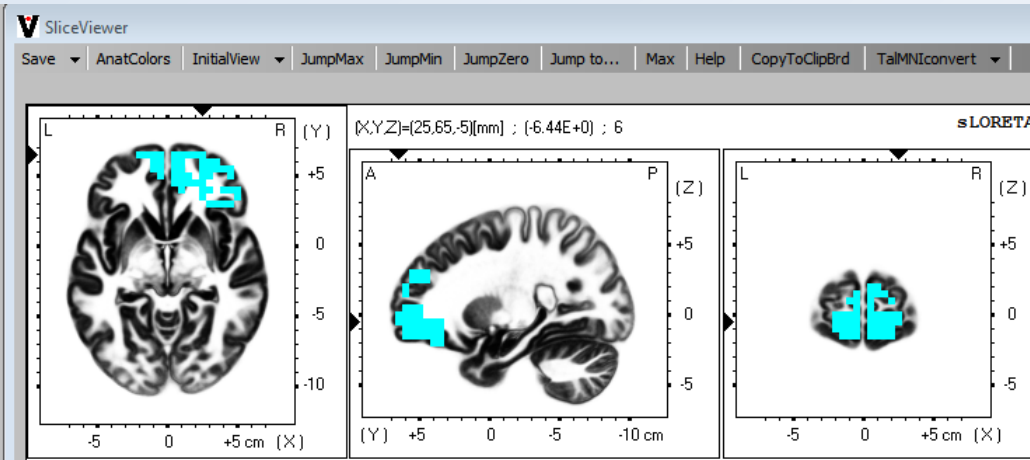
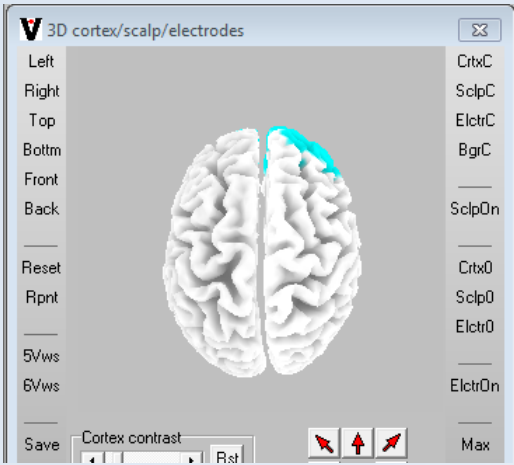
LORETA resting state network 2: (Frontal Delta AND Parietal Alpha1) anti-correlated with Occipital Alpha1



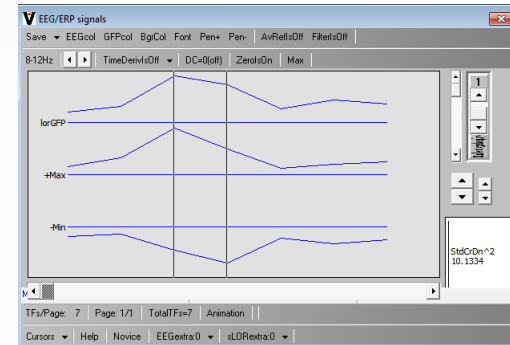
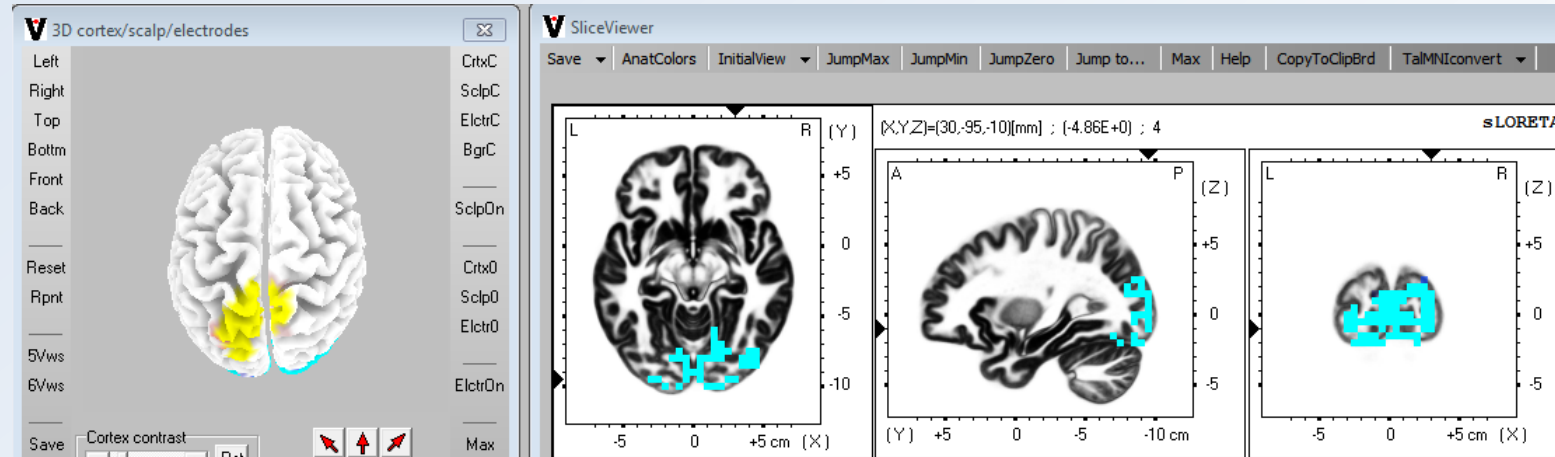
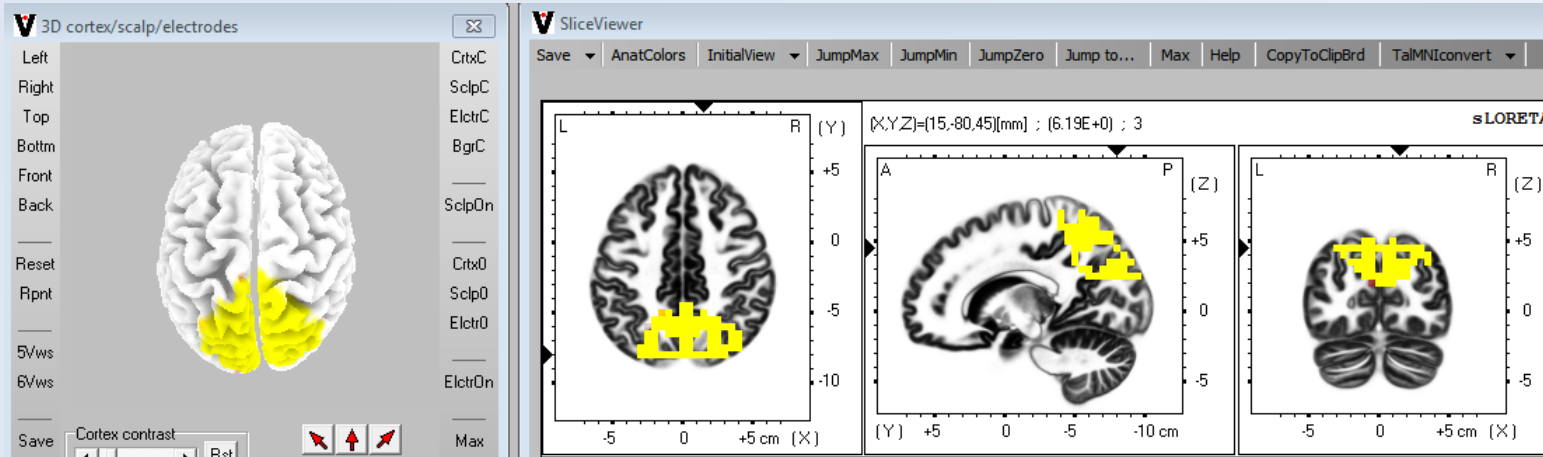
LORETA resting state network 3: Frontal Delta with Occipital Alpha1



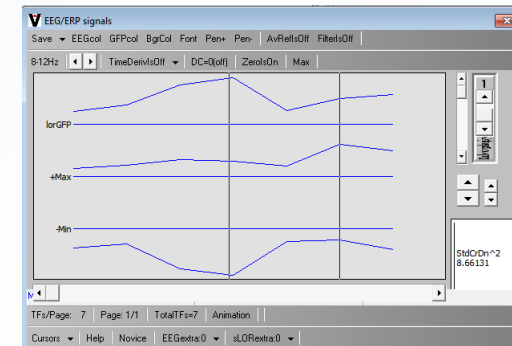
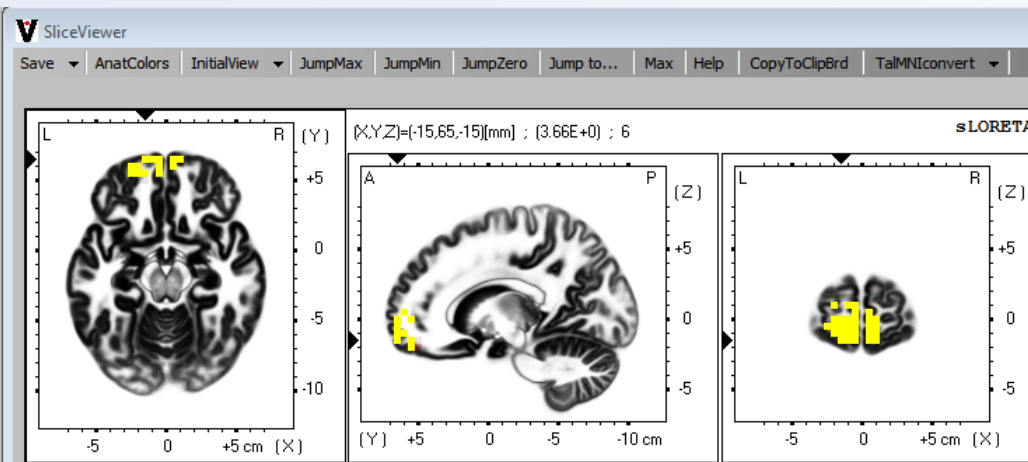
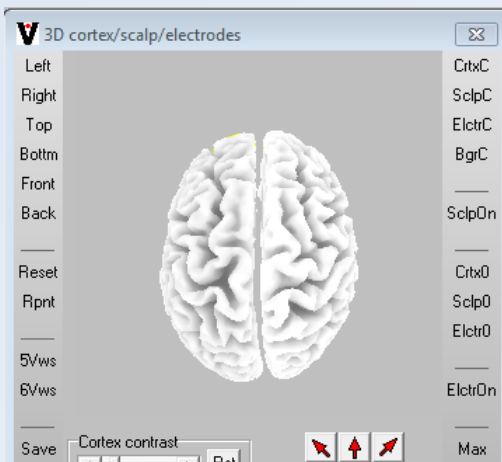
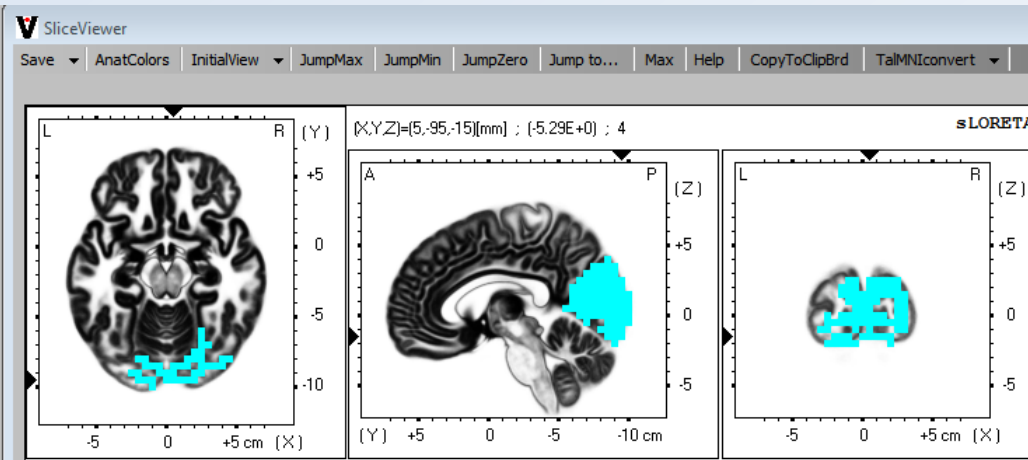
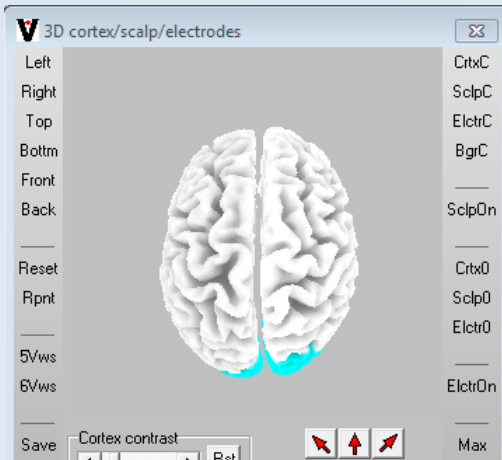
LORETA resting state network 4: Right Frontal Beta2 anti-correlated with Left Frontal Beta3



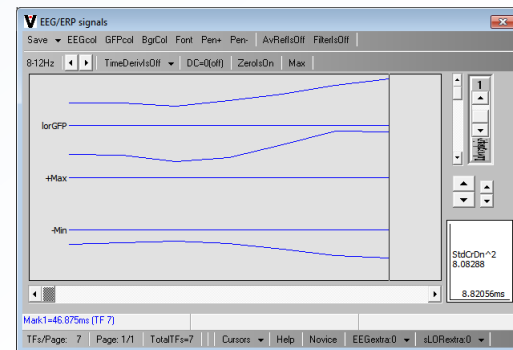
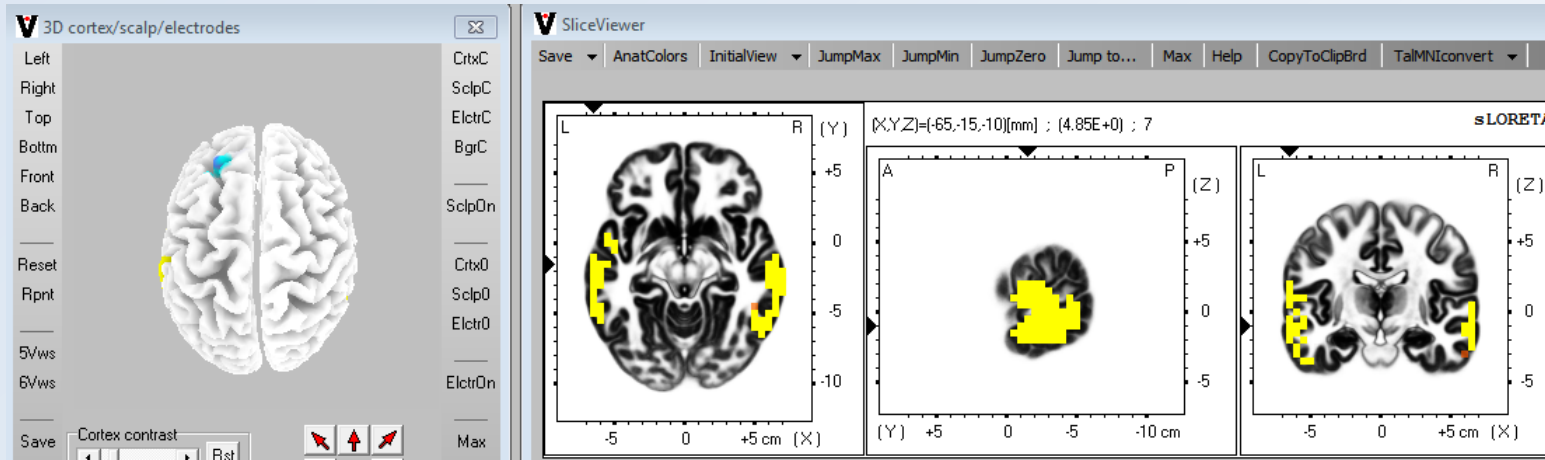
LORETA resting state network 5: Parietal Alpha1 anti-correlated with Occipital Alpha2



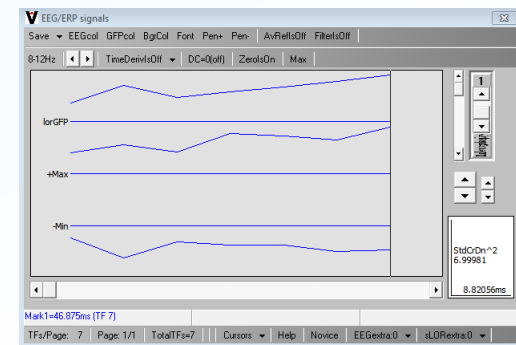
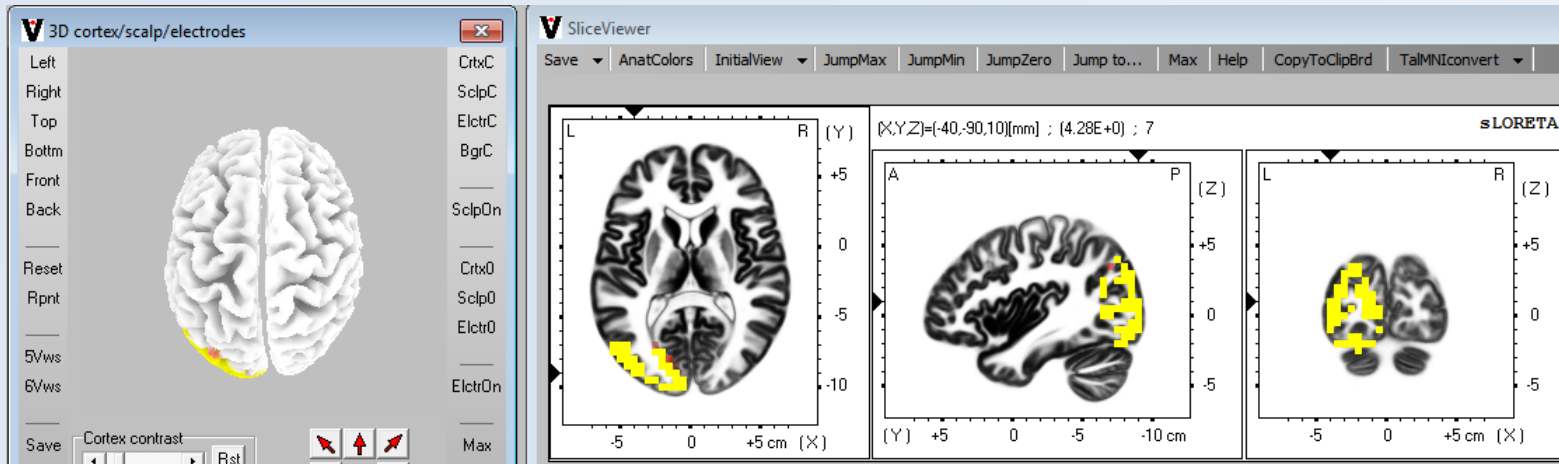
LORETA resting state network 6: Occipital Alpha anti-correlated with Frontal Beta2



LORETA resting state network 9: Temporal (auditory) cortices Beta2 and Beta3



LORETA resting state network 11: Left Occipito-Parietal cortex Alpha2 to Beta3



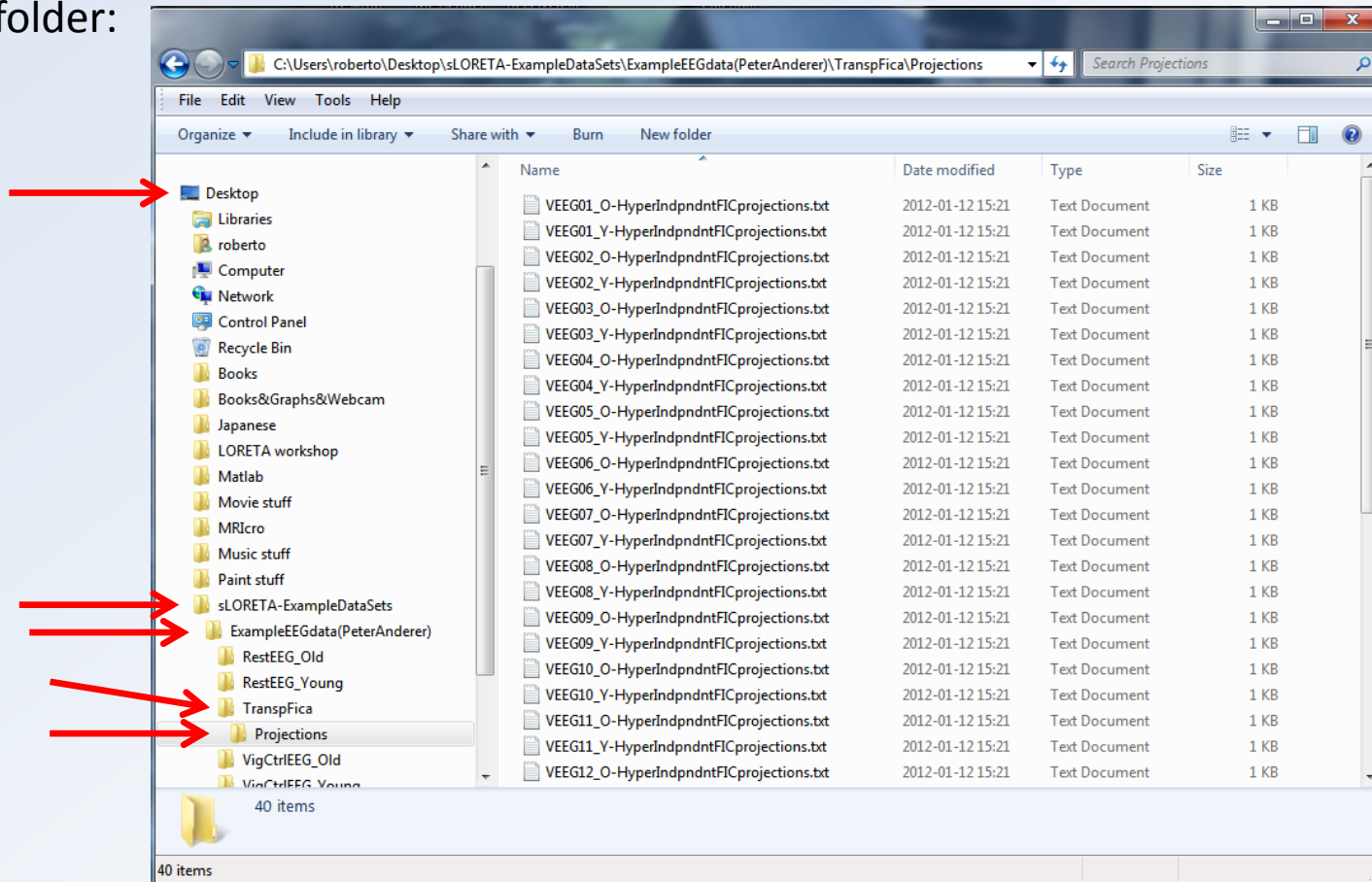
Statistical Analysis of Resting State Networks

The previous 15 resting state networks are common to both groups of subjects (young and old normal controls).

Both types of brain use the same resources (common networks).

However, it may happen that the older subjects use some networks in a different way as compared to the younger subjects.

The usage of the networks for each subject consist of the files located in the “Projections” folder:

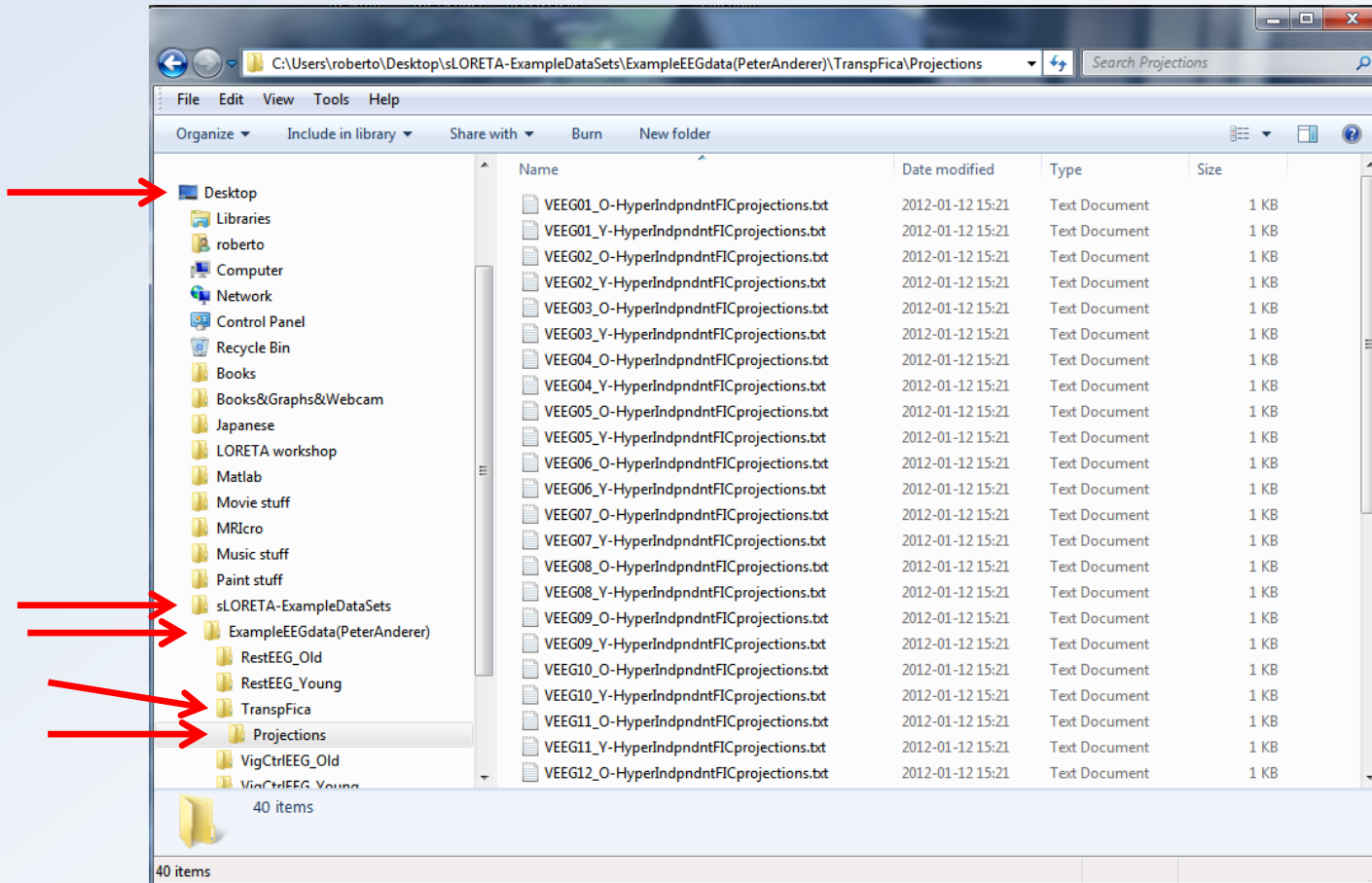


For instance:

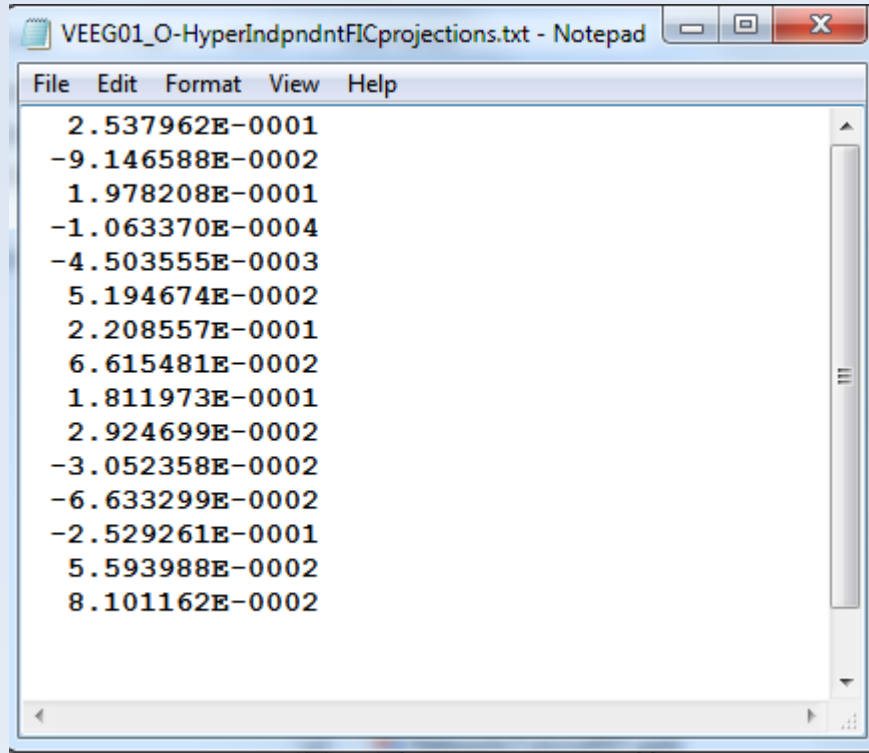
VEEG01_O-HyperIndpndntFICprojections.txt corresponds to old subject number 1;

VEEG01_Y-HyperIndpndntFICprojections.txt corresponds to young subject number 1;

These text files contain 15 coefficients, expressing how each network is used.



For instance, the coefficients for VEEG01_O-HyperIndpndntFICprojections.txt are



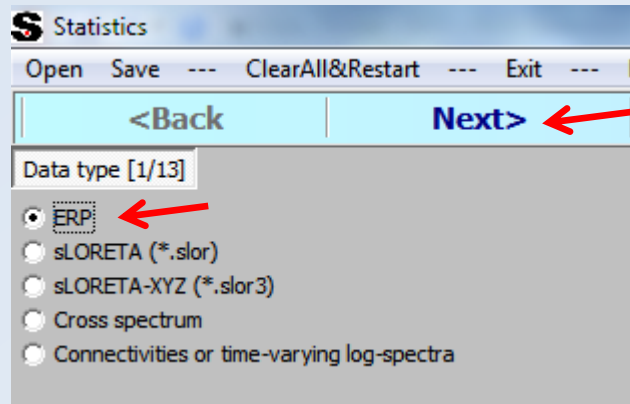
```
VEEG01_O-HyperIndpndntFICprojections.txt - Notepad
File Edit Format View Help
2.537962E-0001
-9.146588E-0002
1.978208E-0001
-1.063370E-0004
-4.503555E-0003
5.194674E-0002
2.208557E-0001
6.615481E-0002
1.811973E-0001
2.924699E-0002
-3.052358E-0002
-6.633299E-0002
-2.529261E-0001
5.593988E-0002
8.101162E-0002
```

One coefficient for each network, expressing how that subject uses that network.

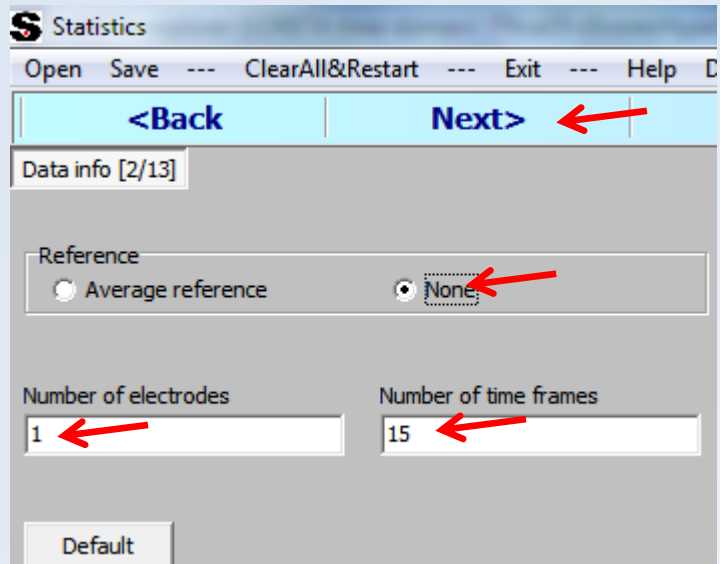
Statistical analysis can be performed on these 15 numbers, comparing Old and Young groups, in search of how the old brain uses the Resting State networks differently from the young brain.

For statistical analysis, these files will be treated as ERP files, with 1 fictitious electrode and 15 fictitious time frames.

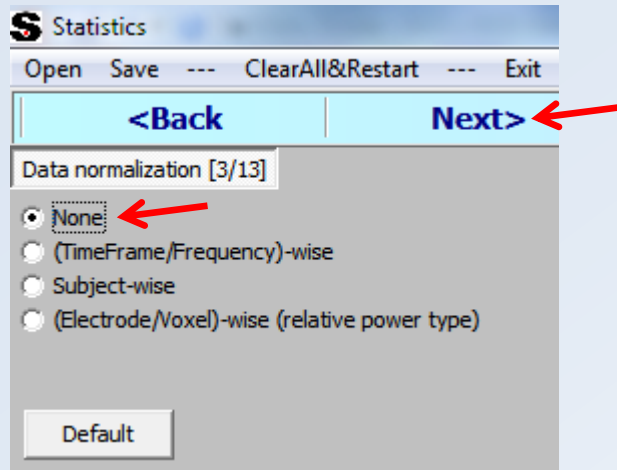
Run the Statistics module and note the arrows:



Continuing Statistics, note the arrows:




Continuing Statistics, note the arrows:




Continuing Statistics, note the arrows:

S Statistics

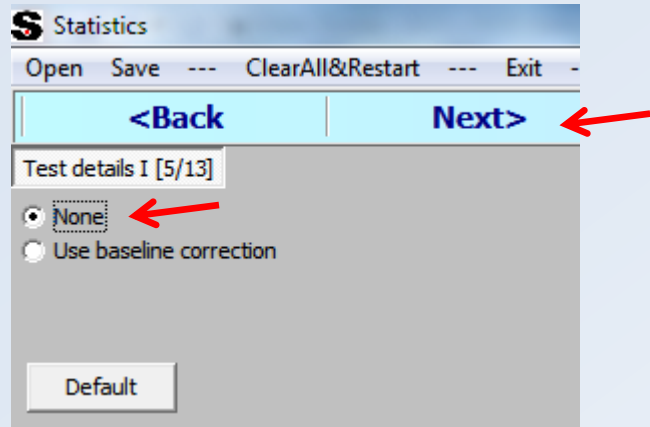
Open Save --- ClearAll&Restart --- Exit --- Help DragDropUtil WindowsExplorer

[<Back](#) [Next>](#)  [HELP](#) [DragDropUtil](#)

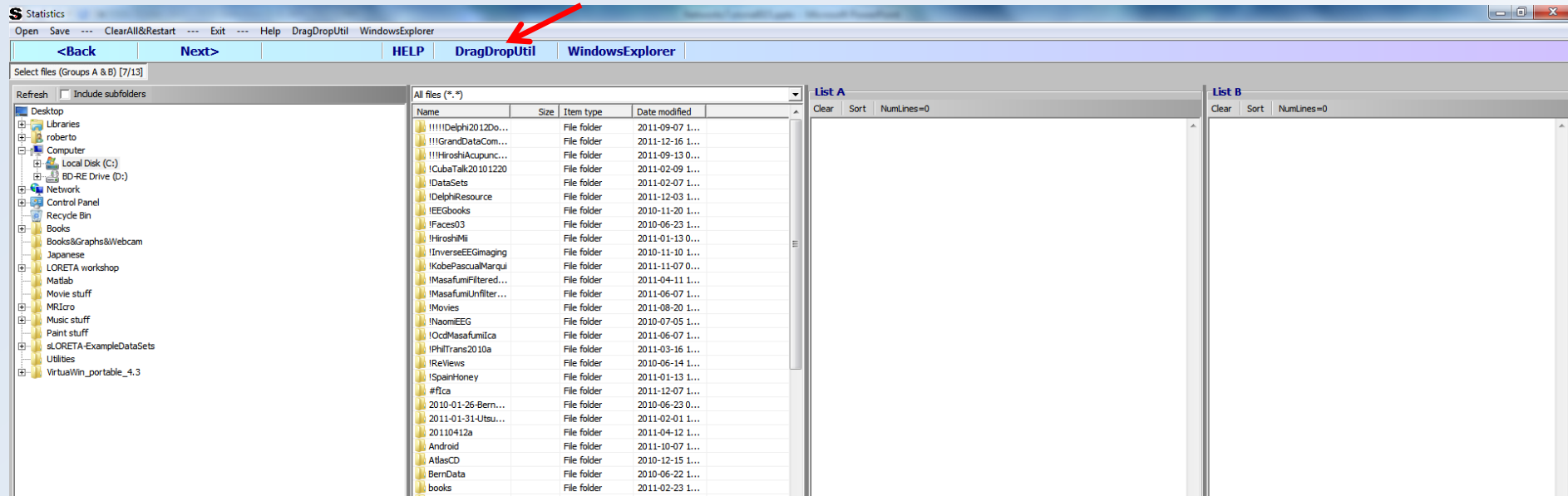
Test type [4/13]

- Paired groups, test $A=B$
- Independent groups, test $A=B$ 
- Single group, zero mean test $A=0$
- Paired groups, test $(A-A_2)=(B-B_2)$
- Independent groups, test $(A-A_2)=(B-B_2)$ [NOTE: A and A2 are paired; B and B2 are paired; but (A,A2) is independent of (B,B2)]
- Regression, single group A vs. external independent variables
- Regression, paired contrast (A_1-A_2) vs. external independent variables

Continuing Statistics, note the arrows:



Continuing Statistics, note the arrows:



At this point the files with the coefficients (projections) must be selected carefully, placing (drag/drop) the old subjects in list A, and the young subjects in list B. This can be achieved manually, using the left side panels. But more conveniently using the DragDropUtil (red arrow).

Continuing Statistics, note the arrows:

The screenshot shows a Windows Explorer window titled "Statistics" with a search for files containing "_O". The search results are displayed in a list view. A red arrow points to the search criteria "_O" in the search bar. Another red arrow points to the "List A" box on the right, which contains the search results. A third red arrow points to the "Projections" folder in the left sidebar.

File name: "VEEG01_O-HyperIndpndntFICprojections.txt" "VEEG02_O-HyperIndpndntFICprojections.txt" "VEEG03_O-HyperIndpndntFICprojections.txt" "VEEG04_O-HyperIndpndntFICprojections.txt" "VEEG05_O-HyperIndpndntFICprojections.txt" "VEEG06_O-HyperIndpndntFICprojections.txt" "VEEG07_O-HyperIndpndntFICprojections.txt" "VEEG08_O-HyperIndpndntFICprojections.txt" "VEEG09_O-HyperIndpndntFICprojections.txt" "VEEG10_O-HyperIndpndntFICprojections.txt" "VEEG11_O-HyperIndpndntFICprojections.txt" "VEEG12_O-HyperIndpndntFICprojections.txt" "VEEG13_O-HyperIndpndntFICprojections.txt" "VEEG14_O-HyperIndpndntFICprojections.txt" "VEEG15_O-HyperIndpndntFICprojections.txt" "VEEG16_O-HyperIndpndntFICprojections.txt" "VEEG17_O-HyperIndpndntFICprojections.txt" "VEEG18_O-HyperIndpndntFICprojections.txt" "VEEG19_O-HyperIndpndntFICprojections.txt" "VEEG20_O-HyperIndpndntFICprojections.txt"

Name	Date modified	Type	Size
VEEG01_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG02_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG03_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG04_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG05_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG06_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG07_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG08_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG09_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG10_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG11_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG12_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG13_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG14_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG15_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG16_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG17_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG18_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG19_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG20_O-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	

The filenames for old subjects include the unique characters “_O”. The search function finds these 20 files, and they are selected and drag/dropped in list A.

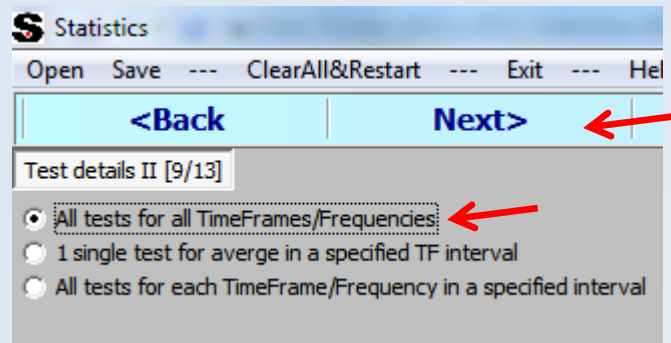
Continuing Statistics, note the arrows:

The screenshot shows a Windows Explorer window with a search for files containing "_Y". The search results are displayed in a table with columns for Name, Date modified, Type, and Size. The files listed are all text documents with names like "VEEG01_Y-HyperIndpndntFICprojections.txt" through "VEEG20_Y-HyperIndpndntFICprojections.txt". A red arrow points to the search results table. Another red arrow points to the "Open" button at the bottom. A dashed red arrow points from the search results to List B on the right, which shows the files being dragged into it.

Name	Date modified	Type	Size
VEEG01_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG02_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG03_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG04_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG05_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG06_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG07_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG08_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG09_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG10_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG11_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG12_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG13_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG14_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG15_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG16_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG17_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG18_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG19_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	
VEEG20_Y-HyperIndpndntFICprojections.txt	2012-01-12 15:21	Text Document	

The filenames for young subjects include the unique characters “_Y”. The search function finds these 20 files, and they are selected and drag/dropped in list B. **Now click next.**

Continuing Statistics, note the arrows:



Continuing Statistics, note the arrows:

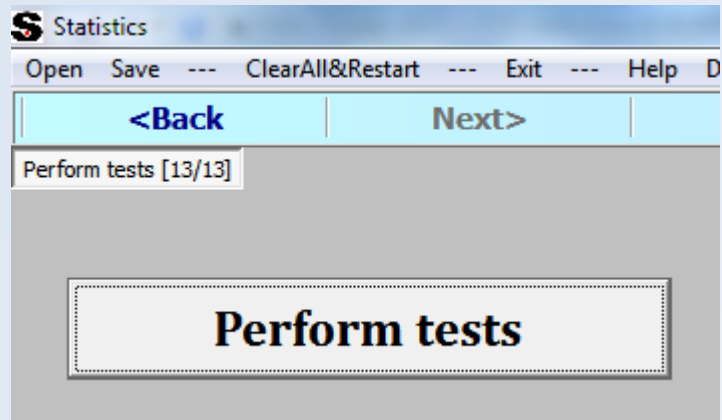
The screenshot shows the Statistics software interface with a file save dialog box overlaid. Red arrows point to various UI elements:

- The **Next>** button in the software's navigation bar.
- The **t-statistic** radio button in the "Statistic [12/13]" section.
- The input field for the "Variance smoothing parameter for t-statistic (range: 0...1)" set to 0.
- The radio button for "Perform randomization SnPM, and compute bullet proof, corr".
- The "Number of randomizations" input field set to 5000.
- The "New folder" button in the "Statistics results will be saved to..." dialog.
- The "ttest" folder in the file list of the dialog.
- The "File name:" input field in the dialog, containing the text "t".

Double-click

Create a New Folder, under Projections, any name OK (e.g. "ttest"), and type any name for the output file (e.g. "t"), click Save.

Finally click perform tests, and wait till finished.



Open the windows explorer, navigate to the “ttest” folder:

The screenshot shows a Windows Explorer window with the following path: sLORETA-ExampleDataSets > ExampleEEGdata(PeterAnderer) > TranspFica > Projections > ttest. The search bar contains 'Search ttest'. The left sidebar shows the folder tree with 'ttest' selected. The main pane displays a table of files:

Name	Date modified	Type	Size
t.TestSetup	2012-01-12 18:21	TESTSETUP File	7 KB
t.txt	2012-01-12 18:21	Text Document	1 KB
t_EmpProb_(A-B)GreaterThanZero.txt	2012-01-12 18:21	Text Document	167 KB
t_EmpProb_(A-B)SmallerThanZero.txt	2012-01-12 18:21	Text Document	167 KB
t_EmpProb_Abs(A-B)GreaterThanZero.txt	2012-01-12 18:21	Text Document	167 KB
t-MaxStatistics.txt	2012-01-12 18:21	Text Document	1 KB
t-TestSetup.txt	2012-01-12 18:21	Text Document	9 KB
t-Thresholds&ExtremePs.txt	2012-01-12 18:21	Text Document	2 KB

A red arrow points from the text box to the file 't-Thresholds&ExtremePs.txt'. The text box contains the instruction: 'Open the thresholds file (it is a text file)'. The status bar at the bottom shows '8 items' and 'Computer'.

```

t-Thresholds&ExtremePs.txt - Notepad
File Edit Format View Help

t(0.01)    t(0.05)    t(0.10)    ExtremeP
One-Tailed (A>B):    3.605     2.932     2.629     0.00320
One-Tailed (A<B):   -3.559    -2.979    -2.658    0.00680
Two-Tailed (A<>B):   3.815     3.232     2.920     0.00600

-----

Exceedence proportion tests:

  Thrsh(1Tailed>0)    Prob(1Tailed>0)    Thrsh(1Tailed<0)    Prob(1Tailed<0)    Thrsh(2Tailed)    Prob(2Tailed)
0.398516             0.442400           -0.373899           0.675600           0.398516           0.706800
0.797033             0.678000           -0.747797           0.277000           0.797033           0.526800
1.195549             0.298400           -1.121696           0.158400           1.195549           0.185400
1.594066             0.249400           -1.495595           0.113800           1.594066           0.146400
1.992582             0.078800           -1.869494           0.024400           1.992582           0.024400
2.391099             0.018800           -2.243392           0.033400           2.391099           0.014800
2.789615             0.004200           -2.617291           0.007400           2.789615           0.002600
3.188132             0.000600           -2.991190           0.000800           3.188132           0.000000
3.586648             0.000200           -3.365088           0.000600           3.586648           0.000000
3.985164             0.003000           -3.738987           0.006800           3.985164           0.005800

```

There is significant difference between the way the old and young subjects use the resting state networks!

The highlighted threshold value is $t=1.99$, for $p=0.02$

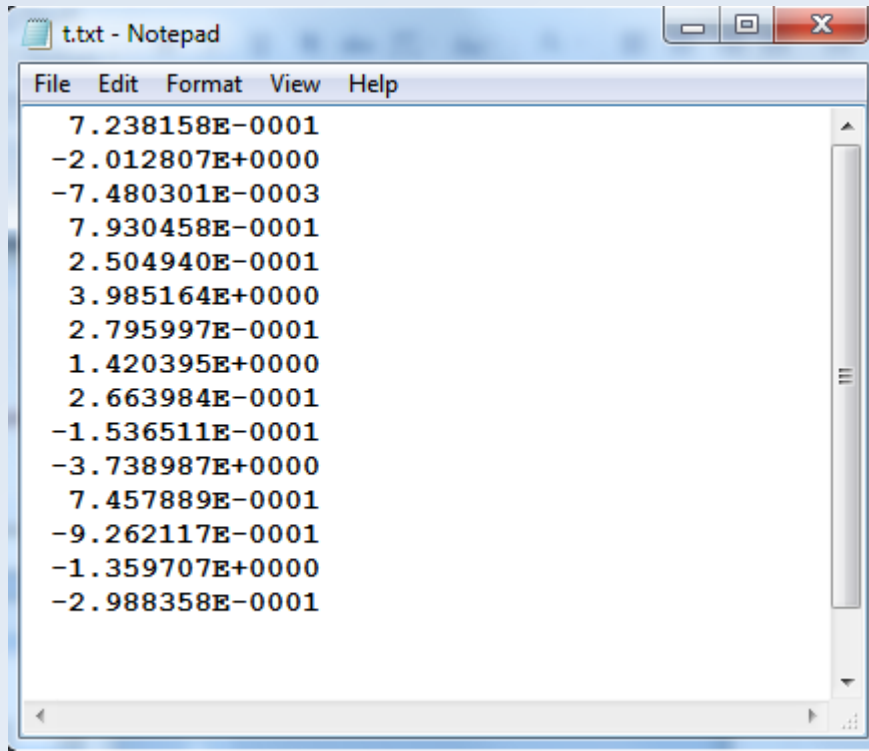
Open the windows explorer, navigate to the “ttest” folder:

The screenshot shows a Windows Explorer window with the following path: sLORETA-ExampleDataSets > ExampleEEGdata(PeterAnderer) > TranspFica > Projections > ttest. The left sidebar shows the folder tree with 'ttest' selected. The main pane displays a list of files:

Name	Date modified	Type	Size
t.TestSetup	2012-01-12 18:21	TESTSETUP File	7 KB
t.txt	2012-01-12 18:21	Text Document	1 KB
t_EmpProb_(A-B)GreaterThanZero.txt	2012-01-12 18:21	Text Document	167 KB
t_EmpProb_(A-B)SmallerThanZero.txt	2012-01-12 18:21	Text Document	167 KB
t_EmpProb_Abs(A-B)GreaterThanZero.txt	2012-01-12 18:21	Text Document	167 KB
t-MaxStatistics.txt	2012-01-12 18:21	Text Document	1 KB
t-TestSetup.txt	2012-01-12 18:21	Text Document	9 KB
t-Thresholds&ExtremePs.txt	2012-01-12 18:21	Text Document	2 KB

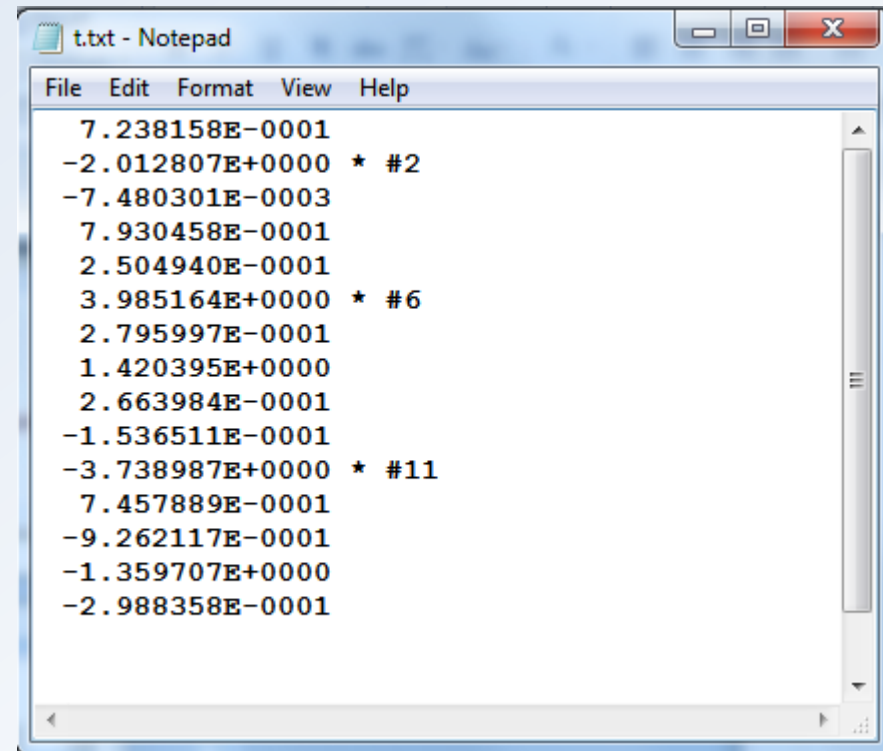
A red arrow points from the 't.txt' file in the list to a text box that says: "Now open the file with the t-values (it is a text file)". Another red arrow points to the 'ttest' folder in the left sidebar.

Original t-values:



```
t.txt - Notepad
File Edit Format View Help
7.238158E-0001
-2.012807E+0000
-7.480301E-0003
7.930458E-0001
2.504940E-0001
3.985164E+0000
2.795997E-0001
1.420395E+0000
2.663984E-0001
-1.536511E-0001
-3.738987E+0000
7.457889E-0001
-9.262117E-0001
-1.359707E+0000
-2.988358E-0001
```

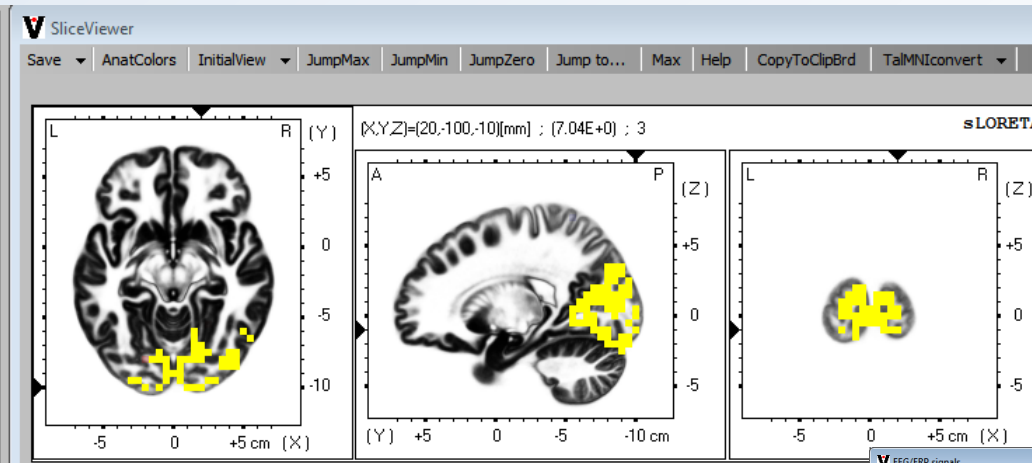
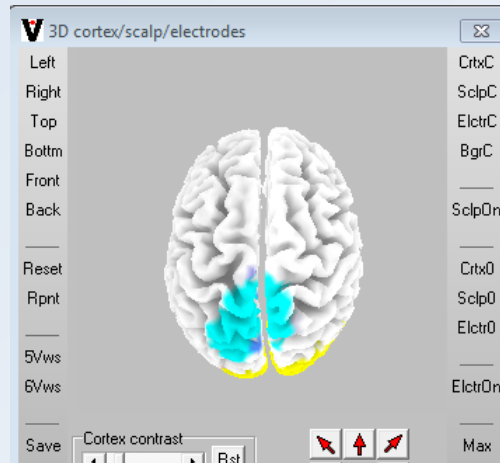
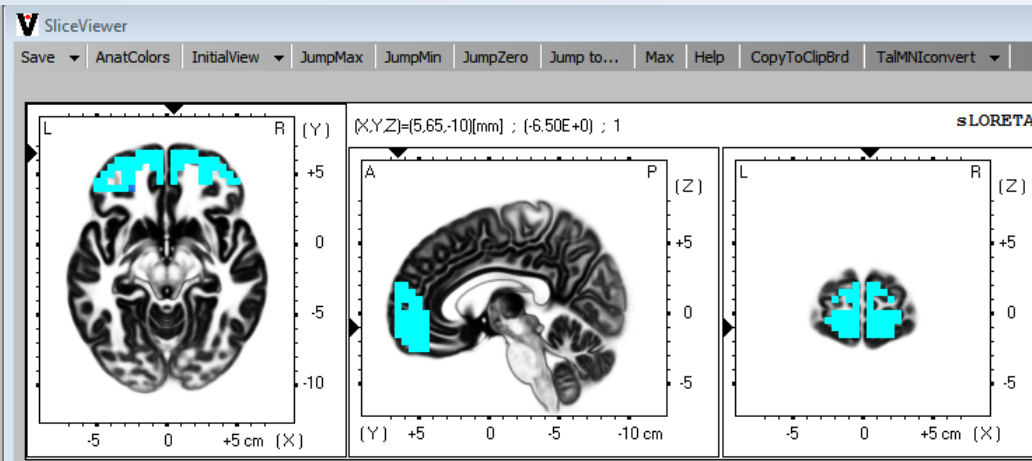
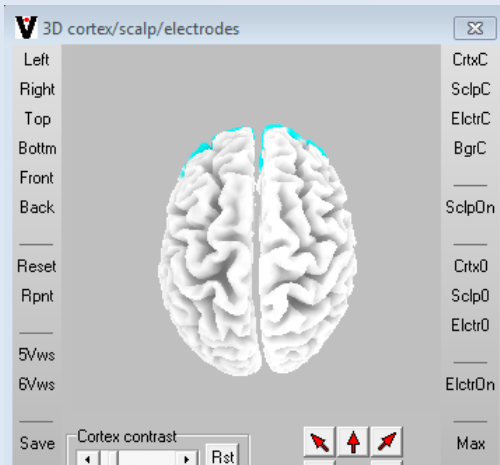
Indicating significant results (t=2, p=0.024)



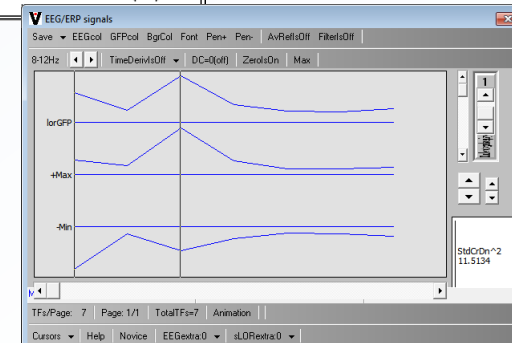
```
t.txt - Notepad
File Edit Format View Help
7.238158E-0001
-2.012807E+0000 * #2
-7.480301E-0003
7.930458E-0001
2.504940E-0001
3.985164E+0000 * #6
2.795997E-0001
1.420395E+0000
2.663984E-0001
-1.536511E-0001
-3.738987E+0000 * #11
7.457889E-0001
-9.262117E-0001
-1.359707E+0000
-2.988358E-0001
```

The use of the resting state networks numbered 2, 6, and 11 are significantly different between old and young subjects

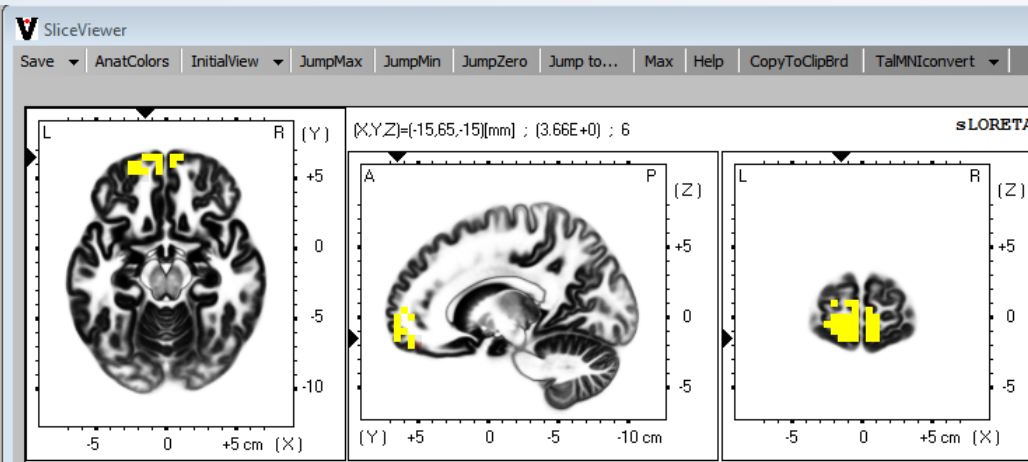
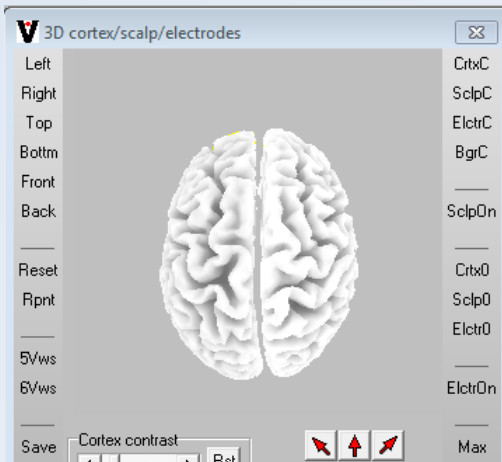
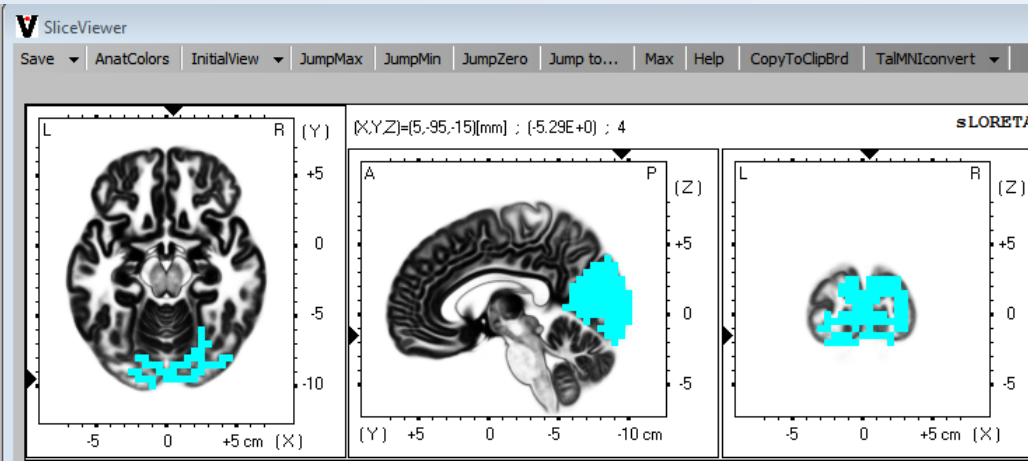
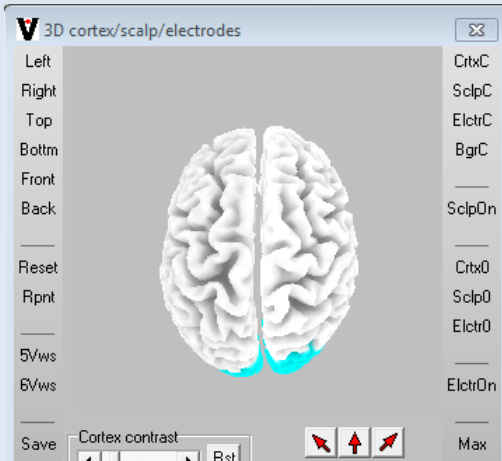
LORETA resting state network 2: (Frontal Delta AND Parietal Alpha1) anti-correlated with Occipital Alpha1



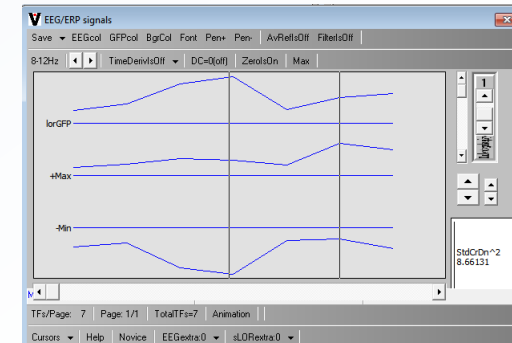
t=-2, invert sign: Old have reduced occipital alpha AND excess frontal delta compared to young (normal aging?)



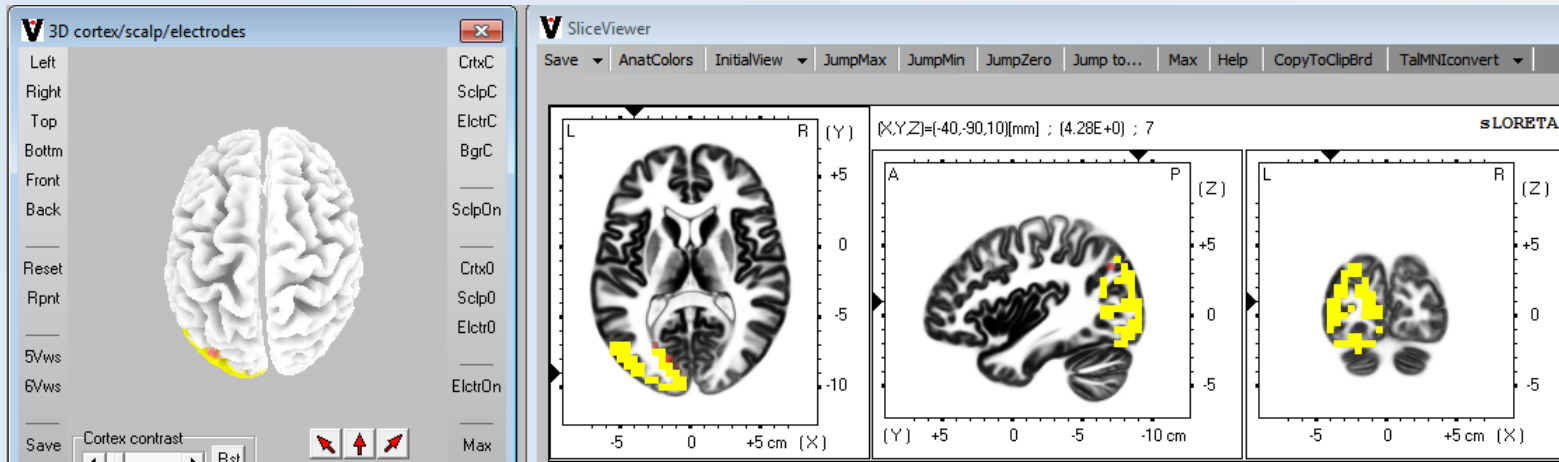
LORETA resting state network 6: Occipital Alpha anti-correlated with Frontal Beta2



t=+4: Old have reduced occipital alpha AND excess frontal beta compared to young (normal aging, hyper-excitable frontal areas try to compensate age effect?)



LORETA resting state network 11: Left Occipito-Parietal cortex Alpha2 to Beta3



t=-3.7, invert sign: Old have reduced left occipito-parietal high frequencies compared to young (normal aging, insufficiently excitable association cortex and language areas?)

