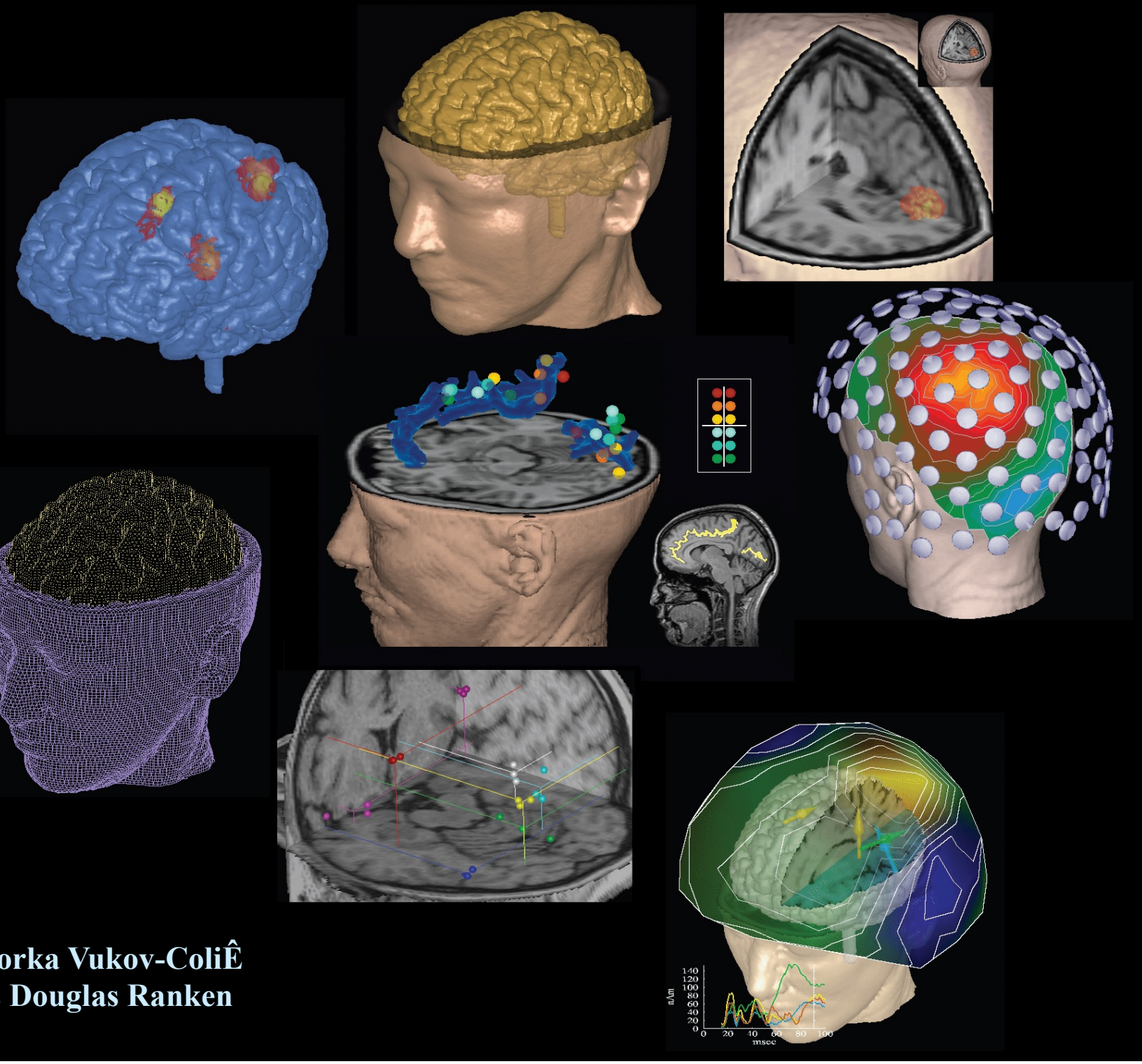
MEG and Neuropsychiatry

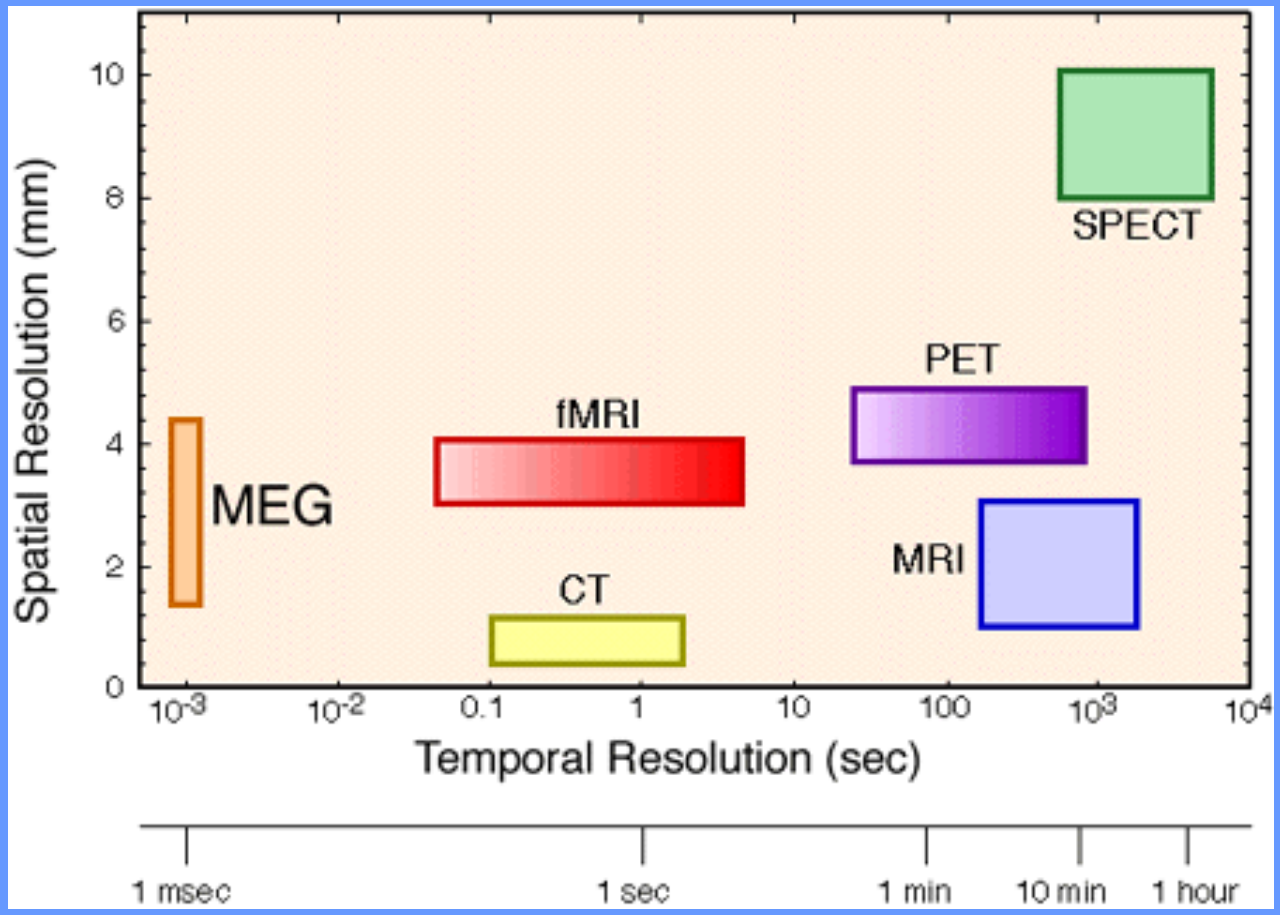
Richard Coppola, D.Sc.

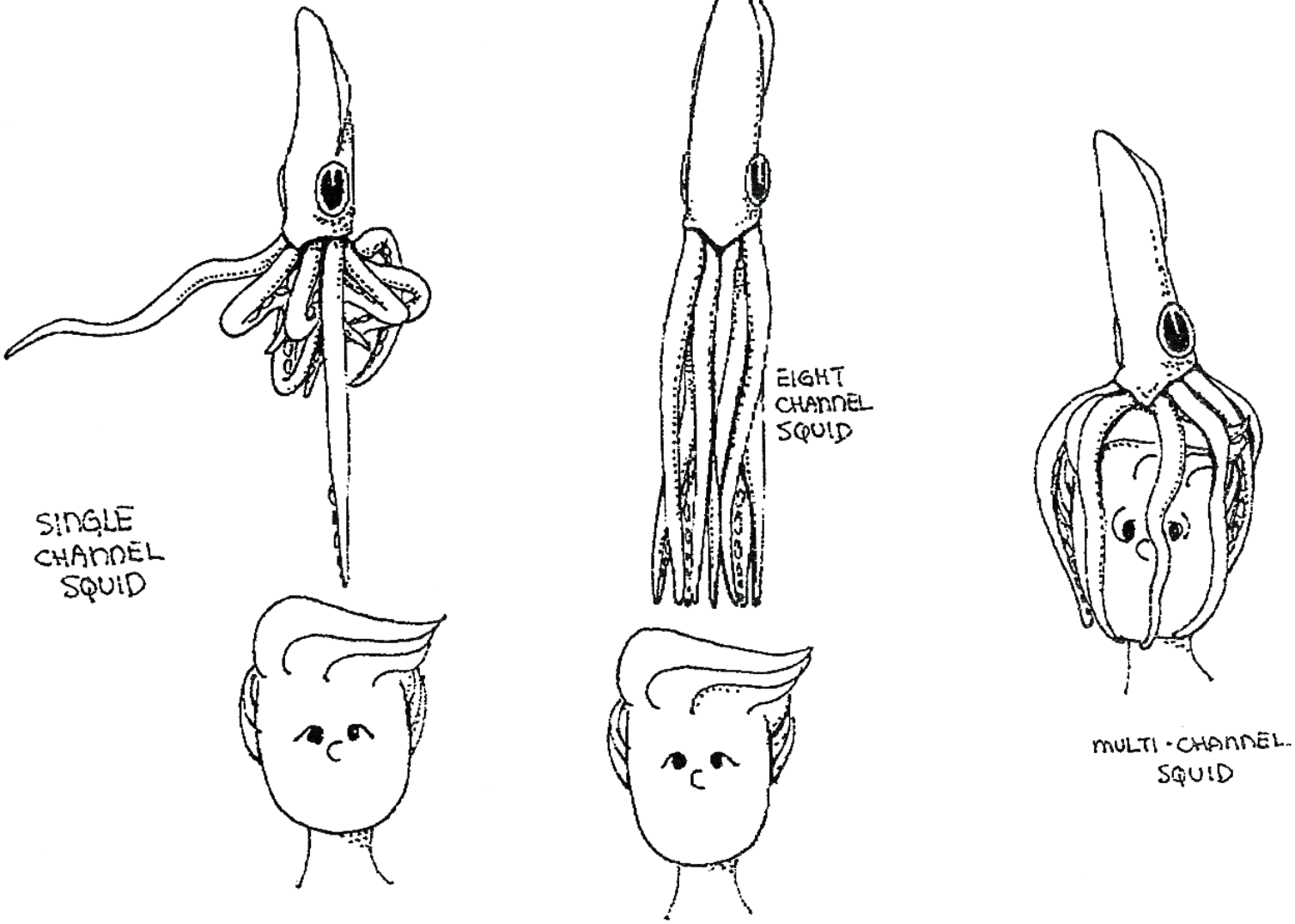
NIMH MEG Core Facility

NIMH
National Institute
of Mental Health



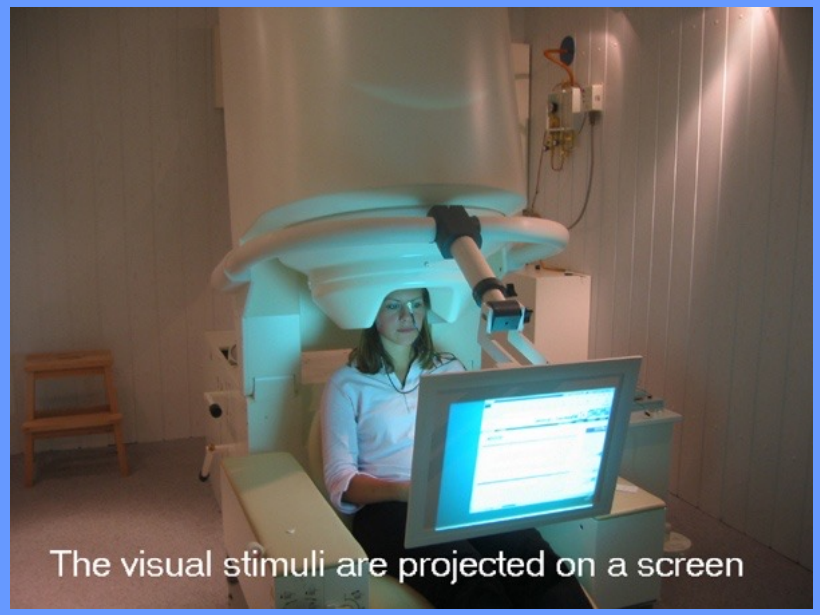
Piše/By **Davorka Vukov-ColiÊ**
Slike/Images **Douglas Ranken**

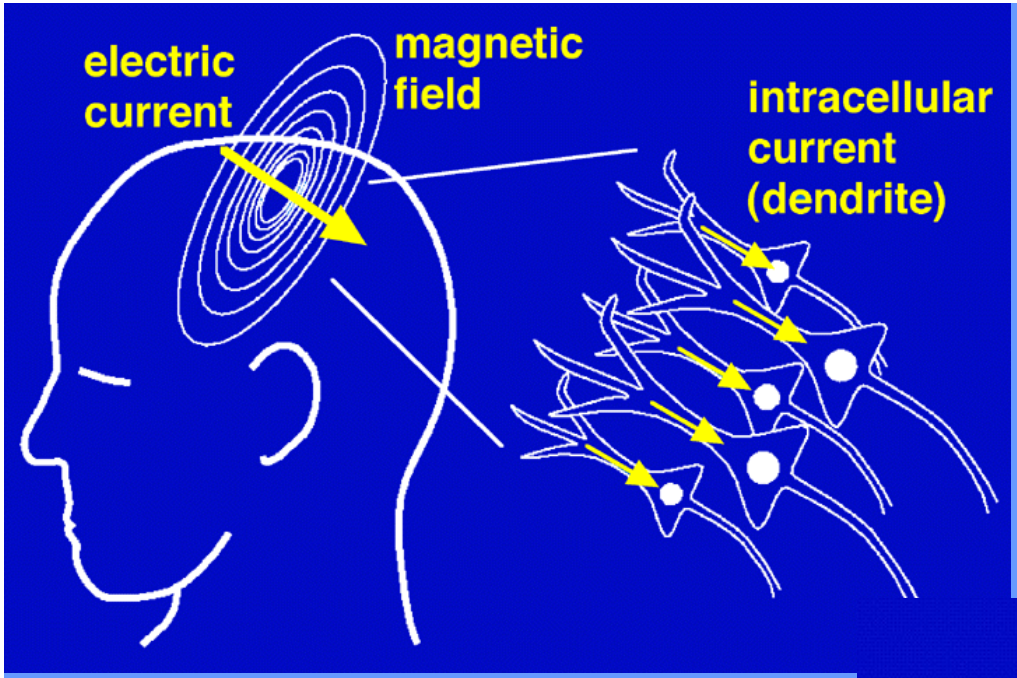

Spatial Resolution (mm)
10
8
6
4
2
0
SPECT
PET
fMRI
MEG
MRI
CT
10^{-3}
10^{-2}
0.1
1
10
100
10^{3}
10^{4}
Temporal Resolution (sec)
1 msec
1 sec
1 min
10 min
1 hour


SINGLE CHANNEL SQUID
EIGHT CHANNEL SQUID
MULTI-CHANNEL SQUID

MEG

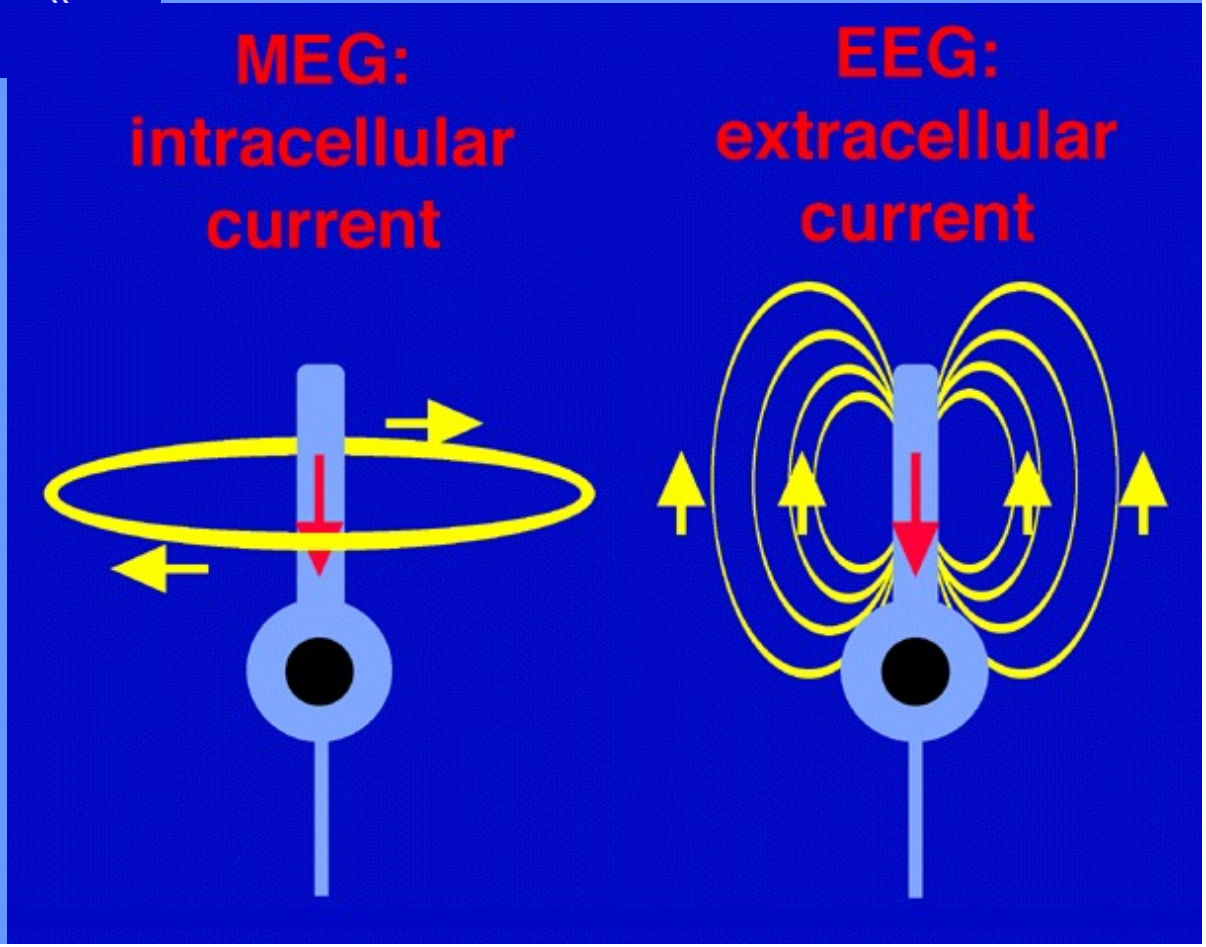
Functional Imaging





A close group of neurons can act as a single current source, which in turn gives rise to a magnetic field over the surface of the head.

MEG's primary response is to tangential fields, whereas EEG can be used to measure radial fields. Furthermore, MEG measures intercellular current while EEG measures volume extracellular currents. The information that is contained with these two measures is complementary.



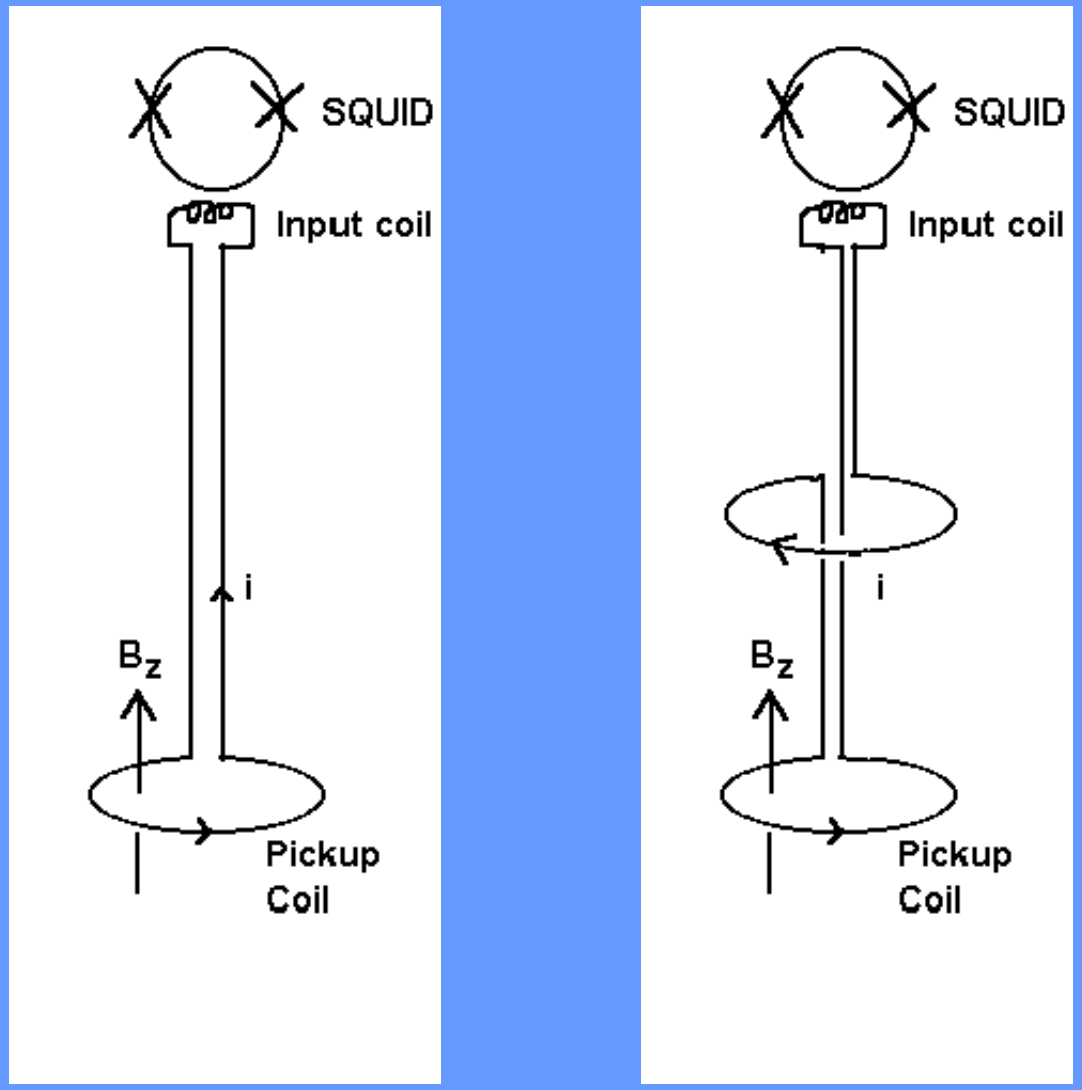
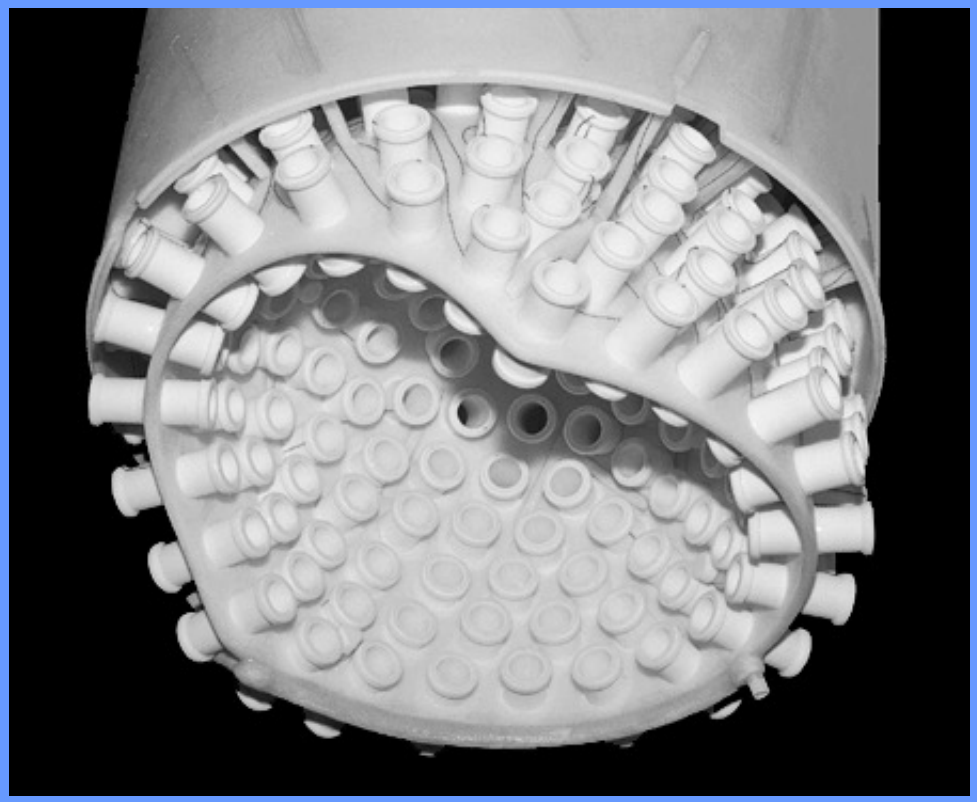
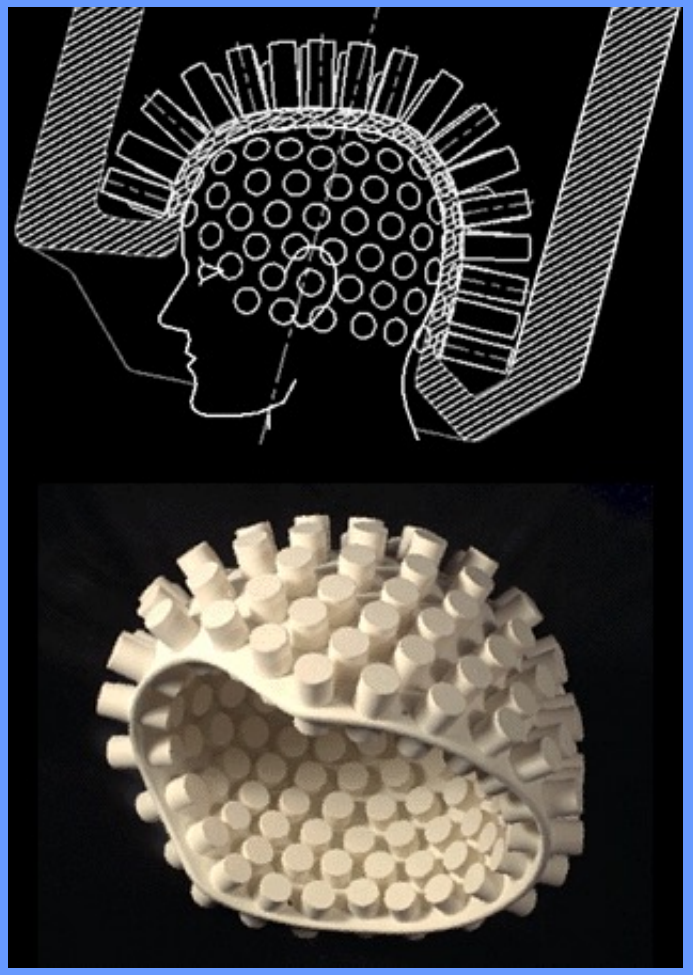


Figure 2. Flux transformers used to transport flux to the SQUID loop.

(a) shows a simple one coil flux transformer, (b) a first order gradiometer.





CTF 151 Channel array

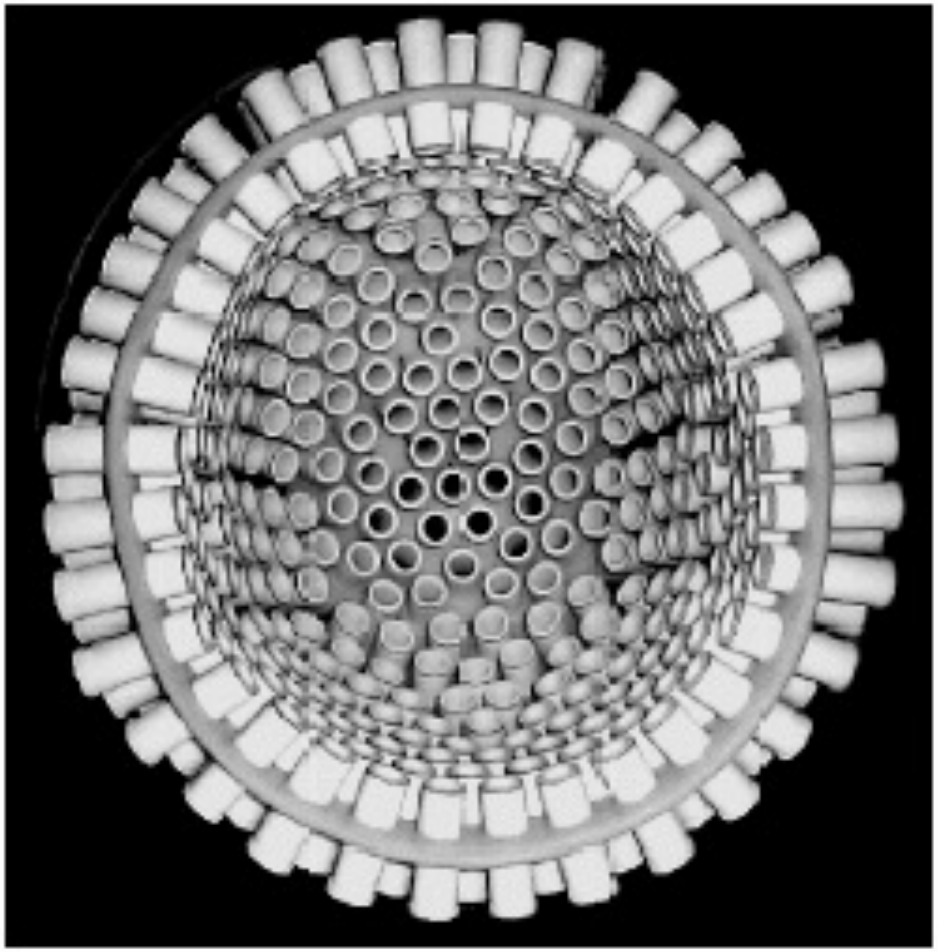
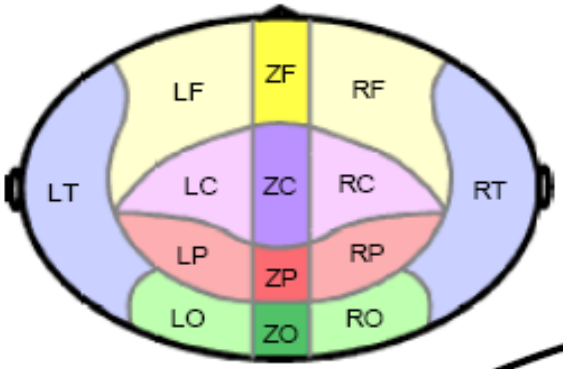


Fig. 2 End (axial) view of the 275-channel MEG sensor array showing 275 radial 1st gradiometers with optimized baselines b_l = 50 mm and coil diameters = 18 mm, mounted in a rigid helmet-shaped support.

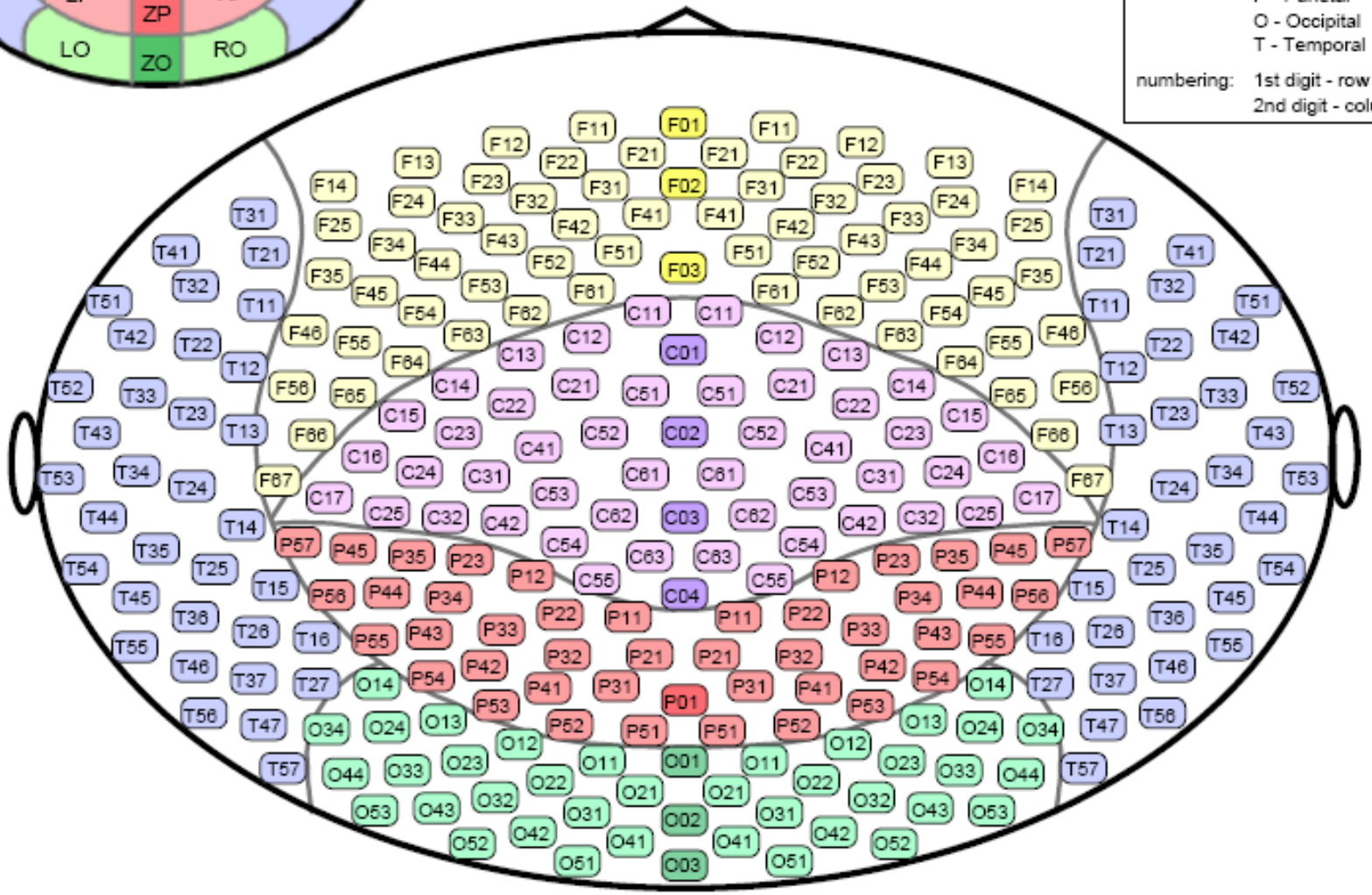


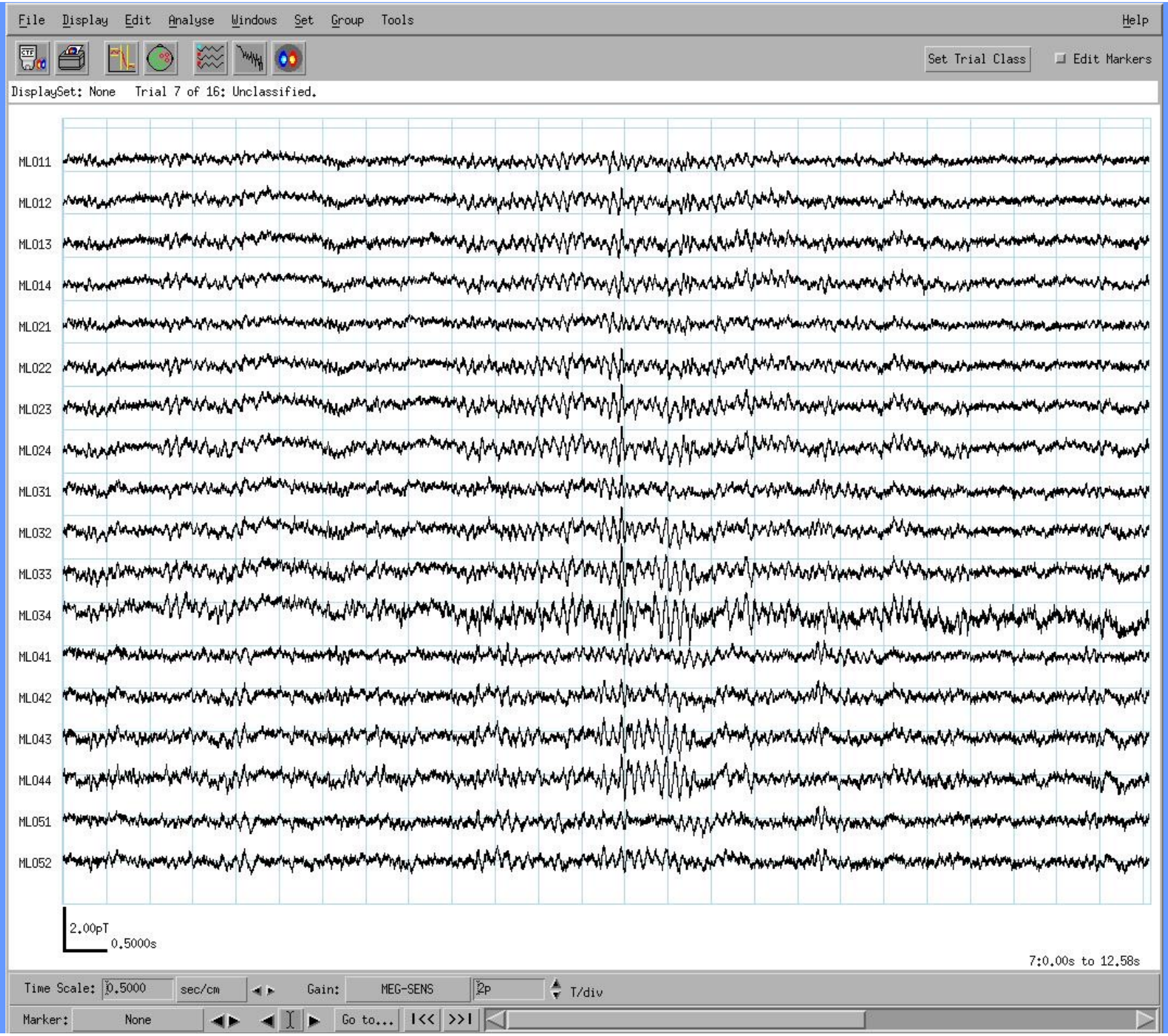
Sensor Names - 275 Channel Systems

CHANNEL COUNT:

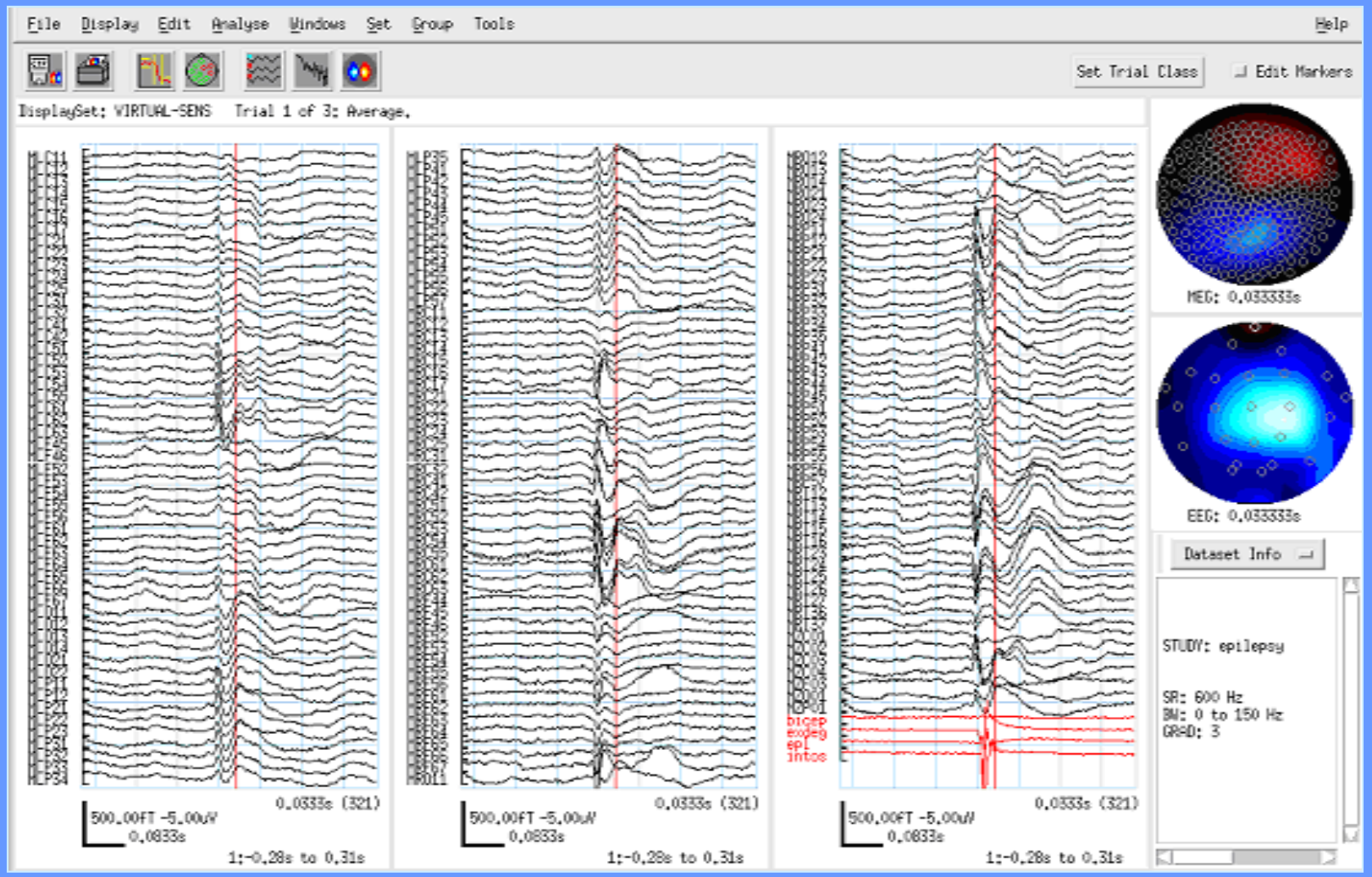
	Frontal	Central	Parietal	Occipital	Temporal	Totals
Z (Midline)	3	4	1	3	0	11
L (Left)	33	24	22	19	34	132
R (Right)	33	24	22	19	34	132
Totals	69	52	45	41	68	275

1st letter:	M - MEG
	E - EEG
2nd letter:	L - Left
	R - Right
	Z - Zenith (midline)
3rd letter:	F - Frontal
	C - Central
	P - Parietal
	O - Occipital
	T - Temporal
numbering:	1st digit - row
	2nd digit - column

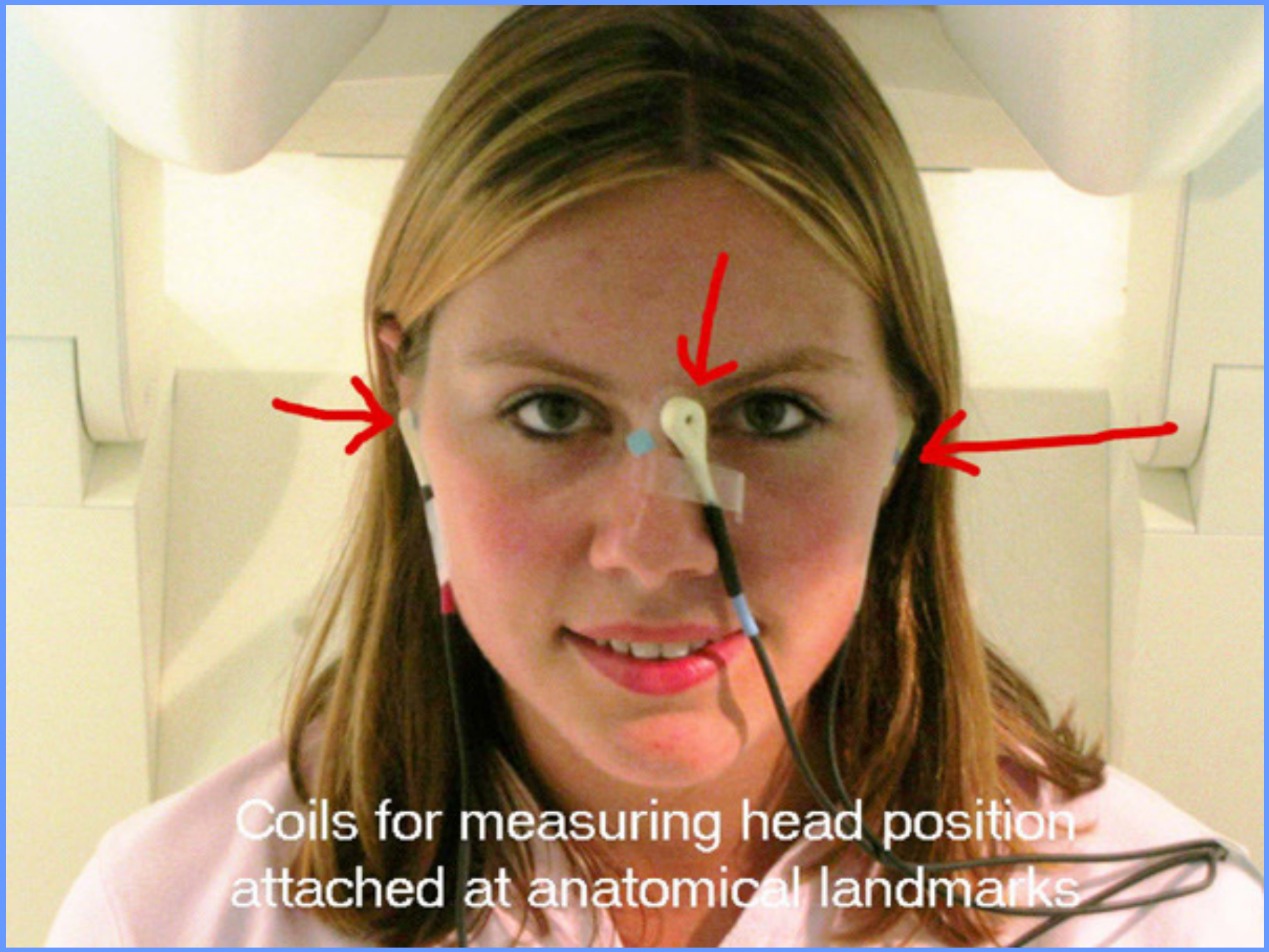


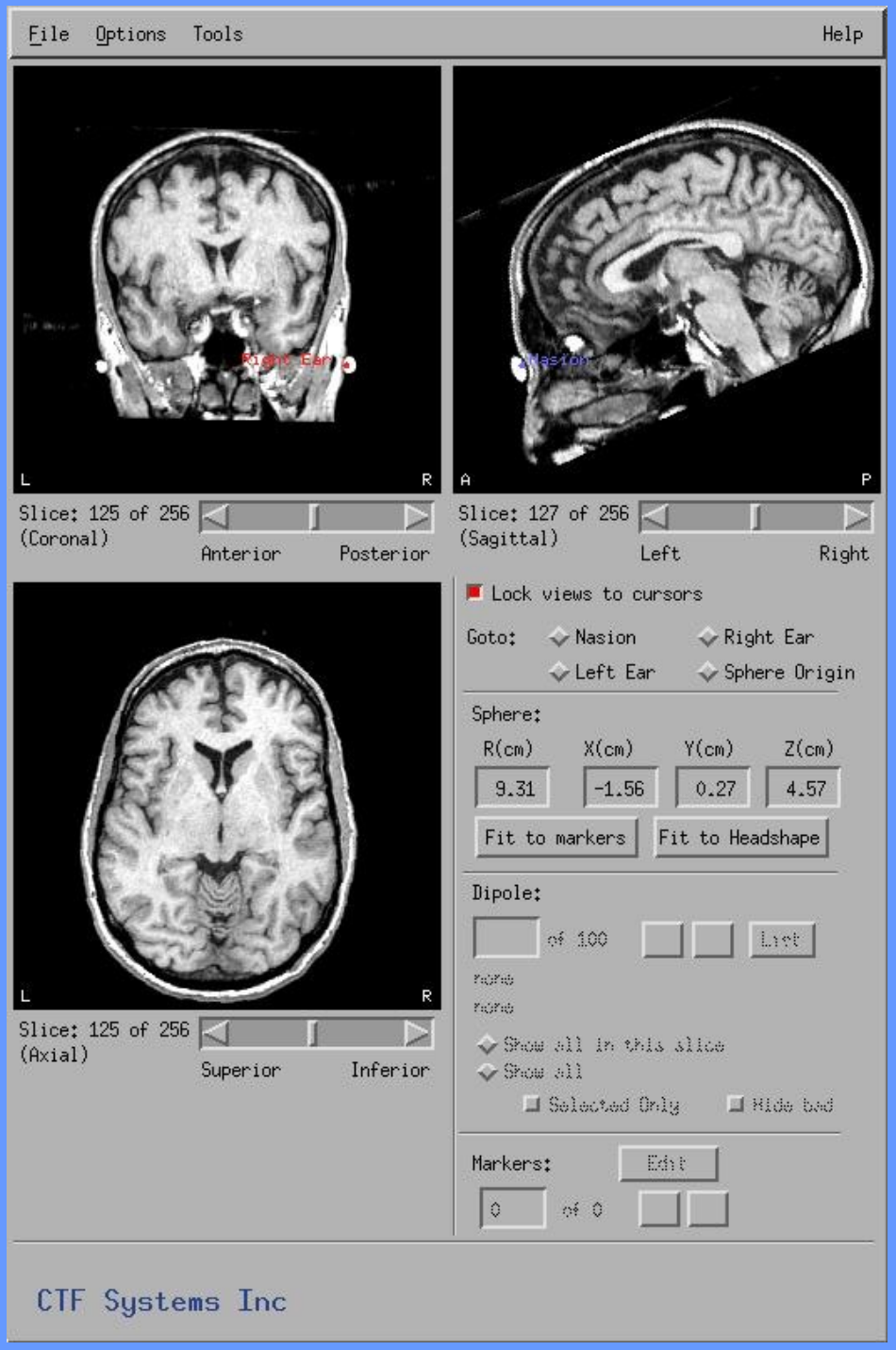

File Display Edit Analyse Windows Set Group Tools Help
Set Trial Class
Edit Markers
DisplaySet: None Trial 7 of 16: Unclassified.
MLO11
MLO12
MLO13
MLO14
MLO21
MLO22
MLO23
MLO24
MLO31
MLO32
MLO33
MLO34
MLO41
MLO42
MLO43
MLO44
MLO51
MLO52
2.00pT
0.5000s
7:0.00s to 12.58s
Time Scale: 0.5000 sec/cm
Gain: MEG-SENS 2P T/div
Marker: None
Go to...
I<< >>I

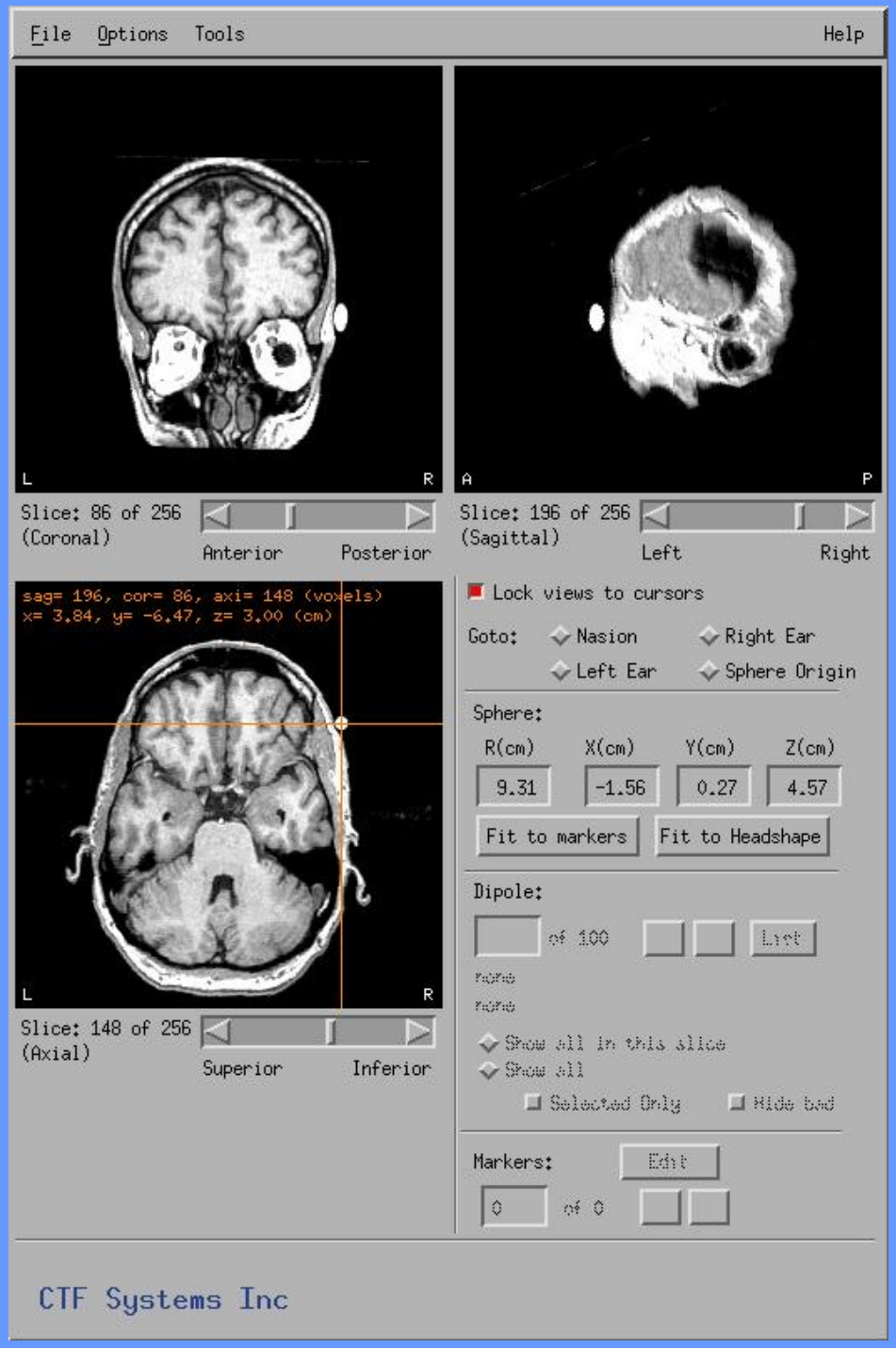
MEG example

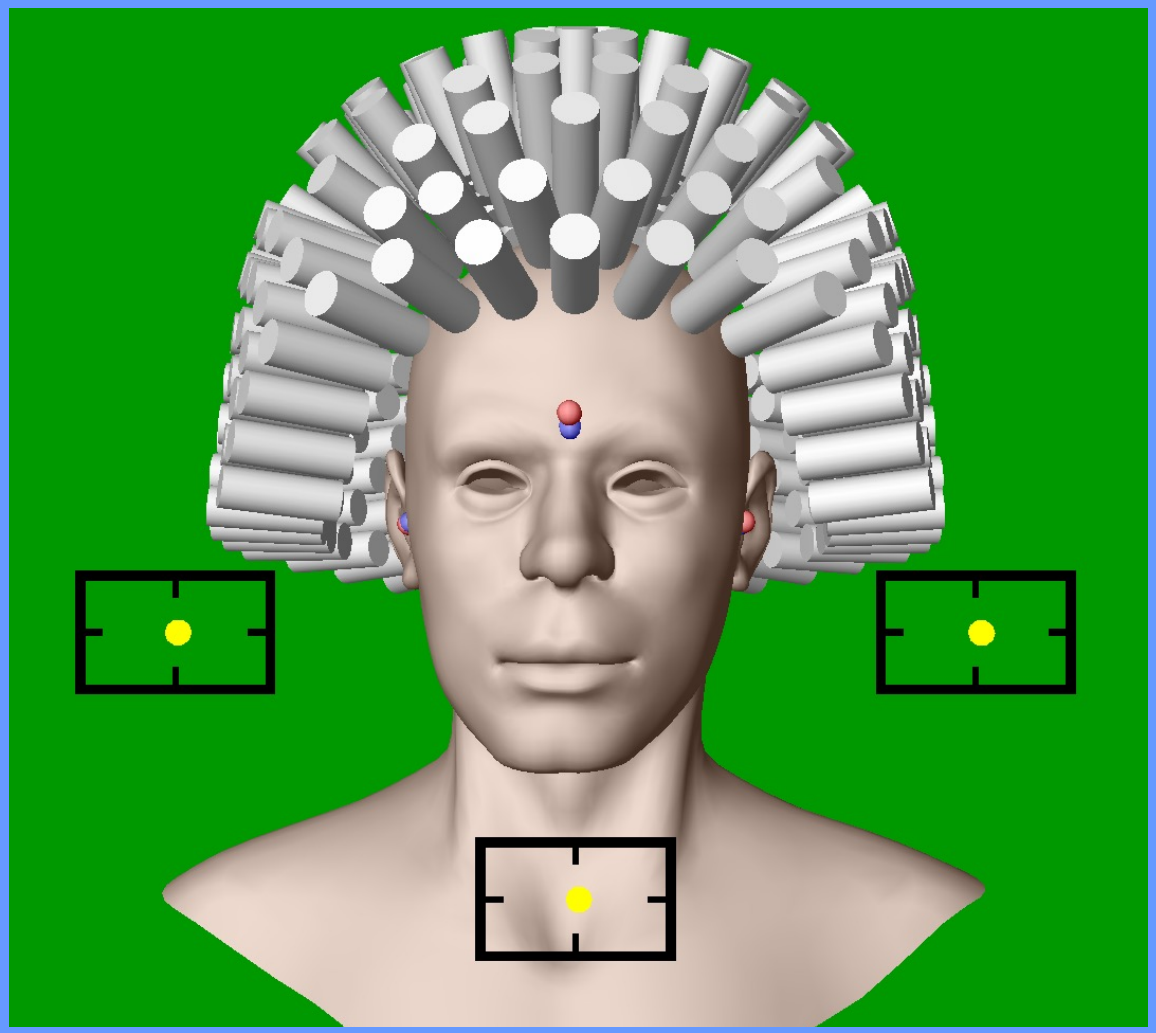


Epileptic spike associated with muscle twitch


Coils for measuring head position
attached at anatomical landmarks


File Options Tools Help
Right Ear
Nasion
L R
A P
Slice: 125 of 256
(Coronal)
Anterior Posterior
Slice: 127 of 256
(Sagittal)
Left Right
Slice: 125 of 256
(Axial)
Superior Inferior
Lock views to cursors
Goto: Nasion Right Ear
Left Ear Sphere Origin
Sphere:
R(cm) X(cm) Y(cm) Z(cm)
9.31 -1.56 0.27 4.57
Fit to markers Fit to Headshape
Dipole:
of 100
List
none
none
Show all in this slice
Show all
Selected Only Hide bad
Markers:
Edit
0 of 0
CTF Systems Inc


File Options Tools Help
sag= 196, cor= 86, axi= 148 (voxels)
x= 3.84, y= -6.47, z= 3.00 (cm)
L R
A P
Slice: 86 of 256
(Coronal)
Anterior Posterior
Slice: 196 of 256
(Sagittal)
Left Right
Slice: 148 of 256
(Axial)
Superior Inferior
Lock views to cursors
Goto: Nasion Right Ear
Left Ear Sphere Origin
Sphere:
R(cm) X(cm) Y(cm) Z(cm)
9.31 -1.56 0.27 4.57
Fit to markers Fit to Headshape
Dipole:
of 100
List
none
none
Show all in this slice
Show all
Selected Only Hide bad
Markers:
Edit
0 of 0
CTF Systems Inc



Target boxes indicate current position relative to previous head localization

Development Project: RealTime Head Localization display

Facilitates repositioning subject in helmet

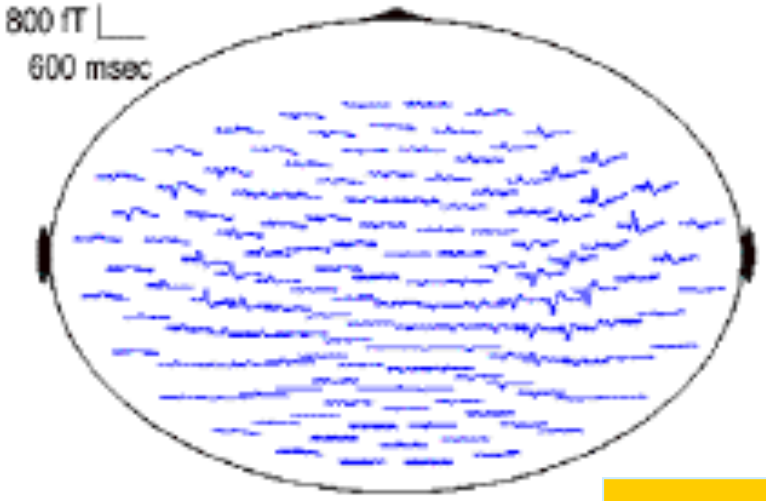
Time Series Analysis

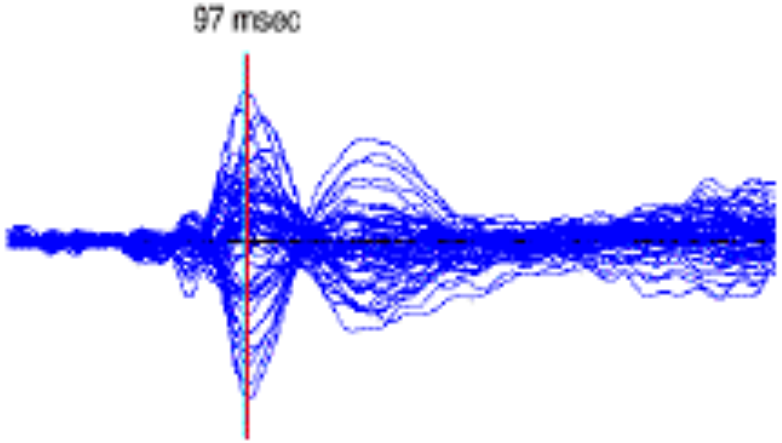
- What are we looking for?
  - Individual spikes or complex waveforms
  - Oscillations at particular frequency bands e.g. theta (4-8Hz), alpha (8-13Hz), beta (14-30Hz), gamma (30-50Hz)
- Magnetoencephalogram (MEG)
  - Raw time series unrelated to a stimulus
  - e.g. epileptic spikes / sleep stages
- Evoked Fields
  - Time series averaged around an event
  - Generic early sensory or motor responses
- Event-related Fields (ERFs)
  - Late cognitive responses (>150ms)
  - Vary depending on experimental context

Source Analysis Techniques
(two of many)

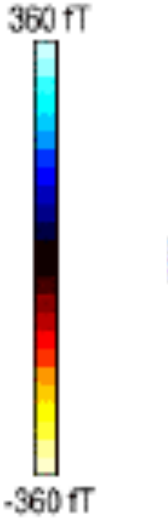
- Dipole Fits
  - Used to find one or a few focal sources
  - Best for primary sensorimotor evoked fields
- SAM (synthetic aperture magnetometry)
  - Produces whole brain estimates of source power for specified frequency bands
  - Best for cognitive event-related experiments

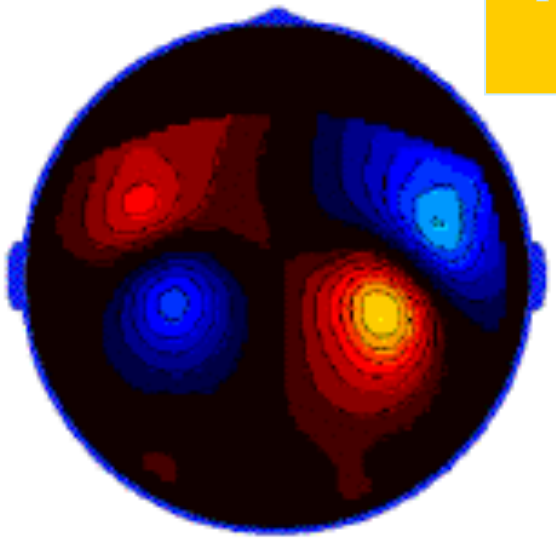
Dipole Fit

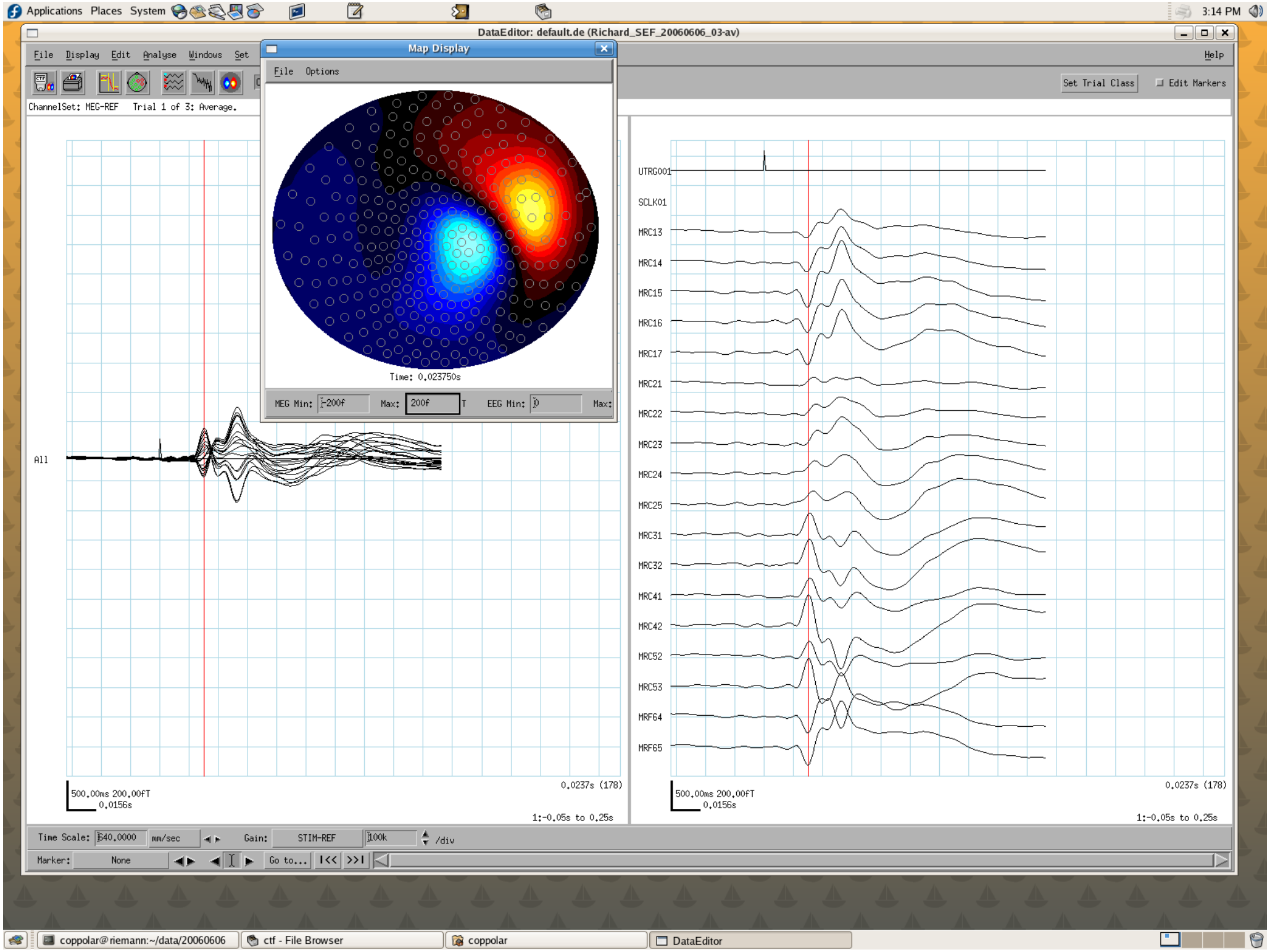




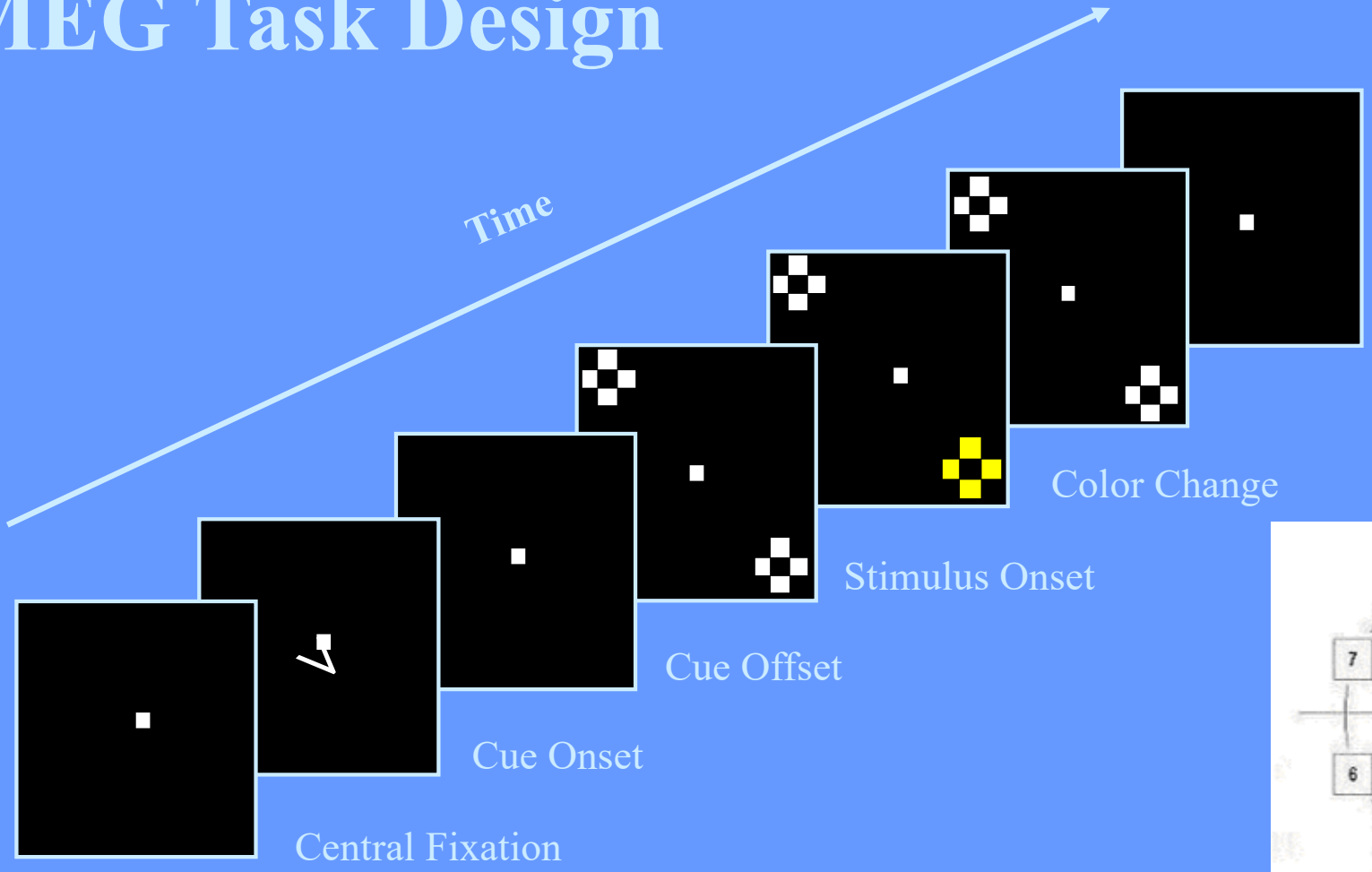
Auditory N100m

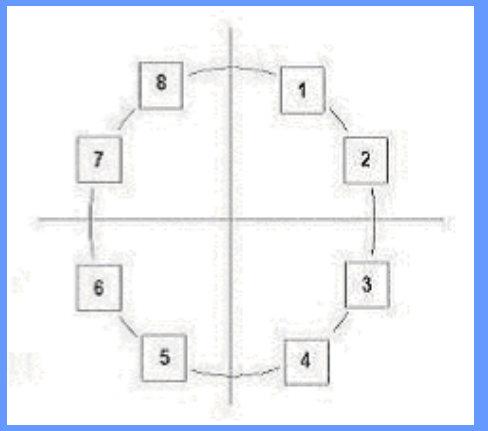


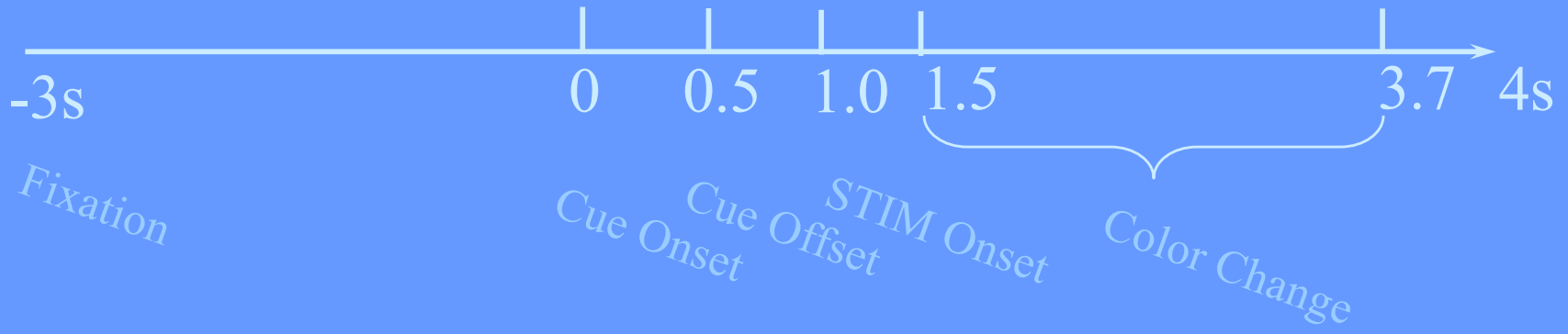



Applications Places System
3:14 PM
DataEditor: default.de (Richard_SEF_20060606_03-av)
File Display Edit Analyse Windows Set
Help
Set Trial Class
Edit Markers
ChannelSet: MEG-REF Trial 1 of 3: Average.
Map Display
File Options
Time: 0.023750s
MEG Min: -200f Max: 200f T EEG Min: 0 Max:
All
UTRG001
SCLK01
MRC13
MRC14
MRC15
MRC16
MRC17
MRC21
MRC22
MRC23
MRC24
MRC25
MRC31
MRC32
MRC41
MRC42
MRC52
MRC53
MRF64
MRF65
500.00ms 200.00fT
0.0156s
0.0237s (178)
1:-0.05s to 0.25s
Time Scale: 640.0000 mm/sec
Gain: STIM-REF 100k /div
Marker: None
Go to...
coppolar@riemann:~/data/20060606
ctf - File Browser
coppolar
DataEditor

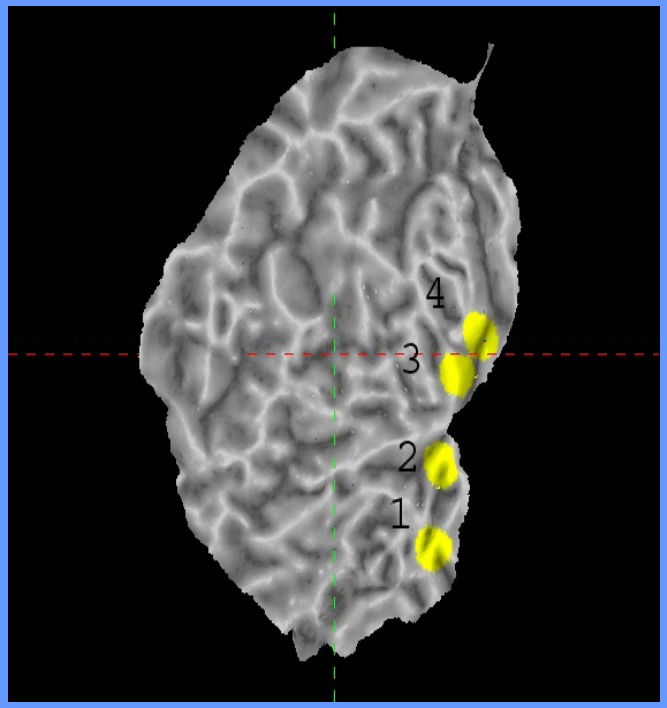
MEG Task Design



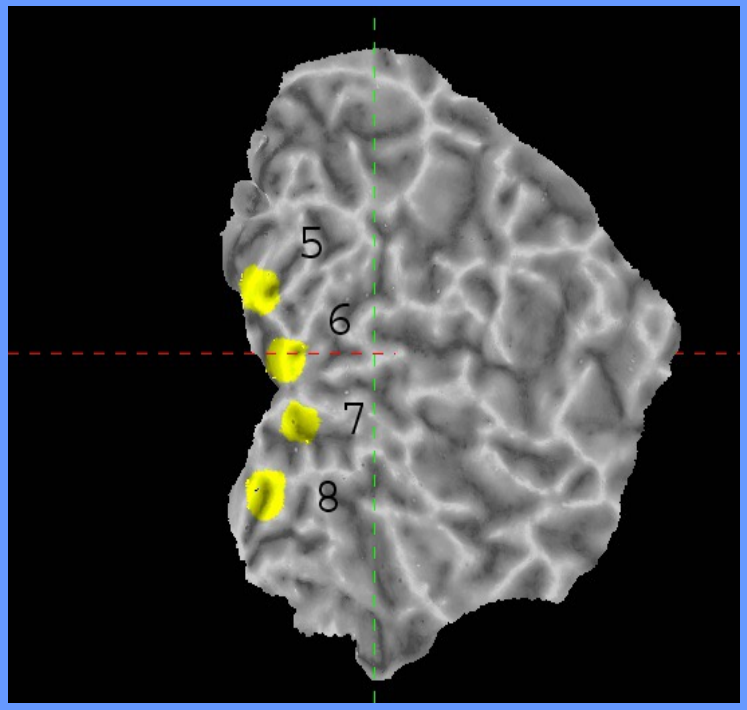




DipoleFit for 7.5Hz Flicker

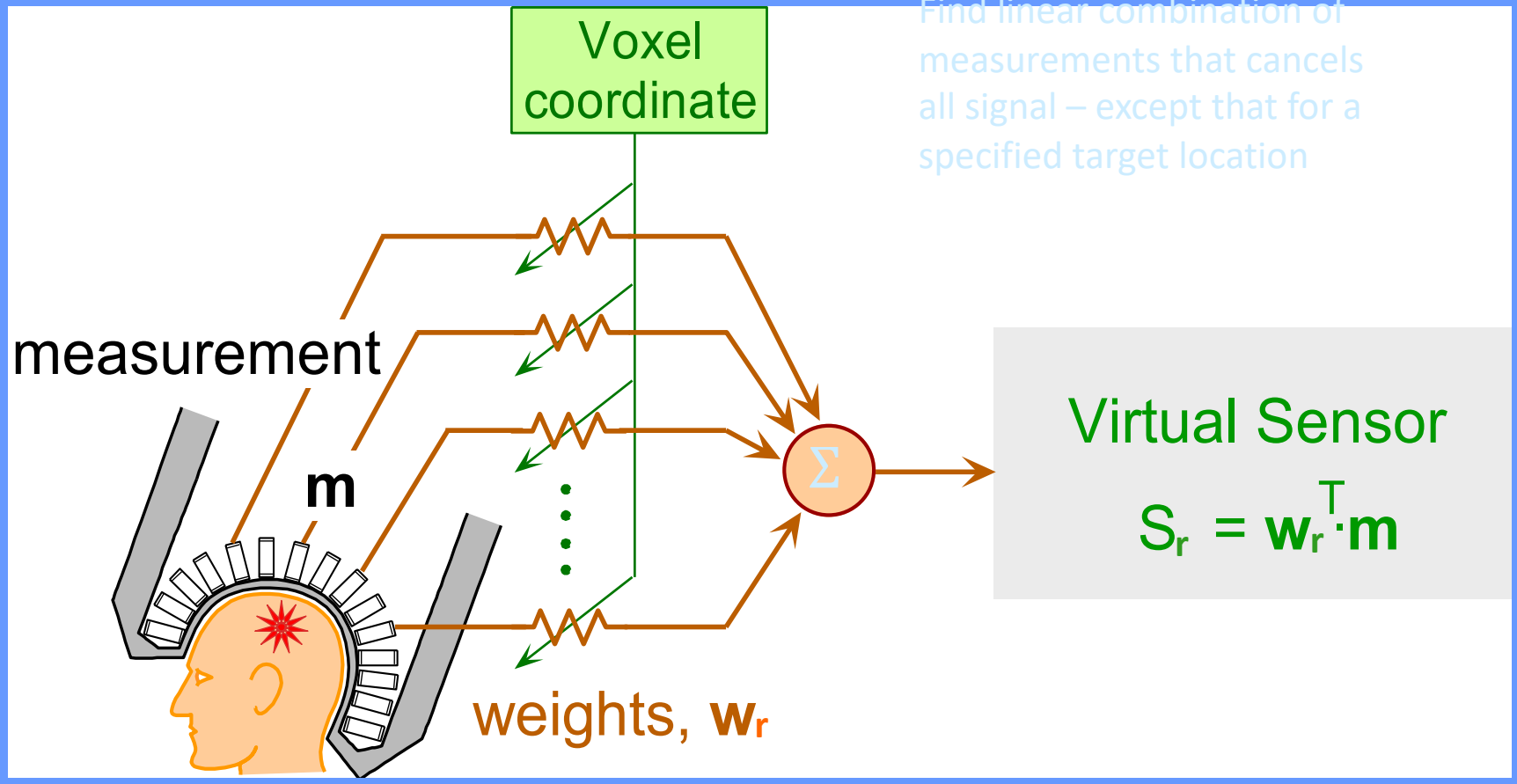


Left Hemisphere



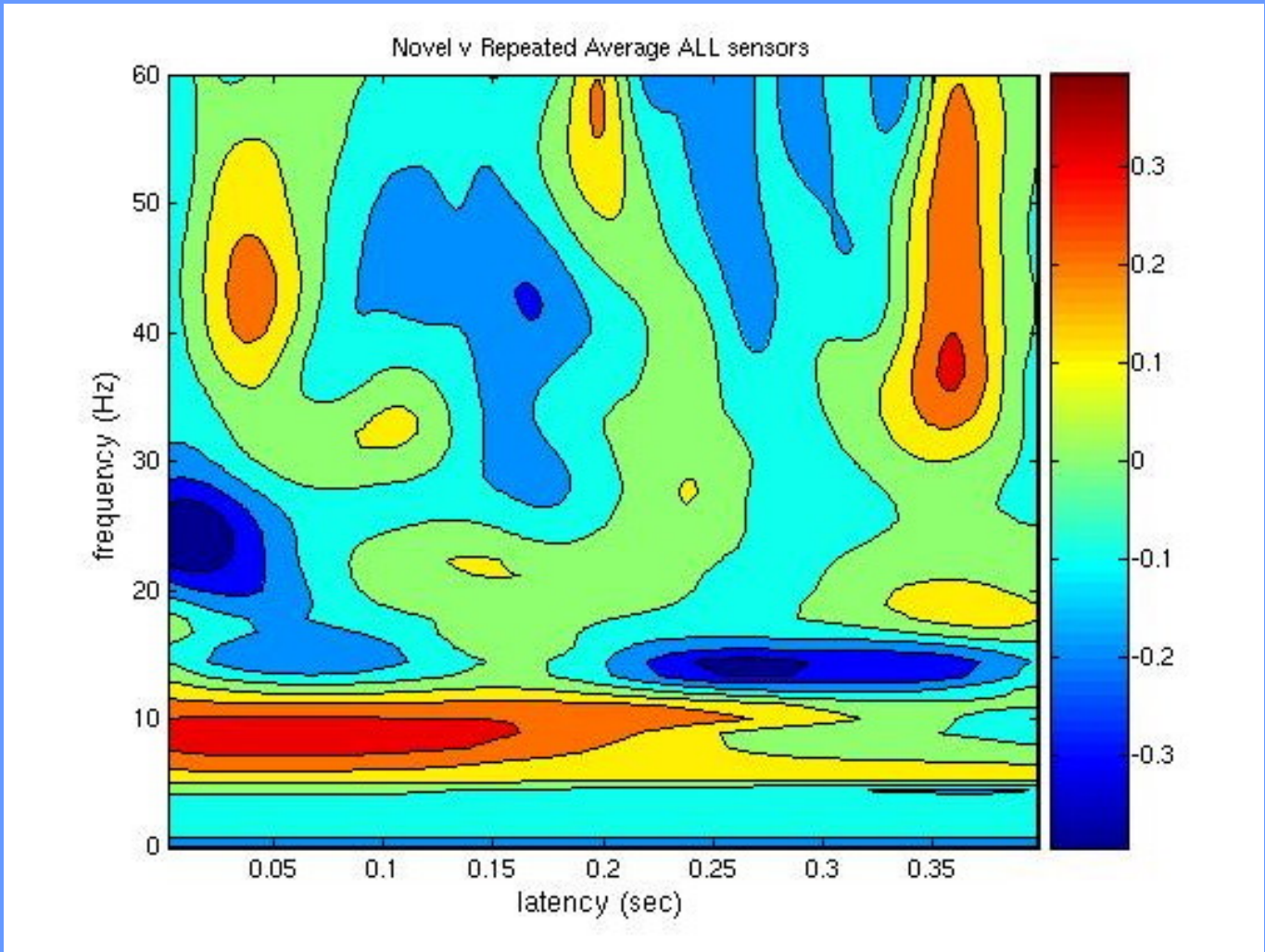
Right Hemisphere

SAM Beamformer Principle

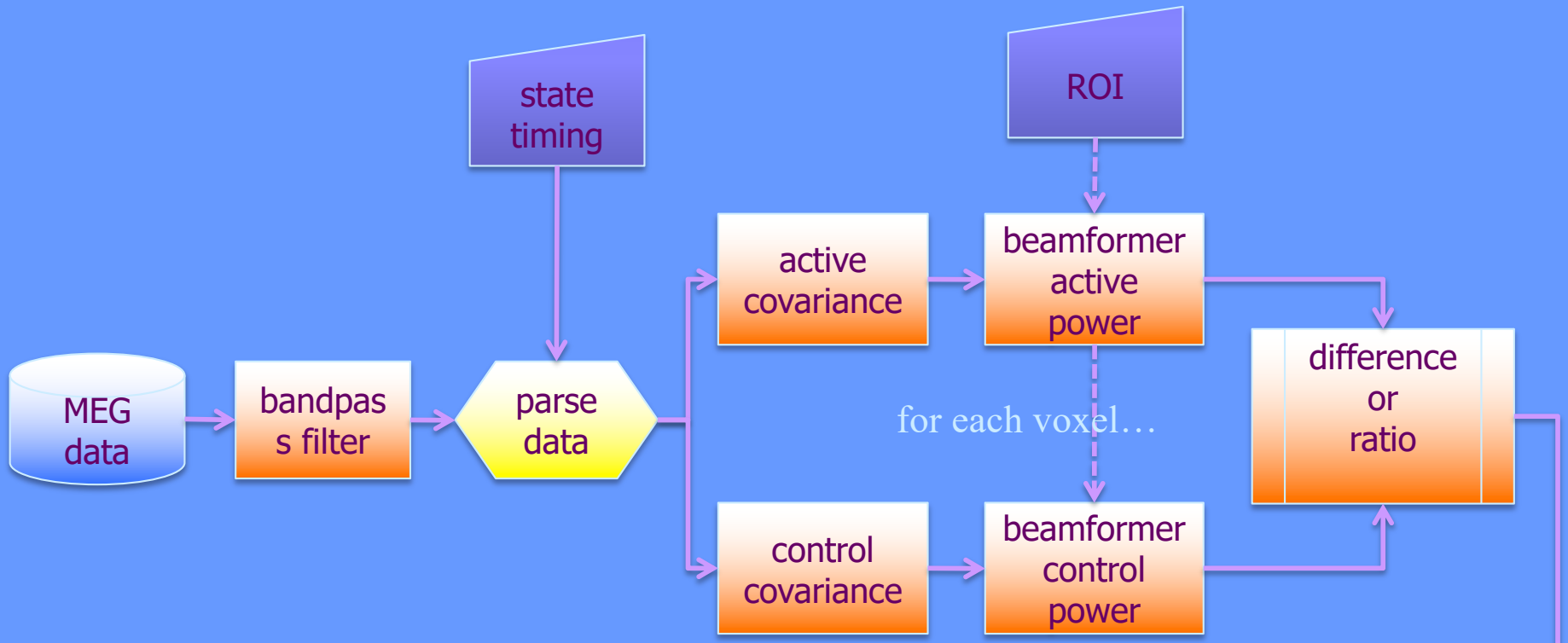


Time-Frequency (Stockwell): Evoked Components

Novel vs Repeated



Dual-State Beamformer Imaging using SAMimg

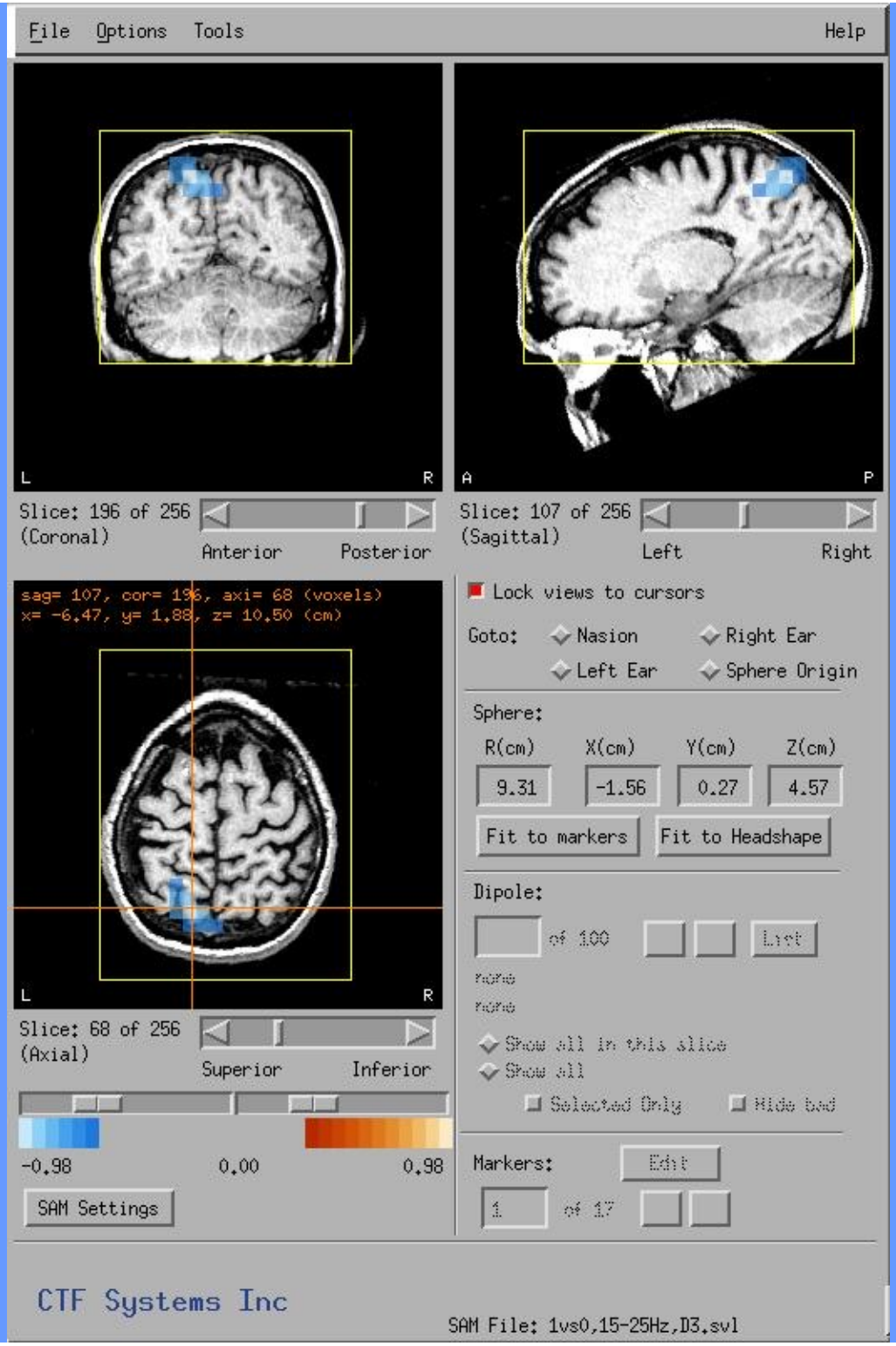


Pseudo-T:

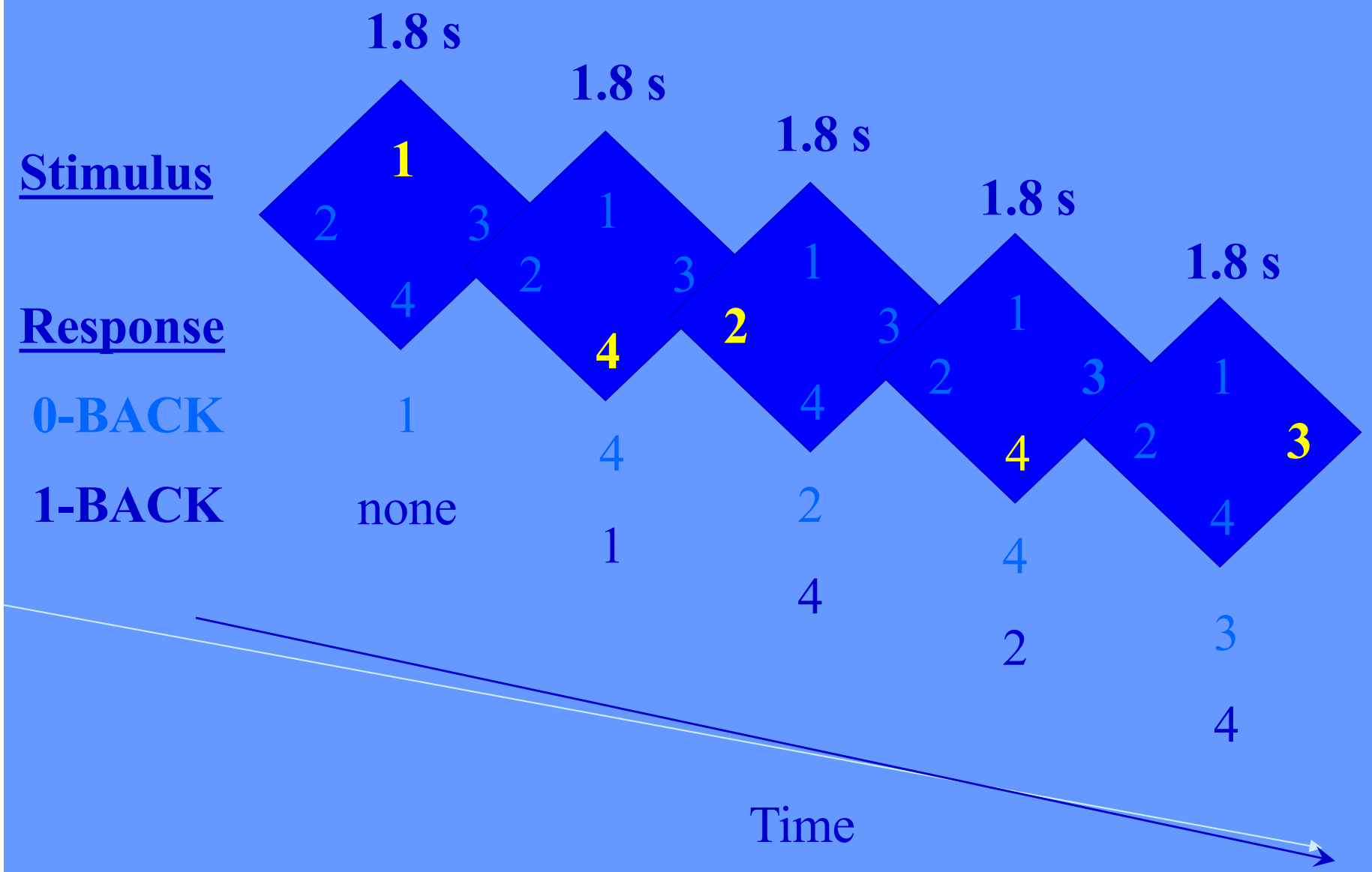
The picture can't be displayed.

Pseudo-F:

The picture can't be displayed.


File
Options
Tools
Help
L
R
A
P
Slice: 196 of 256
(Coronal)
Anterior
Posterior
Slice: 107 of 256
(Sagittal)
Left
Right
sag= 107, cor= 196, axi= 68 (voxels)
x= -6.47, y= 1.88, z= 10.50 (cm)
Lock views to cursors
Goto:
Nasion
Right Ear
Left Ear
Sphere Origin
Sphere:
R(cm)
X(cm)
Y(cm)
Z(cm)
9.31
-1.56
0.27
4.57
Fit to markers
Fit to Headshape
Dipole:
of 100
List
none
none
Show all in this slice
Show all
Selected Only
Hide bad
Slice: 68 of 256
(Axial)
Superior
Inferior
-0.98
0.00
0.98
SAM Settings
Markers:
Edit
1
of 17
CTF Systems Inc
SAM File: 1vs0,15-25Hz,D3,svl

Methods: N-Back Task



DataEditor window with marks in the stimulus and ADC channels

Task Details

- Sixteen 22 sec blocks of alternating 0-back and 2-back
- Stim: one of four numbers (0.5 duration, 1.8 sec ITI)
- normal volunteers strongly right handed
- 2-back accuracy greater than 65%

Data Analysis

- SAM: Synthetic Aperture Magnetometry
- Optimum spatial filter for each .75 cm voxel calculated from dual state freq domain covariance matrix
- Time windows:block(14 sec), stim (500 msec), resp (500 msec)
- Theta, alpha, beta, gamma, freq bands
- Group 3d map from Talairach aligned volumes using AFNI, n=18 NC
- Blue=desynch; Red=power increase

Group Analysis

- MRI's Talairach aligned in AFNI
- SAM image z-score normalized by pooled variance
- AFNI 3dmean averaged warped SAM volumes
- Normalized t statistic (3dttest) to threshold group mean map

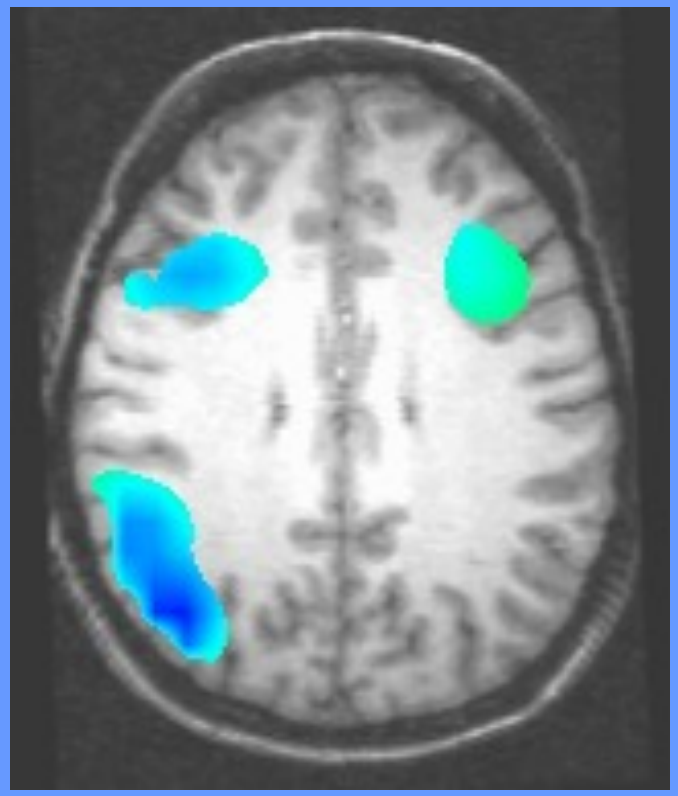
fMRI Processing

- 3T GE EPI-RT, 24 slices, TE 30, TR 2000, FOV 24 cm, voxel 3.75x3.75x6 mm, 64 x 64 matrix
- Structurally aligned, smoothed and normalized to MNI space, SPM99
- Single subj block design contrast for 2back > 0back
- Group second level analysis at approx p>.001

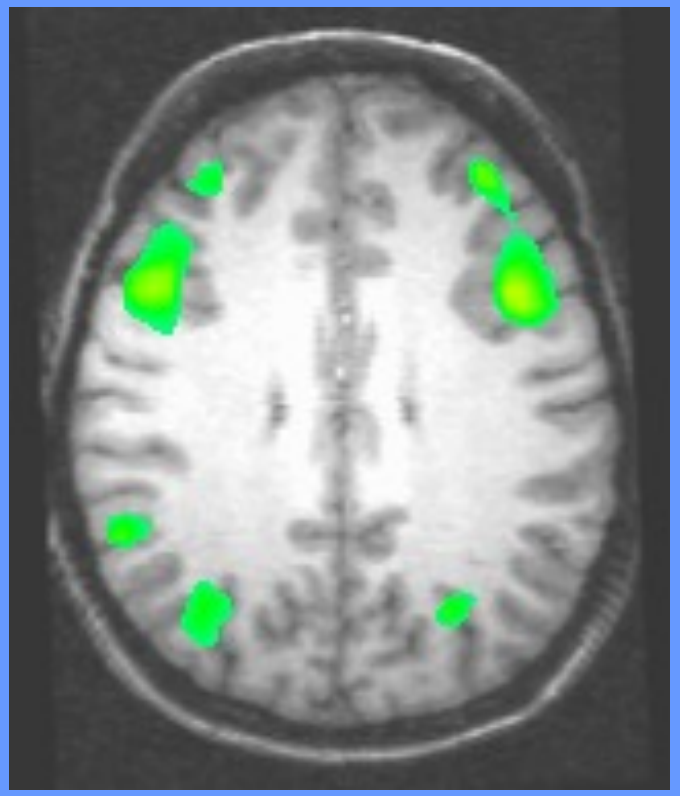
MEG and fMRI

2-back vs 0-back memory task, Block design

same 12 subjects, group map at p approx <.001

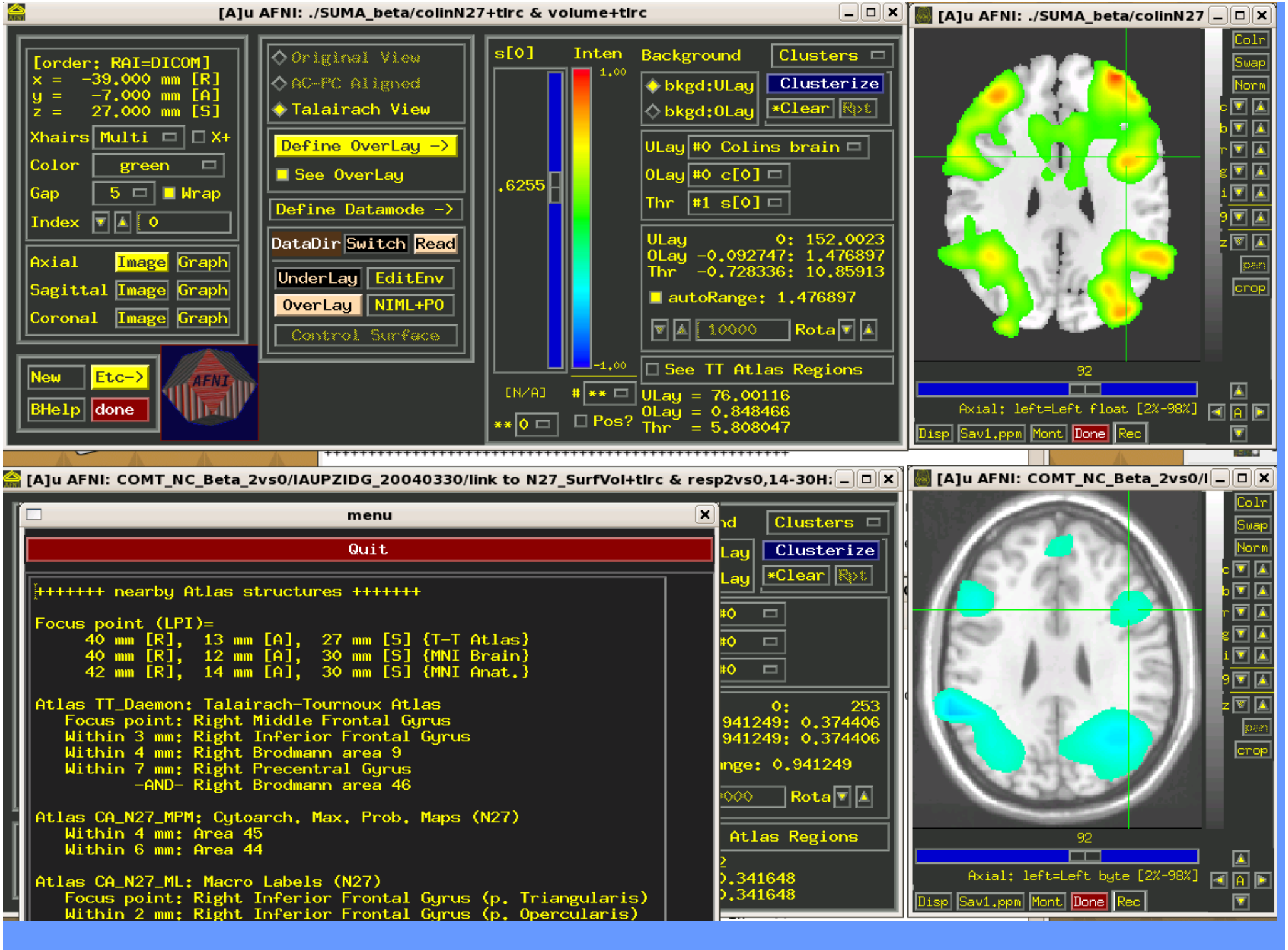


SAM 500 msec window on response, Beta desynchronization



SPM T map 2b>0b {SPM99 t ~ 4.0; $Z_{\equiv}$ ~ 3.10, p ~0.001, k > 10}

CBDB and NIMH MEG Core


[A]u AFNI: ./SUMA_beta/colinN27+tlrc & volume+tlrc
[order: RAI=DICOM]
x = -39.000 mm [R]
y = -7.000 mm [A]
z = 27.000 mm [S]
Xhairs Multi X+
Color green
Gap 5 Wrap
Index 0
Axial Image Graph
Sagittal Image Graph
Coronal Image Graph
New Etc->
BHelp done
Original View
AC-PC Aligned
Talairach View
Define OverLay ->
See OverLay
Define Datamode ->
DataDir Switch Read
UnderLay EditEnv
OverLay NIML+PO
Control Surface
s[0] Inten
1.00
.6255
-1.00
[N/A]
Background Clusters
bkgd:ULay Clusterize
bkgd:OLay *Clear
ULay #0 Colins brain
OLay #0 c[0]
Thr #1 s[0]
ULay 0: 152.0023
OLay -0.092747: 1.476897
Thr -0.728336: 10.85913
autoRange: 1.476897
10000 Rota
See TT Atlas Regions
ULay = 76.00116
OLay = 0.848466
Thr = 5.808047
Pos?
[A]u AFNI: ./SUMA_beta/colinN27
Colr
Swap
Norm
pan
crop
92
Axial: left=Left float [2%-98%]
Disp Sav1.ppm Mont Done Rec
[A]u AFNI: COMT_NC_Beta_2vs0/IAUPZIDG_20040330/link to N27_SurfVol+tlrc & resp2vs0,14-30H:
menu
Quit
+++++++ nearby Atlas structures +++++++
Focus point (LPI)=
40 mm [R], 13 mm [A], 27 mm [S] {T-T Atlas}
40 mm [R], 12 mm [A], 30 mm [S] {MNI Brain}
42 mm [R], 14 mm [A], 30 mm [S] {MNI Anat.}
Atlas TT_Daemon: Talairach-Tournoux Atlas
Focus point: Right Middle Frontal Gyrus
Within 3 mm: Right Inferior Frontal Gyrus
Within 4 mm: Right Brodmann area 9
Within 7 mm: Right Precentral Gyrus
-AND- Right Brodmann area 46
Atlas CA_N27_MPM: Cytoarch. Max. Prob. Maps (N27)
Within 4 mm: Area 45
Within 6 mm: Area 44
Atlas CA_N27_ML: Macro Labels (N27)
Focus point: Right Inferior Frontal Gyrus (p. Triangularis)
Within 2 mm: Right Inferior Frontal Gyrus (p. Operc ularis)
Clusters
Clusterize
*Clear
0: 253
941249: 0.374406
941249: 0.374406
nge: 0.941249
Rota
Atlas Regions
.341648
.341648
[A]u AFNI: COMT_NC_Beta_2vs0/I
Colr
Swap
Norm
pan
crop
92
Axial: left=Left byte [2%-98%]
Disp Sav1.ppm Mont Done Rec

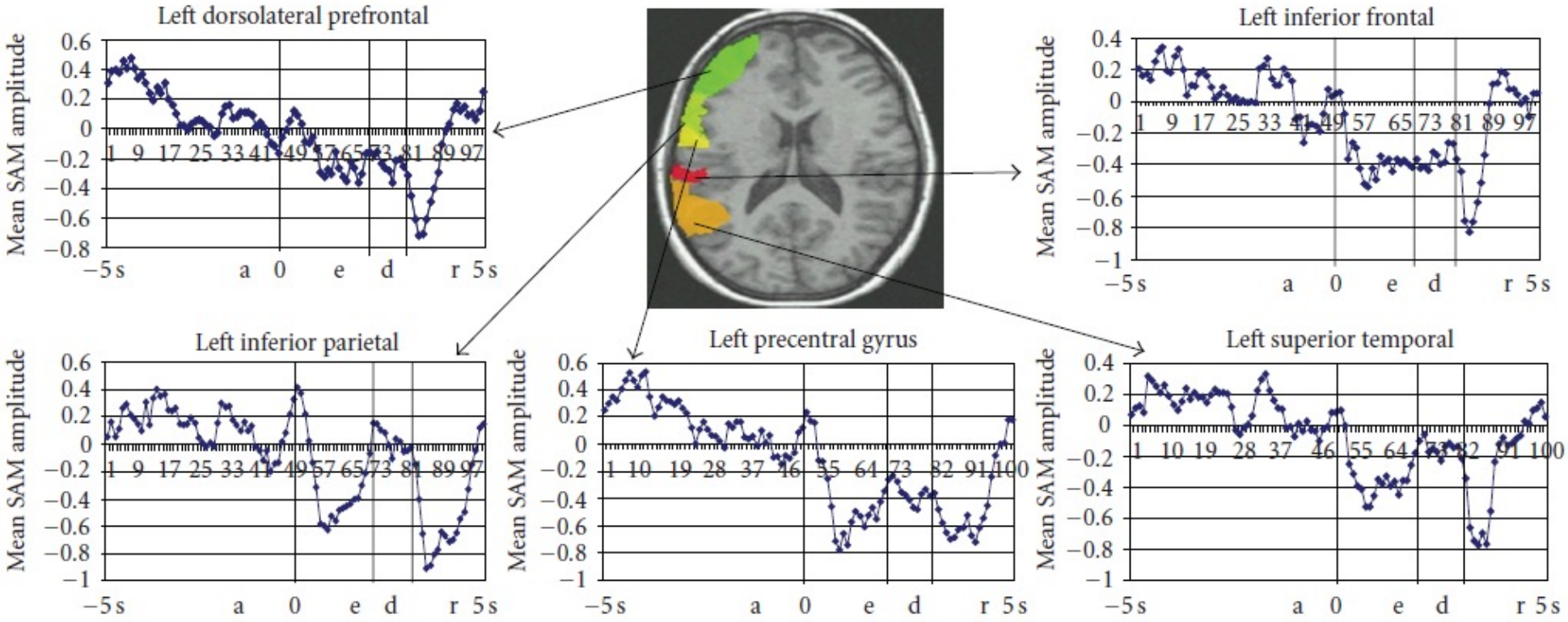
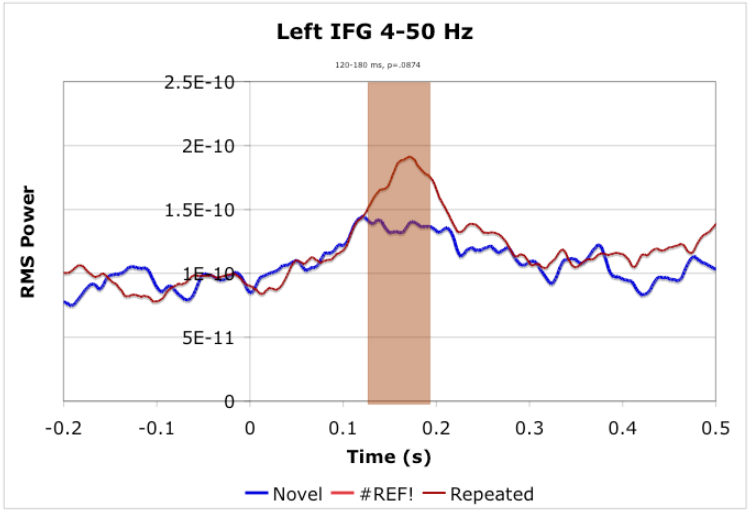


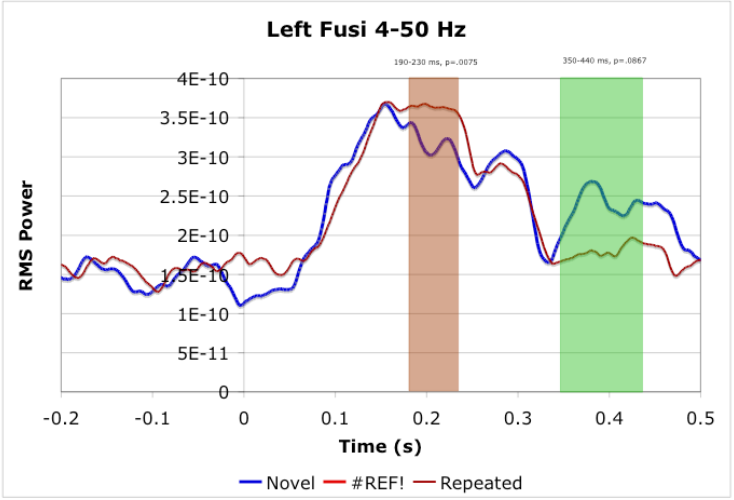
FIGURE 2: ROI templates drawn on a representative participant's MRI scan along with the average time courses from each of the left hemisphere ROIs. a: anticipatory period; e: encoding period; d: delay; r: response period.

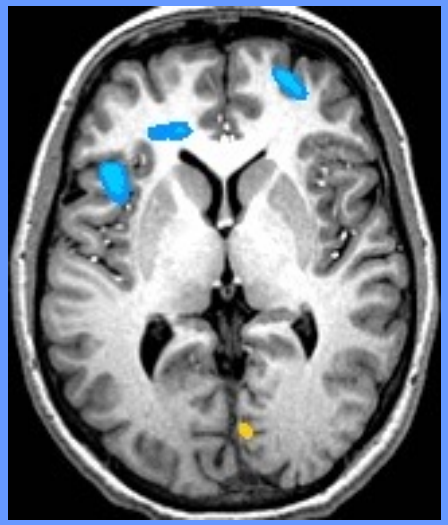
Prefrontal Cortex Modulation during Anticipation of Working Memory Demands as Revealed by Magnetoencephalography

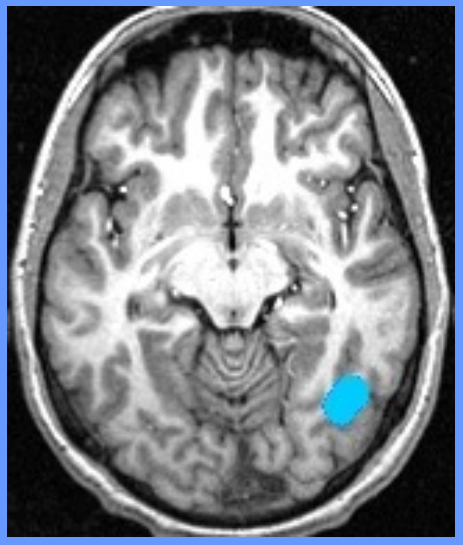
Mario Altamura,[1,2] Terry E. Goldberg,[1] Brita Elvevåg,[1] Tom Holroyd,[3] Frederick W. Carver,[3] Daniel R. Weinberger,[1] and Richard Coppola[1,3]

Top-down modulation during object priming (Gilbert et al)







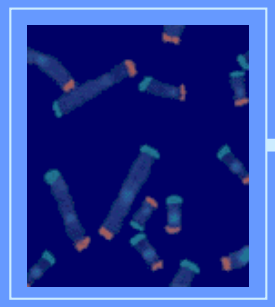


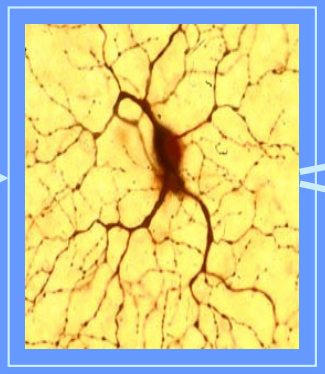
NIMH Sibling Study

Working Hypotheses:

- Different domains of cognitive impairment are heritable
- Define impairment on the basis of cognition, not diagnosis
- Schizophrenia qua schizophrenia is not inherited; impaired information processing is inherited and schizophrenia is emergent
- Investigate cognition via the n-back working memory task: compare probands, unaffected siblings, and normal controls

The path from here to there…





cognition

behavioral phenotypes

temperament

Genes:

multiple susceptibility alleles each of small effect

Cells:

subtle molecular abnormalities

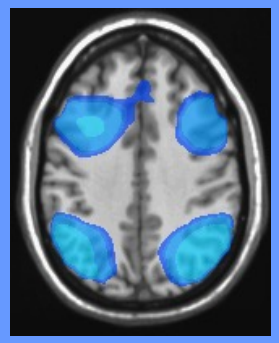
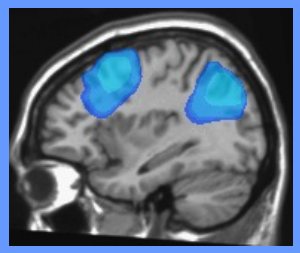
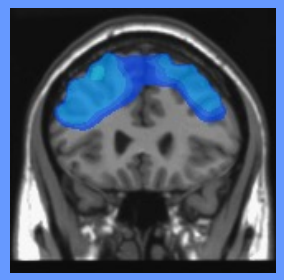
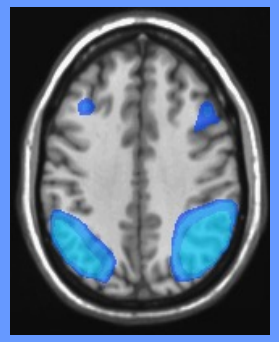
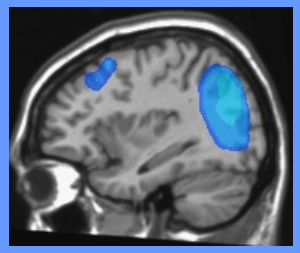
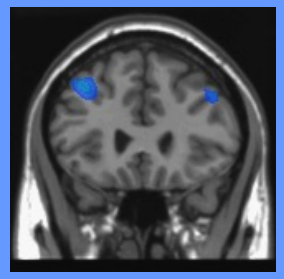
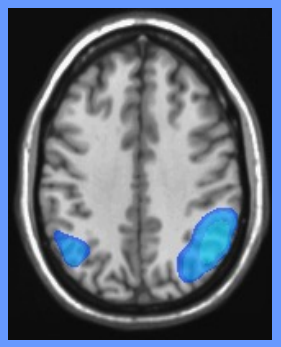
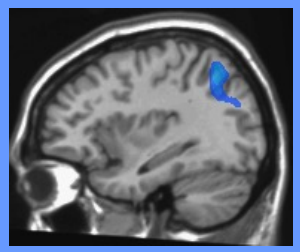
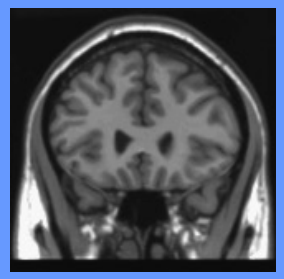
Systems:

abnormal information processing

Behavior:

complex functional interactions and emergent phenomena

Group Means, 2-back vs. 0-back

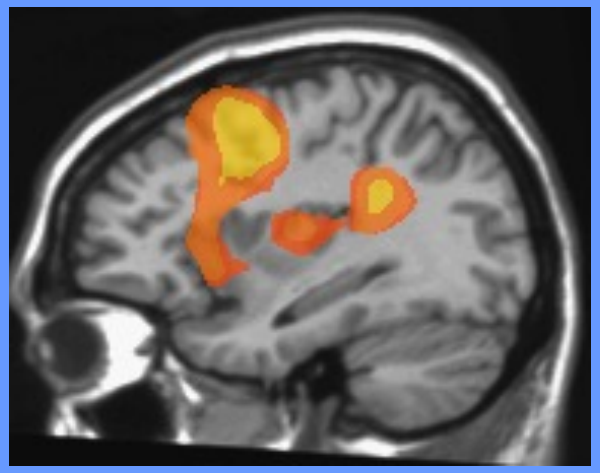
	Axial	Sagittal	Coronal
NC Mean			
Unaffected Mean			
Proband Mean			

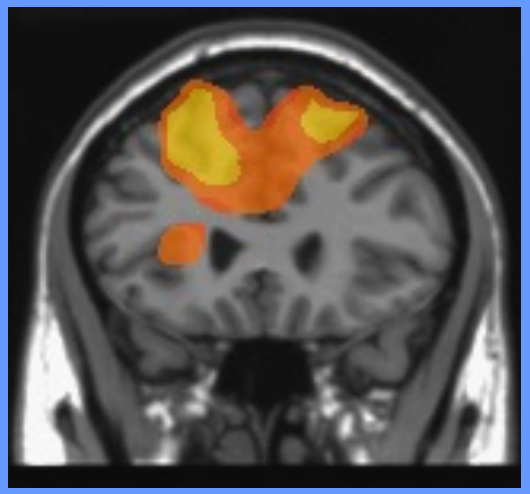
p≤.001, amp≥.5

p≤.001, amp≥.5

p≤.001, amp≥.5

ANOVA, 2-back vs. 0-back

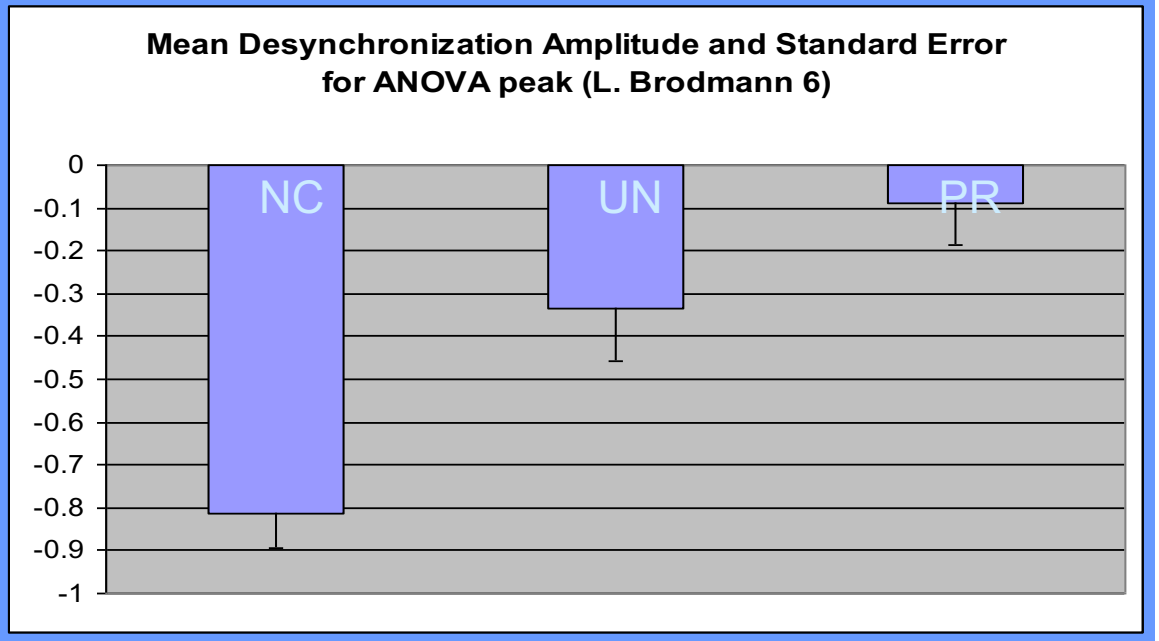




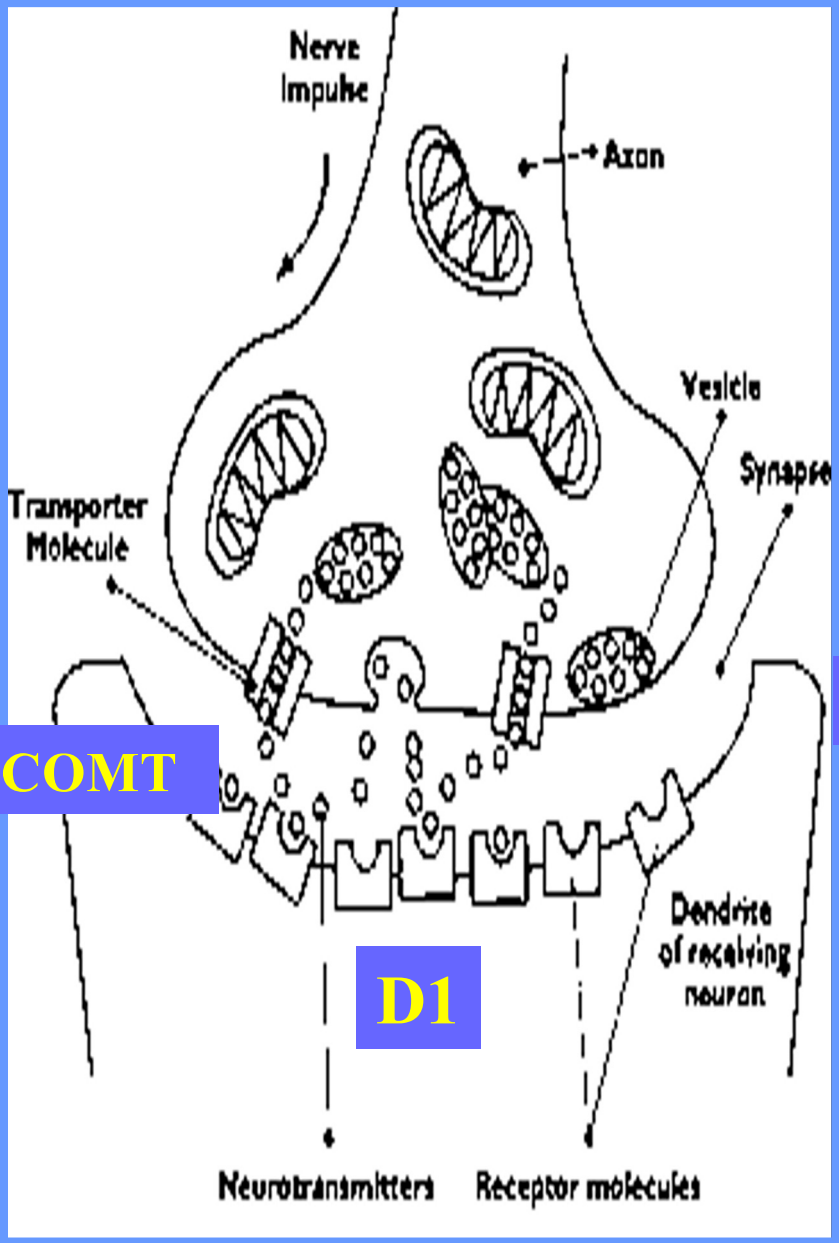
p≤.01

ANOVA Peak Amplitudes

NC: sd = .959587
amp = -.815649
UN: sd = .994324
amp = -.334542
PR: sd = .920169
amp = -.087885



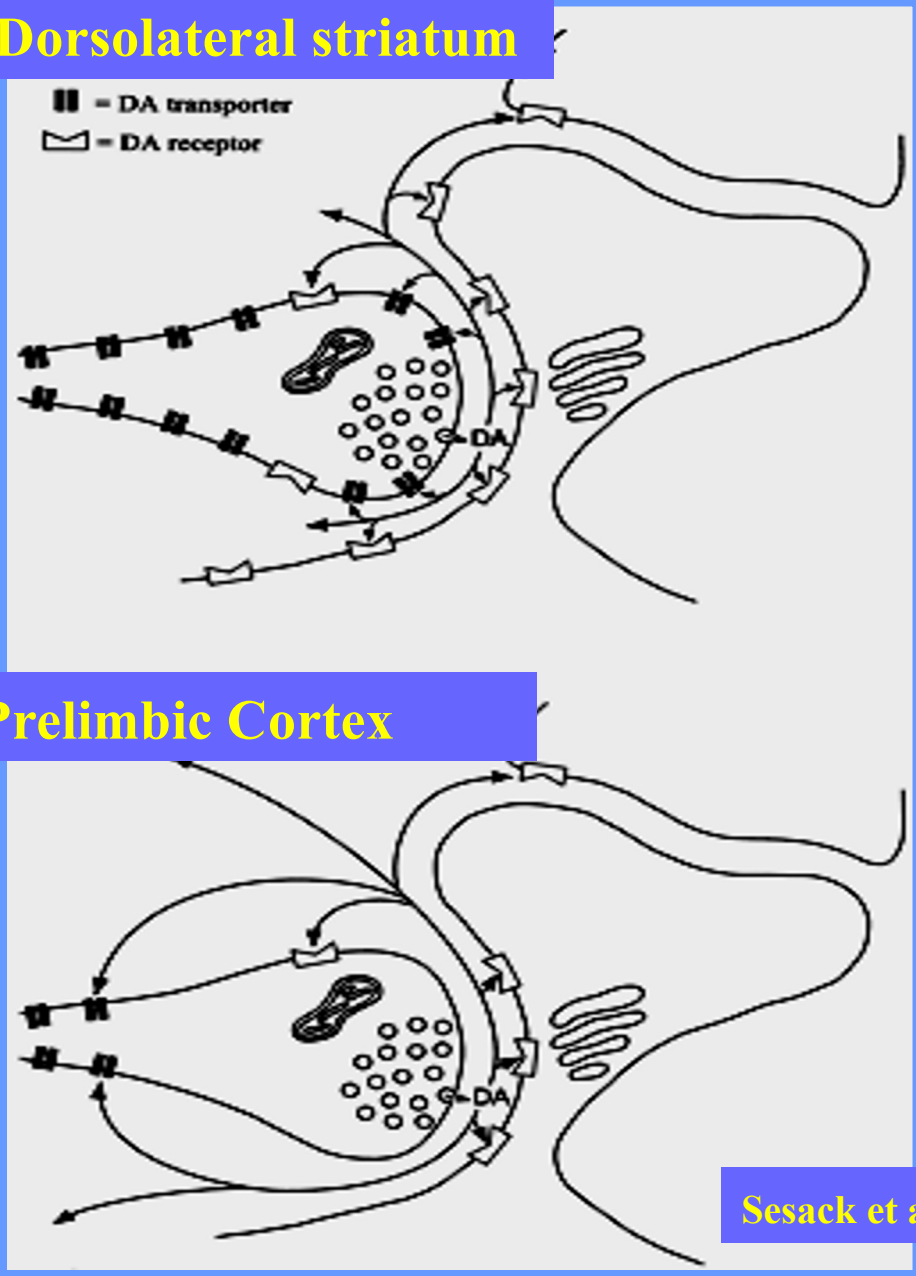
Candidate genes for working memory



COMT

D1

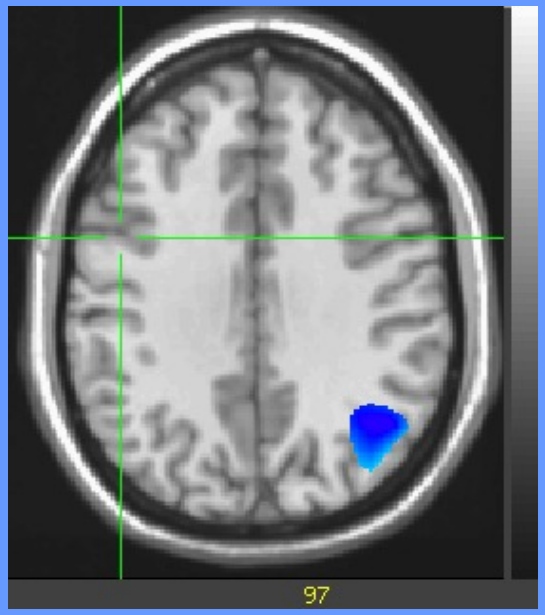
Dorsolateral striatum



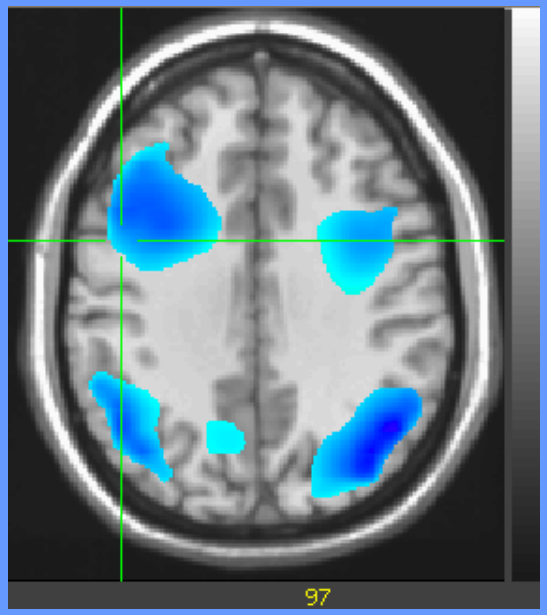
Prelimbic Cortex

Sesack et al.1998

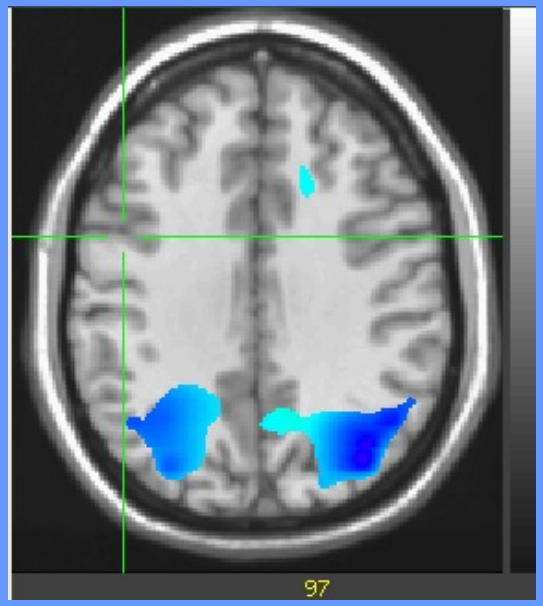
Group means 2-back activation p < .001 beta band, NC's n=66



valval



valmet



metmet

Left Rodmann 9 significant at p < .05 for genotype

Modulation of task-related MEG activity by SCN2A sodium channel genotype

A.H. Gerlich[1], F.W. Carver[1], T. Holroyd[1], J.H. Callicott[2], D. Dickinson[2], K.F. Berman[2], R. Coppola[1]

[1]MEG Core Facility, National Institute of Mental Health, Bethesda, MD, USA
[2]Clinical and Translational Neuroscience Branch, National Institute of Mental Health, Bethesda, MD, USA

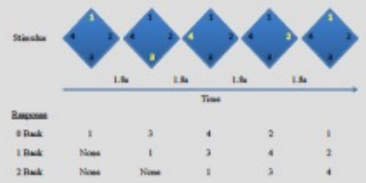
Background

SCN2A, a gene that encodes the alpha-2 subunit of the voltage-gated type II sodium channel, mediates the conformational changes necessary for the formation of action potentials in the CNS. Past studies support that variants in SCN2A underlie certain epileptic seizures and impaired cognitive performance found in various developmental, intellectual, and social spectrum disorders. Additionally, there exists a disparity in general cognitive ability or "g" between carriers of the T allele (T/T or C/T) and those of the homozygous C allele (C/C), and this disparity differs in healthy controls from those with schizophrenia and their unaffected first-degree siblings. In Scult et al. (2015), correlation between fMRI activation in the dl-PFC and dACC was shown to significantly mediate cognitive ability with these disparities in healthy controls. Here, this investigation of genetic modulation is continued using magnetoencephalography.

Methods

Image Acquisition: MEG signals were recorded in a magnetically shielded room using a 275-channel whole head system (CTF). For each participant a structural MRI was co-registered with their MEG head coordinate system.

Task: The task was designed to assess working memory. The stimulus consisted of a diamond-shaped grid containing the digits 1 through 4. Using an inter-stimulus interval of 1.8 seconds, one of the four numbers appeared for 160 ms. Subjects were asked to respond to the appropriate previously-presented digit, as dictated by the specific task (0 Back, 1 Back, or 2 Back).



Genotype Acquisition: SCN2A SNP data was obtained from the NIMH Sibling Study. 30 carriers of the T allele (15 homozygous and 15 heterozygous) and 30 of the homozygous C allele were used.

Analysis: Synthetic aperture magnetometry (SAM) was used to estimate the sources of neuromagnetic activation. SAM creates an optimal spatial filter from MEG channel covariance to estimate source power in a specified time window and frequency band. Independent power estimates for the 2-back, 0-back, and Rest were performed at 5mm cubic voxels throughout the brain volume. The frequency bands were chosen from MEG channel power spectra, and the time windows were from 5s to 21s in each block with dummy blocks used for the resting recording. Each image was normalized by a noise estimate based on the signal covariance, and then converted to a Z-score. AFNI was used to align datasets into a common coordinate system and to perform statistics. A 2x3 genotype-by-task ANOVA was performed using 30 subjects for each genotype.

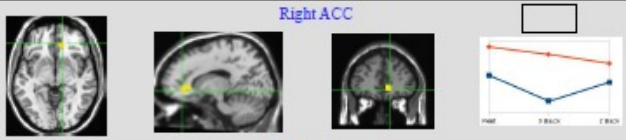
Results

At $p < 0.01$, the analysis revealed four cortical areas of interest as well as two sub-cortical regions. The theta band (4-7 Hz) showed a significant main effect between genotypes in the right ACC (TC/TT > CC). The alpha band (8-12 Hz) showed two significant interactions, one in the left middle frontal gyrus and the other in the right inferior frontal gyrus. The beta band (15-25 Hz) showed a significant interaction in the left middle temporal gyrus. The sub-cortical findings revealed a significant main effect in the high gamma band (65-115 Hz) in the region of the thalamus (TC/TT > CC) as well as in the left cerebellum (CC > TC/TT). At $p < 0.001$ and $q < 0.05$, there were two significant cortical interactions in the high gamma band, one in the dl-PFC and the other in the dACC and the medial frontal gyrus.

Cortical Findings at $p < 0.01$

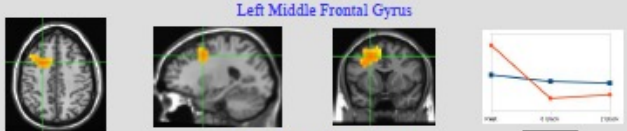
Theta (4-7 Hz)

Right ACC



Alpha (8-12 Hz)

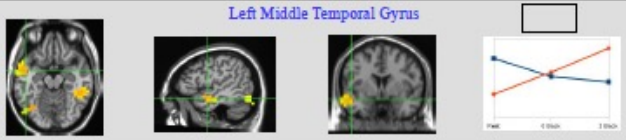
Left Middle Frontal Gyrus



Right Inferior Frontal Gyrus

Beta (15-25 Hz)

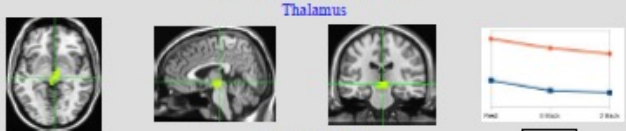
Left Middle Temporal Gyrus



Sub-cortical Findings at $p < 0.01$

High Gamma (65-115 Hz)

Thalamus

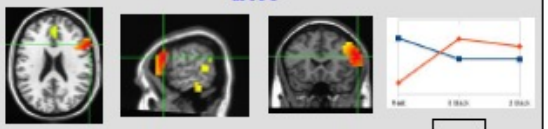


Left Cerebellum

Cortical Findings at $p < 0.001$, $q < 0.05$

High Gamma (65-115)

dl-PFC



dACC/Medial Frontal Gyrus

Discussion

As in Scult et al. (2015), we found genotype-related activation differences in both the dl-PFC and the dACC (in which interactions were found in the high gamma band). Additional areas were also discovered, including regions of the temporal gyrus, inferior frontal gyrus, thalamus, and cerebellum.

Analysis of the alpha band revealed two interactions of genotype and task. The left medial frontal gyrus showed higher power for the TC/TT genotype during rest, but higher power for the CC genotype during both 0 Back and 2 Back. Interestingly, the right inferior frontal gyrus showed the opposite interaction, in which there was higher power for the CC genotype during rest, but higher power for the TC/TT genotype during both the 0 back and 2 Back.

Regarding the sub-cortical regions (thalamus and cerebellum), it is interesting that (while both exhibited main effects) the thalamus showed higher power across all tasks for the TC/TT genotype, while the cerebellum showed higher power across all tasks for the CC genotype.

The only frequency with significant results at $q < 0.05$ was the gamma band (65-115 Hz), suggesting that definitive differences may exist between genotypes at higher frequencies. As high gamma is a relatively new area of investigation, more studies are necessary to parse out the meaning of these results.

The effects of genotype on activation patterns found here may be implicated in differences in cognitive processing and/or intellectual functioning in healthy controls, as mediated by the conformational differences in the type II sodium channel. Further studies utilizing these (as well as other) imaging techniques may also support similar findings in affected populations (e.g. schizophrenia, spectrum, and neurodevelopmental disorders).

References

Dickinson, D., Straub, R. E., Trampush, J. W., Guo, Y., Feng, N., Xie, B., ... Weinberger, D. R. (2014). Differential effects of common variants in SCN2A on general cognitive ability, brain physiology, and messenger RNA expression in schizophrenia cases and control individuals. *JAMA Psychiatry*, *71*(6), 647-656. Retrieved from http://archpsyc.jamanetwork.com/

Scult, M., Trampush, J. W., Zheng, F., Conley, E. D., Lencz, T., Malhotra, A. K., ... Hariri, A. R. (2015). A common polymorphism in SCN2A predicts general cognitive ability through effects on pFC physiology. *Journal of Cognitive Neuroscience*, *27*(9), 1766-74. doi:10.1162/jocn_a_00826

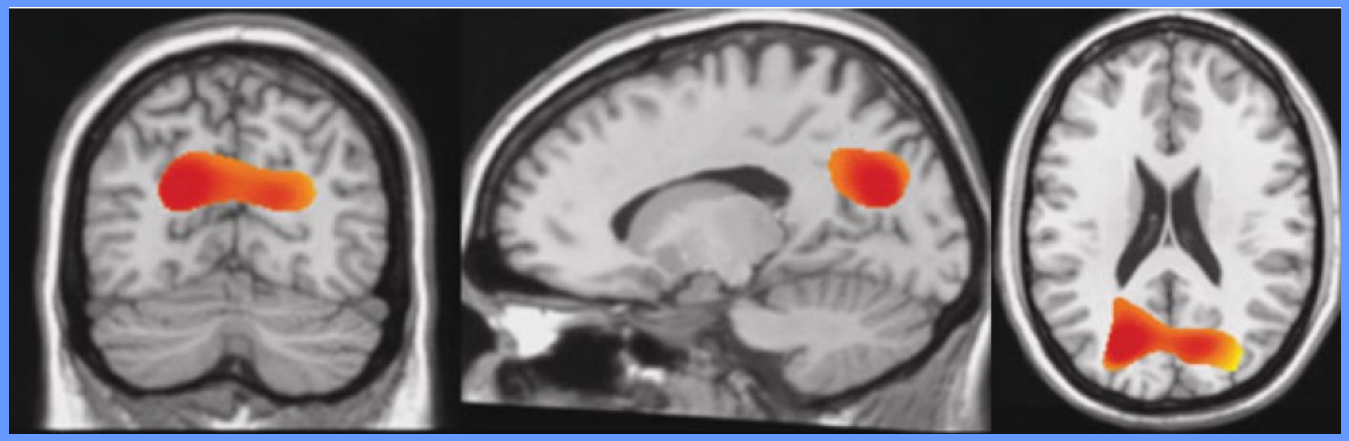
NIH National Institutes of Health

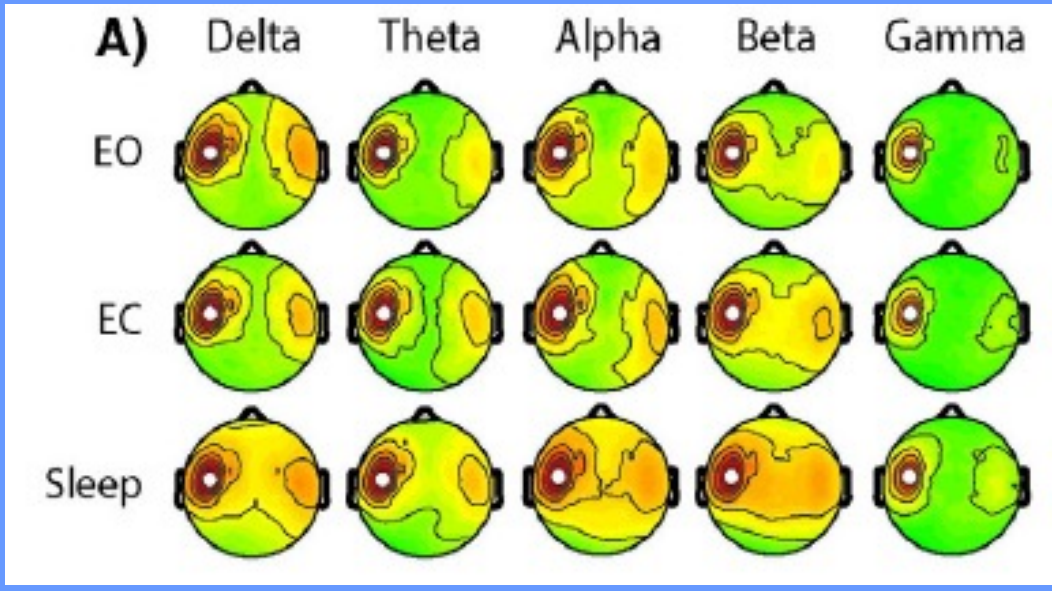
NIMH National Institute of Mental Health

◆ Human Brain Mapping 30:3254–3264 (2009) ◆

Magnetoencephalographic Gamma Power Reduction in Patients with Schizophrenia During Resting Condition

Lindsay Rutter,[1] Frederick W. Carver,[1] Tom Holroyd,[1]
Sreenivasan Rajamoni Nadar,[1] Judy Mitchell-Francis,[1] Jose Apud,[2]
Daniel R. Weinberger,[2] and Richard Coppola[1,2]*



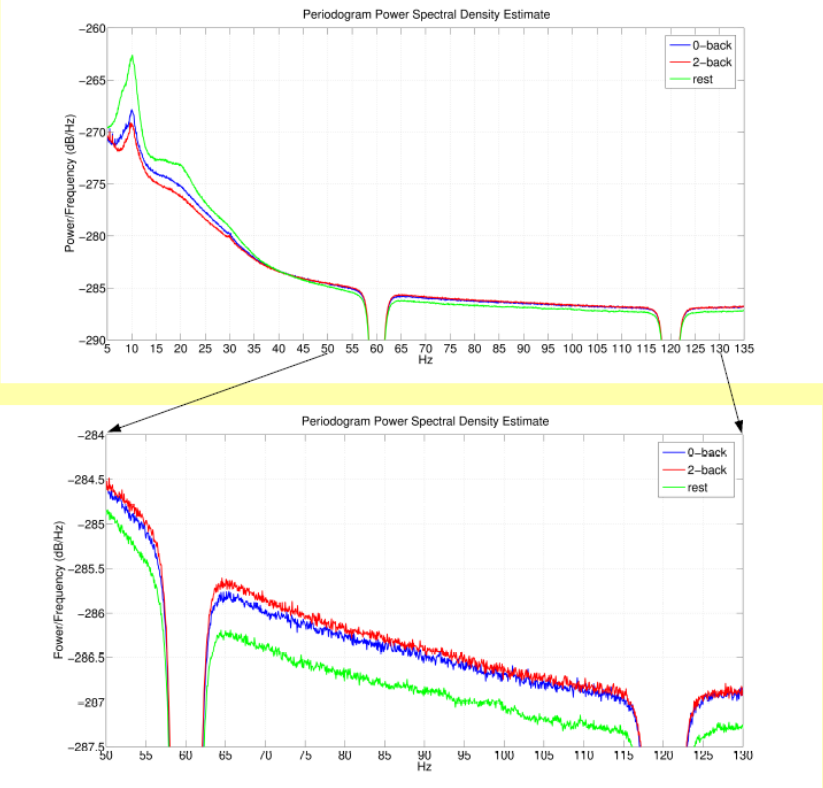


NeuroImage 51 (2010) 102–111

Large-scale spontaneous fluctuations and correlations in brain electrical activity observed with magnetoencephalography

Zhongming Liu *, Masaki Fukunaga, Jacco A. de Zwart, Jeff H. Duyn

Power Spectra Comparing 2-back and 0-back to Rest



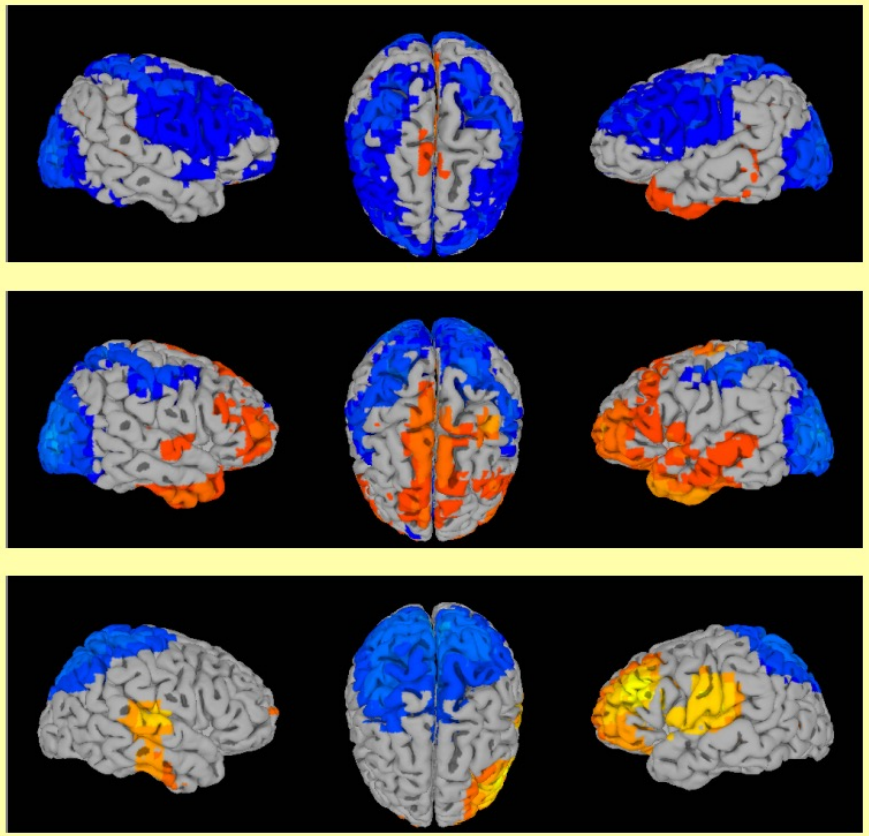
Mean spectra for all MEG channels comparing n-back blocks to dummy blocks in a separate resting eyes closed recording. Alpha and beta band desynchronization occurs in the N-back conditions relative to rest, with more desynchronization in the 2-back condition than the 0-back. The second chart zooms in to show broad band differences in high gamma power, including greater power in the 2-back relative to 0-back and rest.

MEG SAM 0-back > Rest

Alpha (8-12Hz)

Beta (15-25Hz)

Gamma (65-115Hz)



Contrast of 0-back and rest showing difference in signal power in frequency bands determined from the power spectra graphs above. Blue indicates less activation (desynchronization) in the 0-back, and red/yellow greater activation compared to rest ($p<.001$, $q<.05$). The contrast of 2-back to rest produced similar activation maps (results not shown).

Frequency-band specific changes in cortical MEG activation during a working memory task Carver et al SFN 2014

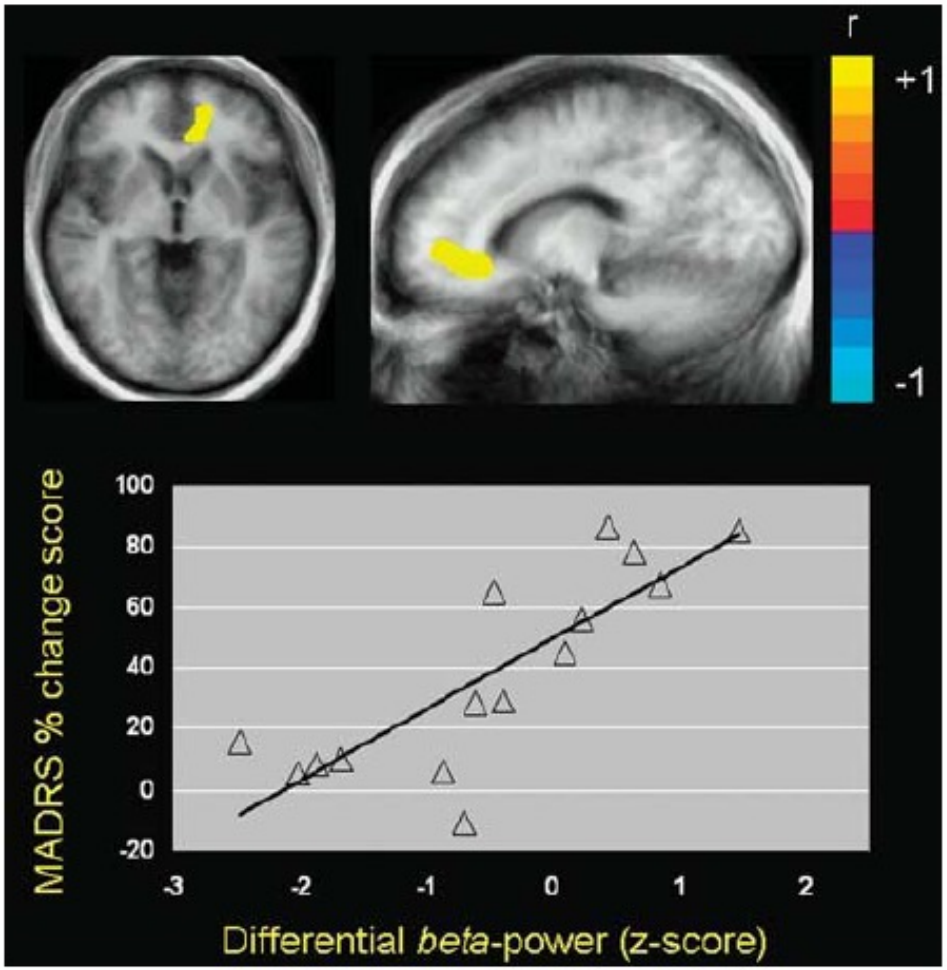


Figure 1 Pearson correlation between beta desynchronization in the anterior cingulate cortex (ACC) and change in depressive symptoms 230 min after ketamine infusion for the 2-back *vs* 1-back comparison in patients with MDD (ACC peak: $x = -15$, $y = 45$, $z = -1$ mm; coordinates expressed according to the stereotaxic atlas of Talairach and Tournoux (Talairach and Tournoux, 1988)). These coordinates localize to the pregenual portion of the ACC, although the cluster of voxel *t*-values

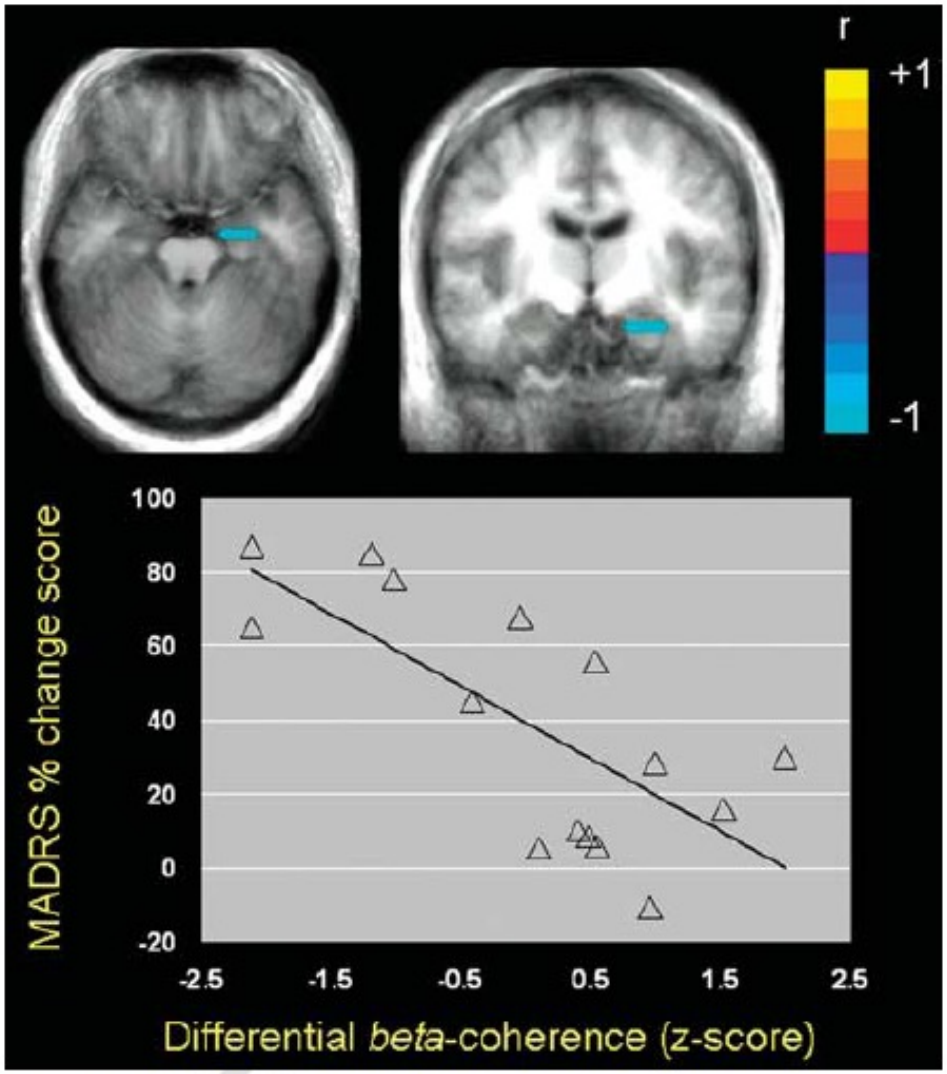
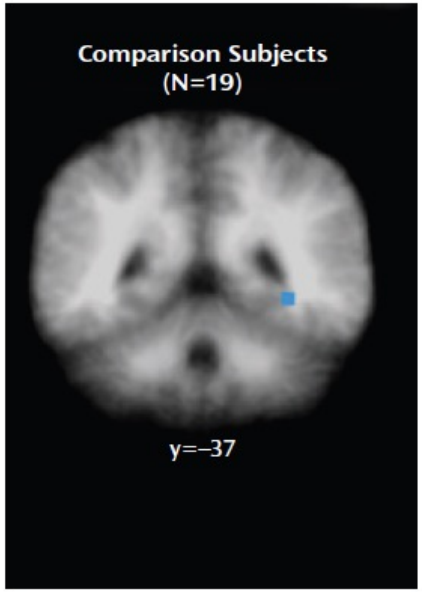


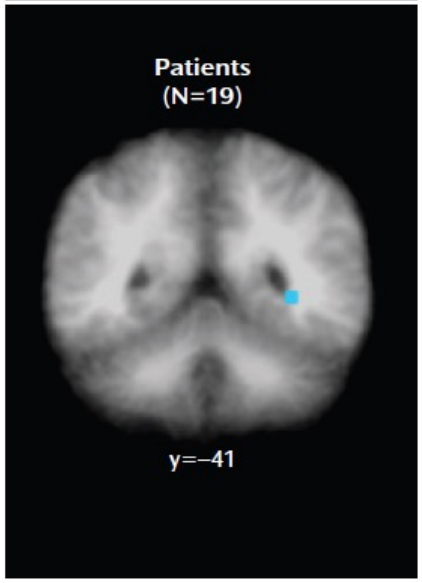
Figure 2 Pearson correlation between differential source coherence of the pgACC with the left amygdala and change in depressive symptoms 230 min after ketamine infusion for the 2-back *vs* 1-back comparison in patients with MDD (left amygdala peak: $x = -30$, $y = -7$, $z = -16$ mm;

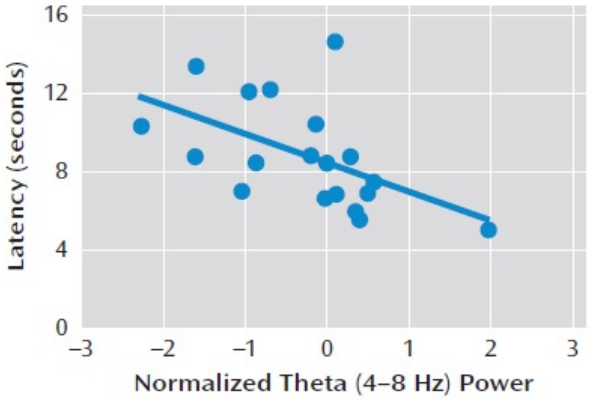
Anterior Cingulate Desynchronization and Functional Connectivity with the Amygdala During a Working Memory Task Predict Rapid Antidepressant Response to Ketamine

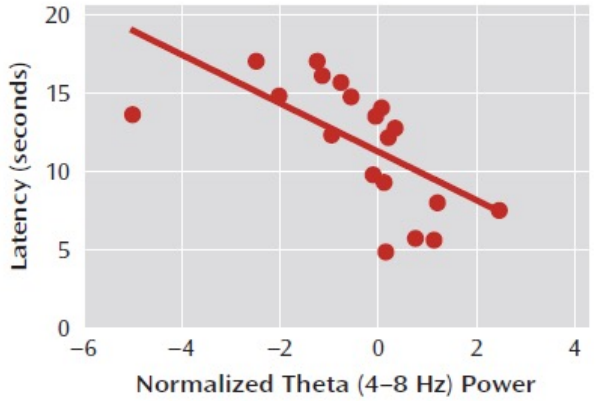
Giacomo Salvadore*[1,2], Brian R Cornwell[2], Fabio Sambataro[3], David Latov[1,2], Veronica Colon-Rosario[1], Frederick Carver[4], Tom Holroyd[4], Nancy Diaz-Granados[1,2], Rodrigo Machado-Vieira[1,2], Christian Grillon[2], Wayne C Drevets[2] and Carlos A Zarate, Jr[1,2]

Neuropsychopharmacology (2010), 1–8









Am J Psychiatry. 2010 Jul;167(7):836-44. Epub 2010 May 3.

Abnormal hippocampal functioning and impaired spatial navigation in depressed individuals: evidence from whole-head magnetoencephalography.

Cornwell BR, Salvadore G, Colon-Rosario V, Latov DR, Holroyd T, Carver FW, Coppola R, Manji HK, Zarate CA Jr, Grillon C.

Mood and Anxiety Disorders Program, NIMH, 15K North Dr., MSC 2670, Bethesda, MD 20892, USA. cornwellb@mail.nih.gov

Neuropsychopharmacology (2010) 35, 1413–1414

www.neuropsychopharmacology.org

Commentary

Psychiatric Stress Testing: Novel Strategy for Translational Psychopharmacology

Stephen M Stahl*[1,2]

[1]Department of Psychiatry, University of California, Carlsbad, CA, USA; [2]Department of Psychiatry, University of Cambridge, Cambridge, UK

Neuropsychopharmacology (2010) **35,** 1413–1414; doi:10.1038/npp.2010.29

A major focus of clinical neuroscience research today is to elucidate how reactions of brain circuits to stressful loads are regulated by genes and by psychiatric disorders. The study of Salvadore *et al* (2010) provides a glimpse into how such 'psychiatric stress tests' may also translate into predictors of who will respond to a specific drug.

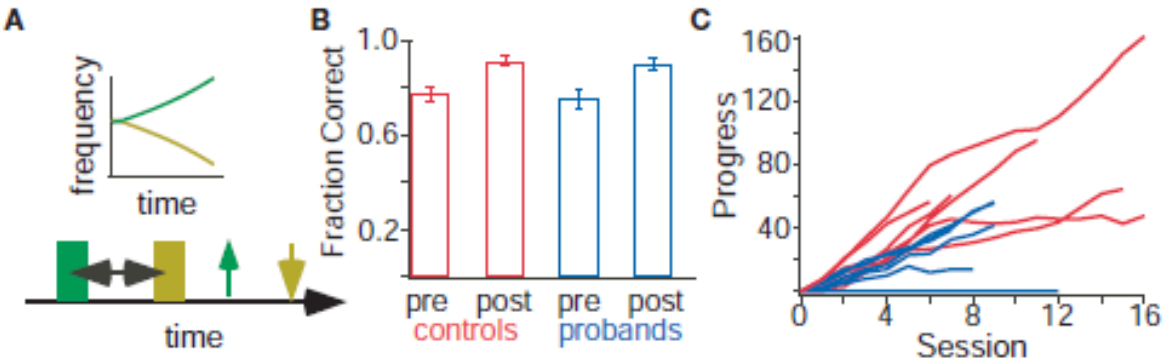


FIGURE 2 | Practice improves performance in the two-tone discrimination task. (A) In the task, two frequency modulated tones (green and yellow) are presented after a variable inter-stimulus interval. The subject makes two selections (up and down arrows) depending on the perceived direction of pitch modulation. **(B)** Progress in "high or low" pitch discrimination task during practice sessions. For both control (red) and proband (blue) subjects, task difficulty during each 15 min session was adaptively adjusted to match skill level. Progress bars are proportional to the number of correct responses during the session and inversely proportional to the number of incorrect responses. **(C)** Task accuracy in controls (red) and probands (blue) before and after practice.

frontiers in
HUMAN NEUROSCIENCE

ORIGINAL RESEARCH ARTICLE
published: 17 August 2011
doi: 10.3389/fnhum.2011.00081

Functional brain network characterization and adaptivity during task practice in healthy volunteers and people with schizophrenia[1]

Shennan Aibel Weiss[1], Danielle S. Bassett[2], Daniel Rubinstein[3], Tom Holroyd[3], Jose Apud[4], Dwight Dickinson[4] and Richard Coppola[4]*

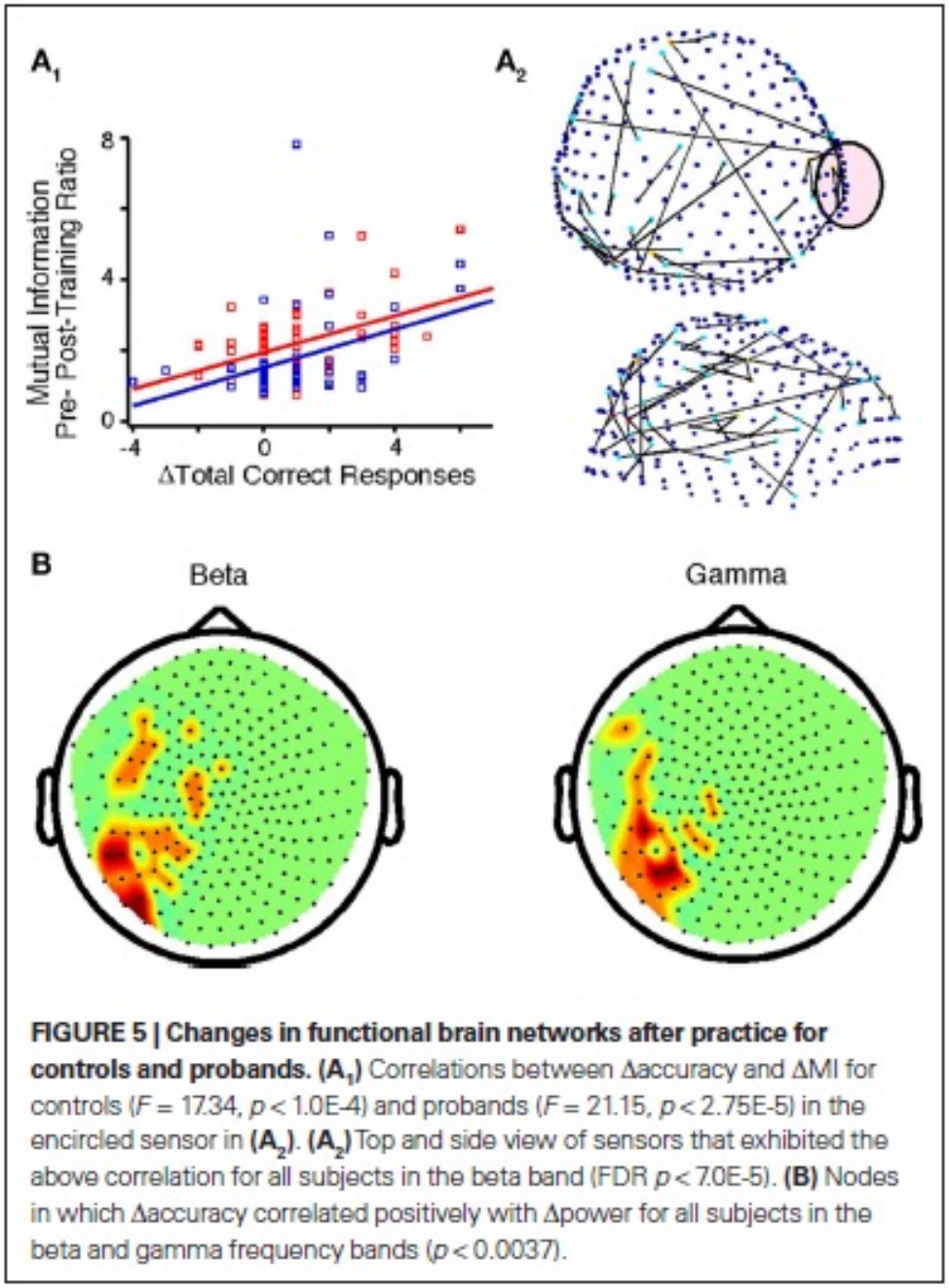


FIGURE 5 | Changes in functional brain networks after practice for controls and probands. **(A_1)** Correlations between Δaccuracy and ΔMI for controls ($F = 17.34$, $p < 1.0E\text{-}4$) and probands ($F = 21.15$, $p < 2.75E\text{-}5$) in the encircled sensor in **(A_2)**. **(A_2)** Top and side view of sensors that exhibited the above correlation for all subjects in the beta band (FDR $p < 7.0E\text{-}5$). **(B)** Nodes in which Δaccuracy correlated positively with Δpower for all subjects in the beta and gamma frequency bands ($p < 0.0037$).

Midbrain dopamine differentially predicts neural response to happy and fearful facial expressions: ^{18}FDOPA PET, fMRI, and MEG Findings

Tiffany A. Nash[1,2], Mbemba Jabbi[1,2], Philip Kohn[1,2], Angela Ianni[1,2], Tom Holroyd[3], Frederick Carver[3], Shane Kippenhan[1], Richard Coppola, and Karen Faith Berman[1,2]

[1]Section on Integrative Neuroimaging, Clinical Brain Disorders Branch, National Institute of Mental Health, Intramural Research Program, National Institutes of Health, Bethesda, MD 20892, USA
[2]Genes, Cognition and Psychosis Program, Clinical Brain Disorders Branch, NIMH, Bethesda, MD, USA
[3]Magnetoencephalography Core Facility, National Institute of Mental Health, National Institutes of Health, Bethesda, MD, USA

INTRODUCTION

The midbrain ventral tegmental area and substantia nigra are the main source of striatal and mesolimbic dopamine (DA). Though it is well-documented that DA is involved in motivational signaling[1], the specific role of midbrain DA in modulating human brain response to emotions remains largely unknown. Because DA differentially codes positive vs. negative signals in a time-dependent fashion[2,3], we accounted for the dynamics aspect of facial emotional stimuli in the present experiment, as they evolve into full blown emotional expressions over time. In line with the excitation or depression of DA neurons in response to rewarding and aversive stimuli[3], respectively, we predicted dissociable influences of midbrain DA synthesis on neural responses to emotional dynamics for positive vs. aversive social stimuli. Further, we anticipated that these influences would be observed in regions innervated by midbrain DA (Figure 1).

To test these hypotheses, we investigated the relationship between midbrain DA synthesis, measured with ^{18}FDOPA PET, and BOLD response to specific stimulus attributes (duration and dynamics) of happy and fearful facial expressions. In order to better capture the temporal dynamics of DA-mediated neural response—a sub-second response—we examined the oscillatory response to the stimuli using magnetoencephalograpy (MEG). We particularly focused on gamma band oscillations, which have been associated with emotional processing[4], and which have been found to be modulated by DA agonists[5].

Figure 1.
Midbrain Dopamine targets[6].

METHODS

•functional magnetic resonance imaging (fMRI)

- •Twenty-one participants (6 females; mean age= 31.19) viewed short (1s) and long (3s) presentations of dynamic and static emotional (fear and happiness) or neutral (for dynamic stimuli, eye blinks) facial expressions (Figure 2).
- • Data acquired on 3T; TR = 2.21s, TE = 75, number of slices = 27, FOV = 20
- •Preprocessing and first level analyses of the fMRI response to emotions were carried out using SPM5.

Figure 2.
Sample frame of videos. The static pictures used are shown in fourth frame.

•Magnetoencephalography (MEG)

- •Data acquired for 16 of the 21 participants (4 females; mean age=34.2).
- •CTF 275 MEG system with a whole-head array of 275 radial 1st order gradiometer/SQUID channels[7].
- •Coregistration of subjects' MEG scans to their anatomical MRIs (Figure 3).
- •Synthetic aperture magnetometry, a method for estimation of source power for each voxel of the brain using a beamformer, was carried out.

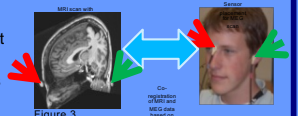


Figure 3.
Coregistration of MEG and MRI

•Positron emission tomography (PET)

- •Two sixty-second, 12 mCi [^{15}O]H_2O rCBF emission scans, and a 90-minute series of dynamic 16 mCi ^{18}F-DOPA emission scans were acquired following oral administration of carbidopa to decrease peripheral metabolism.
- •Using a voxel-wise Patlak method with a cerebellum reference region, FDOPA Ki, reflecting presynaptic DA synthesis, was determined for every voxel in the brain.
- •A midbrain volume of interest was manually delineated on each individual's structural MRI (Figure 4) and coregistered to the native space FDOPA PET scans for extraction of average midbrain Ki values.

Figure 4.
Example MB mask.

•Correlation analyses were performed using midbrain Ki values as predictors of BOLD response and MEG signal response in the gamma frequency band (30-50Hz). Results are threshold at 0.005, uncorrected, for display. Significance is reported for peak voxels.

RESULTS

DA-Modulated Neural Response to Positive Stimuli

Dynamics

DA-BOLD Coupling During Viewing of Static Happiness

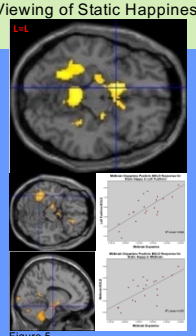


Figure 5.
MB DA Correlates with BOLD in left fusiform ($p=2.2x10^{-5}$) and midbrain ($p=0.001$)

DA-Gamma Coupling During Viewing of Static Happiness

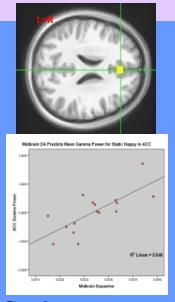


Figure 6.
a) MB DA correlates with gamma power in ACC ($p=0.001$)

Duration

DA-BOLD Coupling During Viewing of Short Happiness

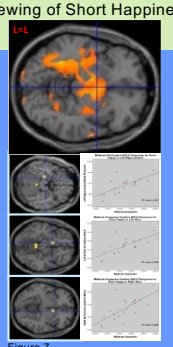


Figure 7.
MB DA Correlates with BOLD in left hippocampus ($p=1.79x10^{-4}$), left NAcc ($p=1.88x10^{-4}$), right NAcc ($p=2.29x10^{-4}$)

DA-Gamma Coupling During Viewing of Short Happiness

Figure 8.
a) MB DA correlates with gamma power in left STS and midbrain ($p=0.001$)

DA-Modulated Neural Response to Negative Stimuli

Dynamics

DA-BOLD Coupling During Viewing of Dynamic Fear

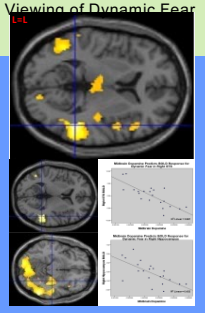


Figure 9.
MB DA Correlates with BOLD in right STS ($p=1.8x10-5$) and right hippocampus ($p=0.001$)

DA-Gamma Coupling During Viewing of Dynamic Fear

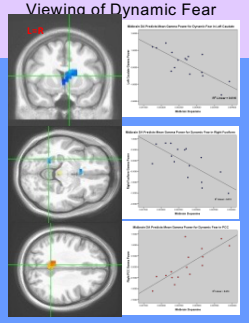


Figure 10.
a) MB DA correlates with gamma power in left caudate ($p=0.001$), right PCC ($p=0.001$), and right fusiform ($p=0.002$)

Duration

DA-Gamma Coupling During Viewing of Short Fear

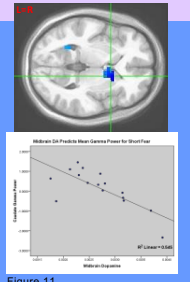


Figure 11.
a) MB DA correlates with gamma power in left caudate ($p=0.001$)

DISCUSSION

DA differentially mediated neural response to environmentally-relevant stimulus attributes in a valence-specific fashion. While there was a largely positive DA-mediated neural response for happy expressions, negative relations were apparent between DA and neural response for fearful stimuli. These results suggest that happy and fearful facial expressions may provoke reward and aversion, respectively, and are in line with previous studies demonstrating an excitatory role of DA in response to reward and an inhibitory role in response to aversive stimuli.

Our results support previous research on the role of DA in reward coding and fear processing[8], and confirm a role for DA in modulation of emotions. The DA modulated gamma oscillatory findings may reflect faster, more transient neural coding of emotional information, which may not have been captured by fMRI's coarser temporal resolution[9]. These differential findings for negative and positive emotions offer potential insight for studies of affective disorders.

REFERENCES: 1. Wise R Neurotox Res 2008 2. Matsumoto M et al. Nature 2009 3. Schultz W Annu Rev Neurosci 2007 4. Luo Q Neuroimage 2007 5. Brown et al J Neurosci 2001 6. Ferrer et al. Drugs Fut 2007 7. Fife A et al. Conf Biomagnetism 2002 8. Wise R Nature Rev Neurosci 2004 9. Kapur S et al. HBM 2007

Abnormalities in Resting State Connectivity in Bipolar Disorder

Allison C. Nugent[1], Stephen E. Robinson[2], Richard Coppola[2], Maura L. Furey[1], Carlos A. Zarate, Jr. [1]

[1] Experimental Therapeutics and Pathophysiology Branch, National Institute of Mental Health, National Institutes of Health, Bethesda MD, USA
[2]NIMH Magnetoencephalography Core Facility, National Institute of Mental Health, National Institutes of Health, Bethesda MD, USA

1. Background

- ICA analysis on band-pass limited Hilbert-envelope MEG resting state data reveals similar networks as those seen in fMRI (1).
- Regions within these networks exhibit correlated low frequency fluctuations of the smoothed Hilbert envelope.
- We previously demonstrated reduced connectivity in MDD compared to healthy subjects between a precentral/middle frontal C and subgenual anterior cingulate cortex (sgACC), as well as increased connectivity within limbic/temporal networks (2). This is the first similar analysis in bipolar disorder (BD).

2. Methods

- MEG recordings were acquired for 17 subjects with BD (age=45±12.7, 7 female) and16 control (HC) subjects (age=39±8.6, 8 female). Subjects did not differ significantly on age (p>0.05). Twelve BD subjects were medicated with either lithium or valproate monotherapy.
- MEG acquired on a 275-channel CTF system at 1200Hz for 250s, T1 MRI scans were acquired for coregistration.
- Recordings were beta (14-30 Hz) band-pass filtered, and projected into anatomical space of the T1 MRI at isotropic 5mm resolution using SAM (3)
- Hilbert envelopes were calculated, smoothed, and sampled at 1Hz
- Data from all subjects was temporally concatenated after transformation to standard space, and temporal ICA was performed to extract 25 independent components (ICs)
- Linear regression was used to obtain group and individual subject IC maps
- Subject maps were compared between groups using independent samples t-tests in AFNI (Analysis of Functional Images, NIMH/NIH Bethesda MD) (4)
- T-score images were initially thresholded at p<0.005 uncorrected and clusters surviving correction for multiple comparisons at p_{corr}<0.05 are reported.

3. Results

A. Out of 25 estimated components, 20 were either distributed networks or single nodes.

B. Connectivity between a left insular node and bilateral motor cortex was reduced in BD.

C. Connectivity between a unique limbic network (encompassing orbitofrontal and parahippocampal cortex) and middle occipital cortex was reduced in BD.

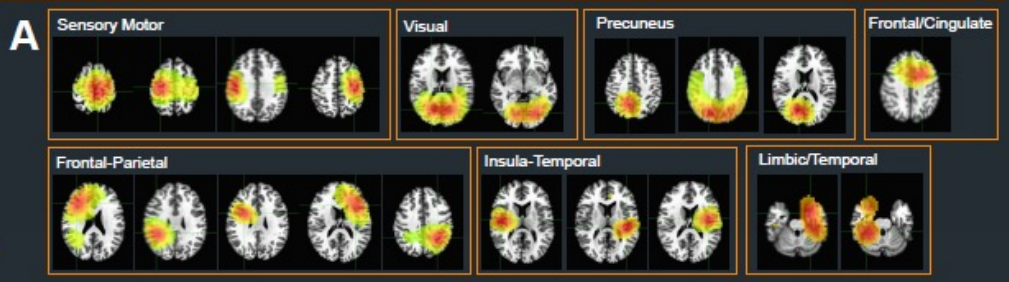
D. Connectivity between an IC covering bilateral paracentral motor areas with insula and amygdala was reduced in BD.

E. Connectivity between a medial visual IC and cerebellum was reduced in BD.

F. Connectivity between left and right lateralized sensorimotor IC's was reduced in BD to similar areas in contralateral postcentral gyrus, superior/middle frontal gyrus, and inferior frontal gyrus. Connectivity to R precentral gyrus was additionally reduced in the subgenual cingulate and orbitofrontal cortex, similar to our finding in subjects with MDD (2).

4. Discussion

- In this preliminary study of MEG resting state connectivity in bipolar disorder, the first to use an ICA analysis, we have found a widespread pattern of reduced connectivity compared to controls.
- Similar to healthy controls, we find reduced connectivity between a precentral motor network and subgenual ACC (2). In addition, our subjects with BD show decreased connectivity between motor regions and the insula and amygdala, regions known to interact with the sgACC.
- In general, BD subjects exhibited impaired connectivity to locations contralateral to the primary node location. This is consistent with reduced corpus callosum volume in BD (5) and impaired inter-hemispheric connectivity (6).
- MEG resting state connectivity may reveal unique abnormalities in BD, potentially informing treatment.

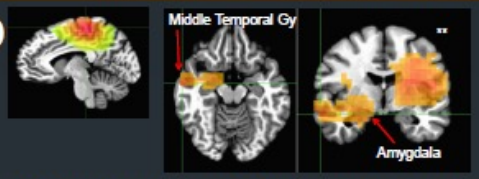


HC Connectivity to Insula > BD Connectivity to Insula

Peak:	27.5	27.5	47.5	171 voxels	t=4.24	p<<0.01
	-27.5	37.5	57.5	58 voxels	t=4.13	p<0.04

HC Connectivity to orbito-temporal > BD Connectivity to orbito-temporal

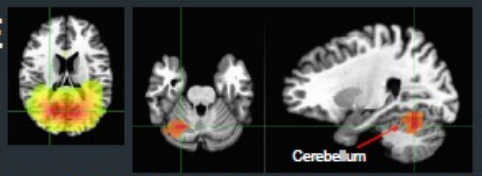
Peak:	-37.5	77.5	17.5	170 voxels	t=3.99	p<<0.01



HC Connectivity to Paracentral > BD Connectivity to Paracentral

Peak:	12.5	27.5	42.5	720 voxels	t=4.78	p<<0.01
	-57.5	7.5	-12.5	133 voxels	t=3.98	p<0.01

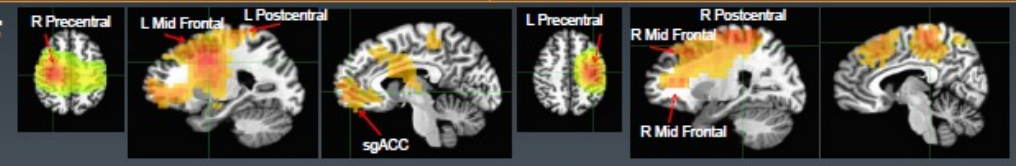
**Large cluster encompasses L insula, L inferior frontal, R middle frontal, and dorsal cingulate



HC Connectivity to Medial Visual > BD Connectivity to Medial Visual

Peak:	-22.5	57.5	-22.5	69 voxels	t=3.92	p<0.02

**Cluster in contralateral cerebellum does not survive correction for multiple comparisons



HC Connectivity to Precentral > BD Connectivity to Precentral

Peak:	22.5	2.5	32.5	1400 voxels	t=5.25	p<<0.01
	47.5	7.5	-27.5	73 voxels	t=4.20	p<0.02

HC Connectivity to Postcentral > BD Connectivity to Postcentral

Peak:	-12.5	37.5	52.5	1061 voxels	t=5.26	p<<0.01
	32.5	-17.5	32.5	49 voxels	t=4.33	p<0.06

5. References

1. Brookes, MJ., et al. (2011), PNAS 108(40): 16783-16788.
2. Nugent, A.C., et al. (2014), Society for Neuroscience Annual Meeting, San Diego, CA.
3. Robinson and Vrba (1999), In Recent Advances in Biomagnetism, pp. 302-305.
4. AFNI: Analysis of Functional NeuroImages, SSCC/NIMH/NIH, Bethesda, MD,
5. Amone, D., et al. (2008), Acta Psychiatrica Scandinavica 115(5):357-362.
6. Leow, A., et al. (2013), Biological Psychiatry 72(2):183-193.

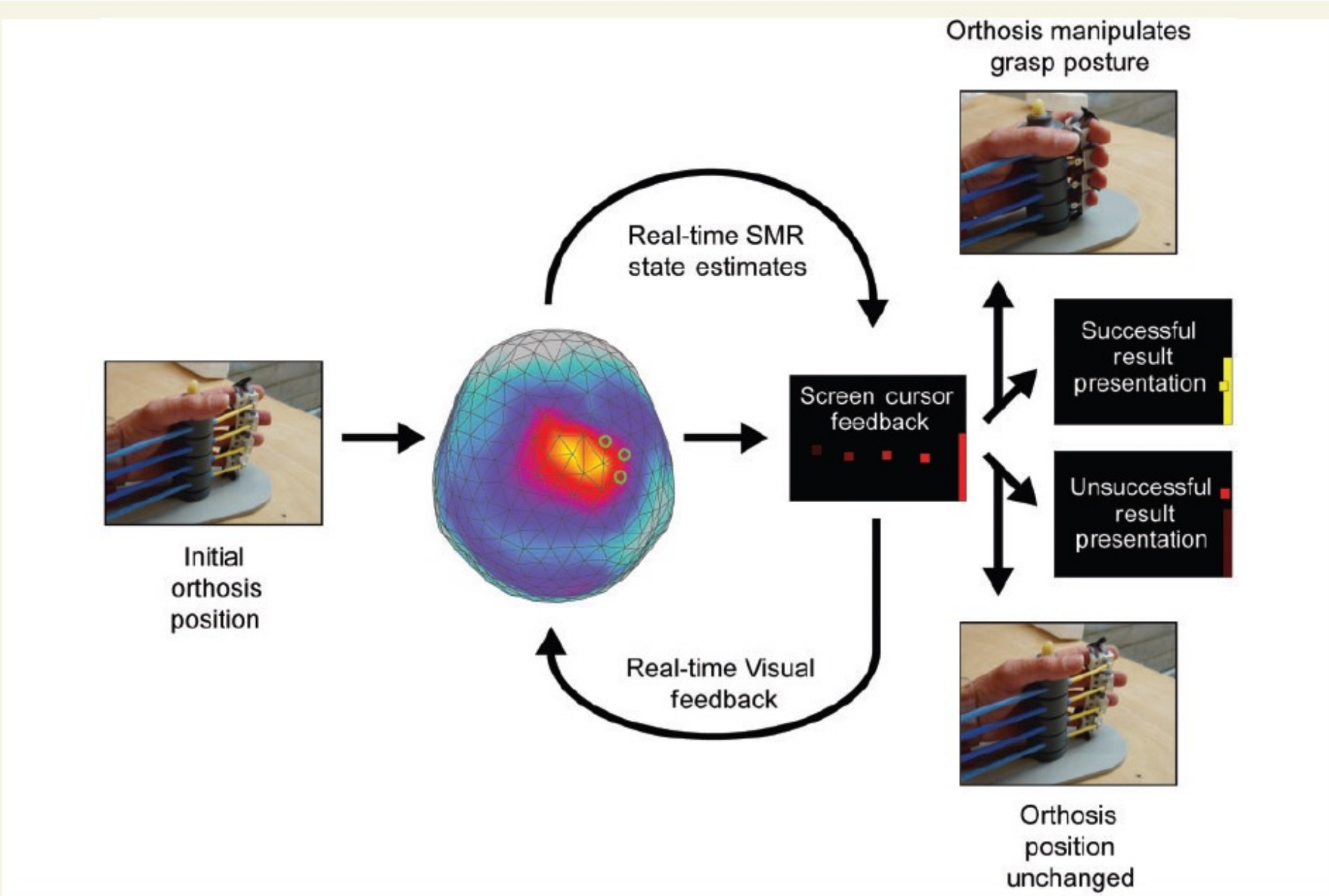
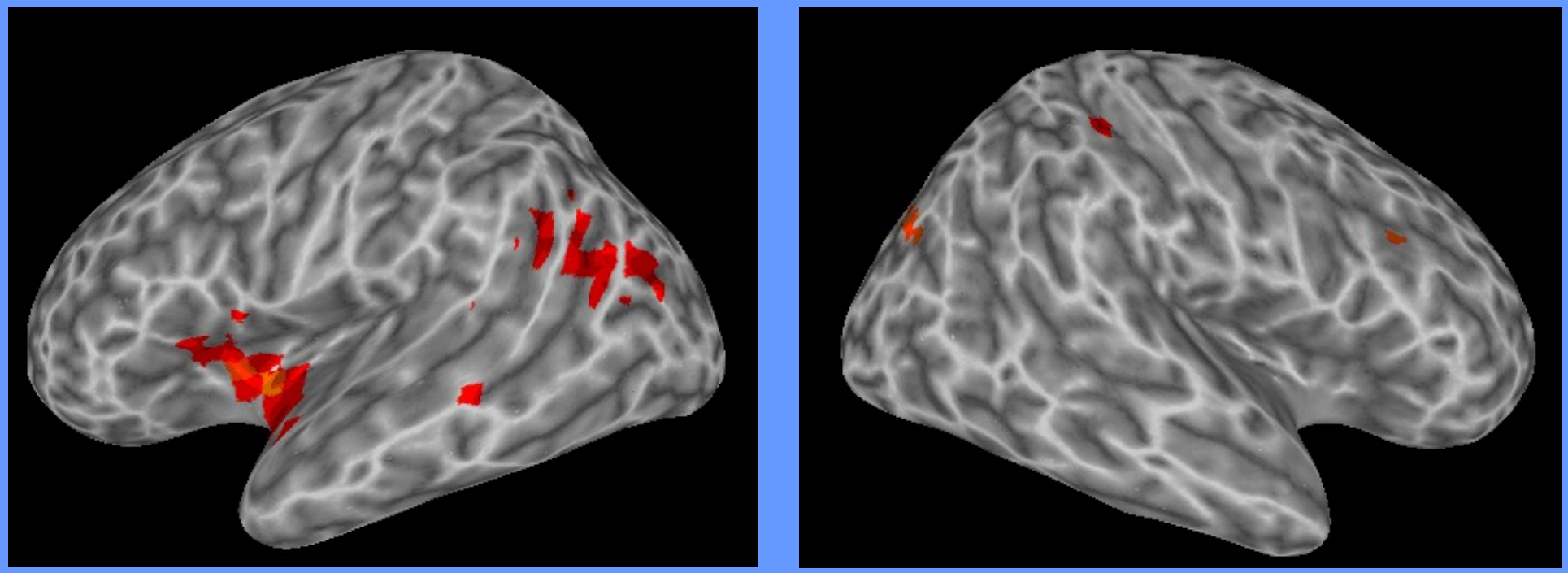


Figure 2 Trial description for sensorimotor rhythm (SMR) modulation through grasping imagery training. Whole-head magnetoence-

Gamma band activity during auditory stimulation



NIMH MEG Core Facility

- Dr. Richard Coppola, Director
- Dr. Tom Holroyd, Staff Scientist
- Dr. Fred Carver
- Dr. Stephan Robinson
- Judy Mitchell-Francis, Lab Mgr
- Samantha Fradkin, Post-Bac IRTA

CTNB Sib Study

- K. Berman
- J. Apud
- S. Marenco
- J.H. Callicott

MAP

- Carlos Zarate
- Alison Nugent
- Brian Cornwell

NIMH
National Institute of Mental Health

POLICIES AND PROCEDURES

These documents comprise the official policies and procedures for the MEG lab.

- Mission Statement

- **Operations (1.00)**
  - Hours of Operation
  - Laboratory Access
  - Dress Code

- **Scheduling (2.00)**
  - Scheduling Procedures
  - Facility Access Requests

- **User/Subject Guidelines (3.00)**
  - User Guidelines
  - Normal Control / Subject Guidelines
  - Inpatient Guidelines
  - Data Access Accounts / Data Access
  - Variance Reporting

- **MEG / EEG Setup (4.00)**
  - MEG Setup Procedures
  - Fiducial Points Placement
  - EEG Easy Cap Setup Procedures
  - EEG 10-20 Electrode Placement System
  - Electrodes Specifications Guidelines
  - Polhemus Digitization System
  - Head Stabilization Pillow
  - MEG System Impedance Check
  - Grass Impedance Meter Check

- **Magnetically Shielded Room (MSR) / Support System (5.00)**
  - Magnetically Shielded Room (MSR)
  - Gantry Operation
  - Chair Operation
  - Bed Operation

- **Stimulus / Response Equipment (6.00)**
  - Panasonic DLP Projector
  - Grass Nerve / Muscle Stimulator
  - Auditory Stimulation
  - Response Pads
  - VCR Operation
  - Video Camera Operation
  - Voice Intercom System Operation
  - Video Display Monitor
  - Infrared Lighting

- **Data Acquisition (7.00)**
  - Data Acquisition
  - Transferring Data to the RAID Array

- **Infection Control (9.00)**
  - Infection Control
  - Cleaning, Disinfection & Sterilization of MEG Equipment
  - Hand Hygiene, Cleaning & Washing Procedures
  - Infection Control - CHS Processing Procedure

- **Quality Assurance / Risk Management (10.00)**
  - Quality Improvement Plan
  - MEG System Calibration
  - Routine Noise Collection
  - Head Coil Calibration Procedures
  - Magnetic Phantom Calibration
  - EEG System Calibration
  - MEG Lab System Monitors
  - Material Safety and Data Sheets (MSD Sheets)
  - Liquid Helium Safety
  - Compressed Helium Gas Safety
  - Compressed Helium Gas Level Check
  - Liquid Helium Refill Procedure
  - Possible Seizure Event
  - Medical Emergency / Suspected Cardiac or Respiratory Event
  - Laboratory Safety
  - Subject / Patient Identification
  - Power Failure
  - Chemical or Biological Materials Incident
  - Radiation Incident
  - Bomb Threat Incident
  - Evacuation / Emergency Preparedness Plan
  - Variance / Safety / QI Reporting

- **Training & Education (11.00)**
  - Training & Education

- **Compliance / Credentialing (12.00)**
  - Compliance/Credentialing

NIMH MEG Core Facility Schedule

NIMH MEG Core Facility Wisdom of the Moment:

Time is infinite. In particular, you can schedule slots for evening times by clicking on *any* slot and changing the start time.

January 25, 2015 - January 31, 2015

(Week 03)

Administrator

	Sun January 25	Mon January 26	Tue January 27	Wed January 28	Thu January 29	Fri January 30
8:00					8:00> Grillon/Balderston	
8:30						
9:00				9:00> Zarate/Berg		
9:30		9:30> Zarate/Berg				
10:00			10:00> COPPOLA / J Mitchell			
10:30					10:30> Inati	
11:00				11:00> Inati/Scott		11:00> COPPOLA / J Mitchell
11:30			11:30> Zarate/Berg			
12:00						
12:30						
13:00						
13:30						13:30> COPPOLA / J Mitchell
14:00		14:00> Zarate/Banerjee	14:00> COPPOLA / J Mitchell	14:00> Zarate/Lundin		
14:30						
15:00					15:00> Zarate/Lundin	
15:30						
16:00			16:00> He / Maniscalco	16:00> Maintenance		
16:30						16:30> He / Maniscalco
17:00				17:00> Grillon/Balderston		
17:30					17:30> Grillon/Balderston	
18:00						
18:30						
19:00						
19:30						
20:00						
20:30						20:30> Zarate/Berg

Adaptive reconfiguration of fractal small-world human brain functional networks

Danielle S. Bassett*†‡, Andreas Meyer-Lindenberg†§, Sophie Achard*, Thomas Duke‡, and Edward Bullmore*§

19518–19523 | PNAS | December 19, 2006 | vol. 103 | no. 51

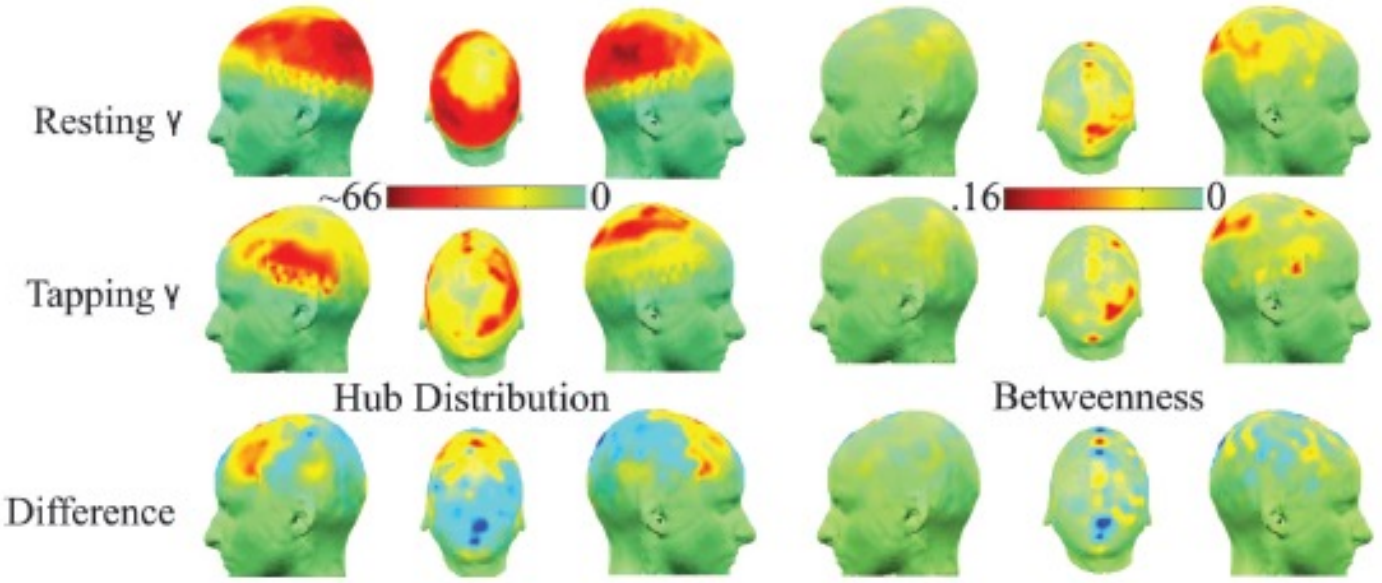
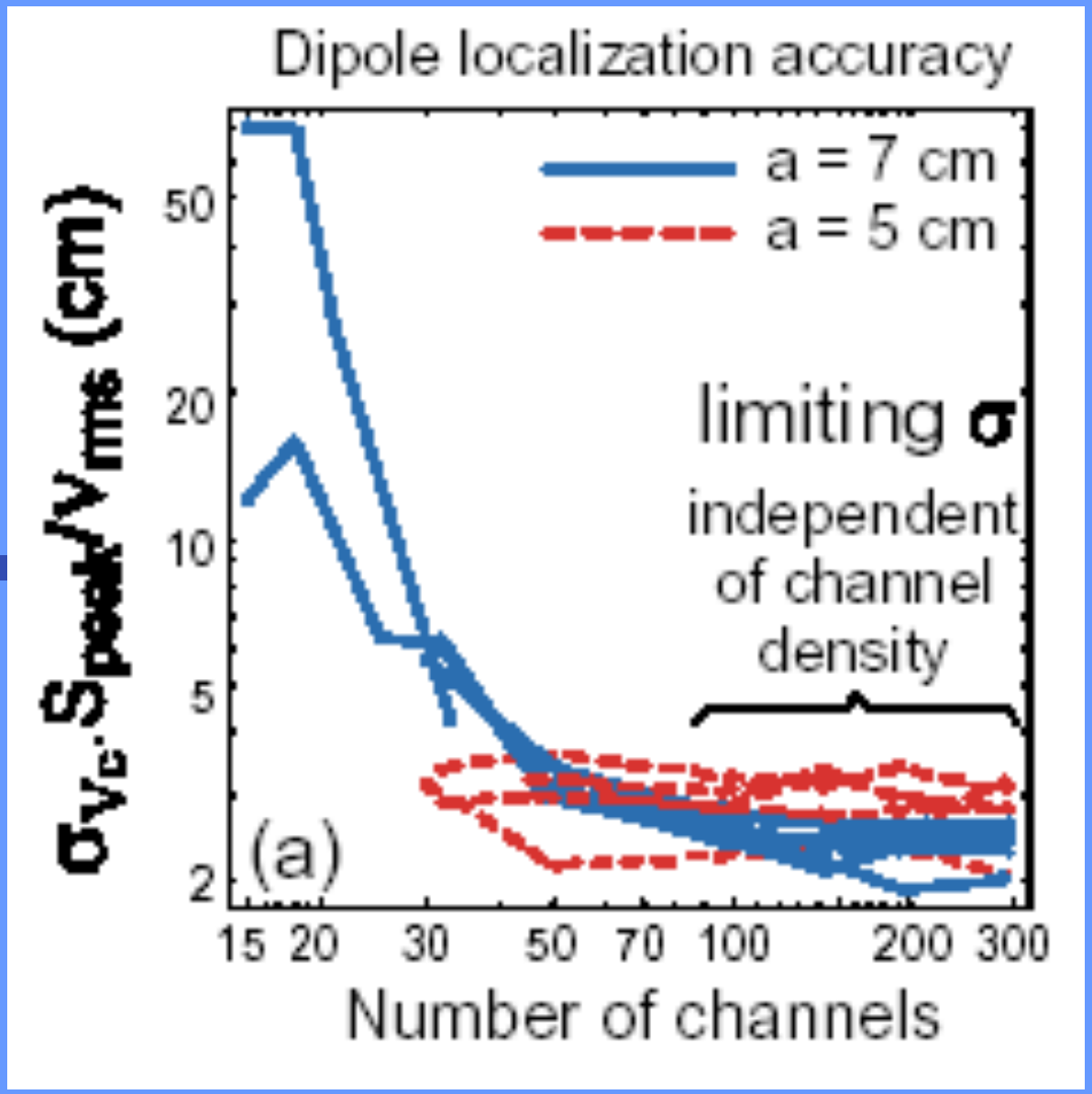


Fig. 3. State-related differences in spatial configuration of the highest frequency γ network. The top row shows the degree distribution and betweenness scores for the resting state γ network; the middle row shows the same maps for the motor γ network; the bottom row shows the between-state differences in degree and betweenness. It is clear that motor task performance is associated with emergence of greater connectivity in bilateral prefrontal and premotor nodes, and appearance of topologically pivotal nodes (with high betweenness scores) in medial premotor, right prefrontal, and parietal areas. See SI Fig. 7 for the betweenness distributions in both states at all frequency bands.


Dipole localization accuracy
a = 7 cm
a = 5 cm
limiting σ
independent of channel density
(a)
50
20
10
5
2
15 20 30 50 70 100 200 300
Number of channels
σVc·Speak/Vrms (cm)

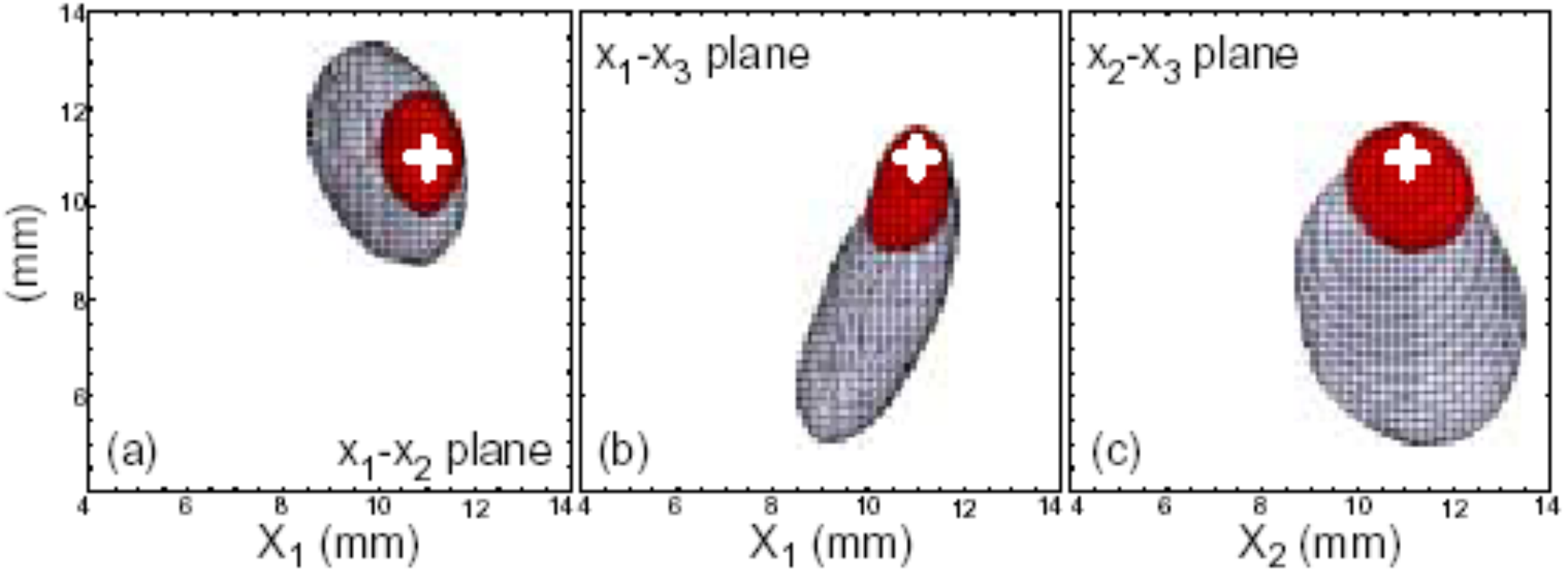
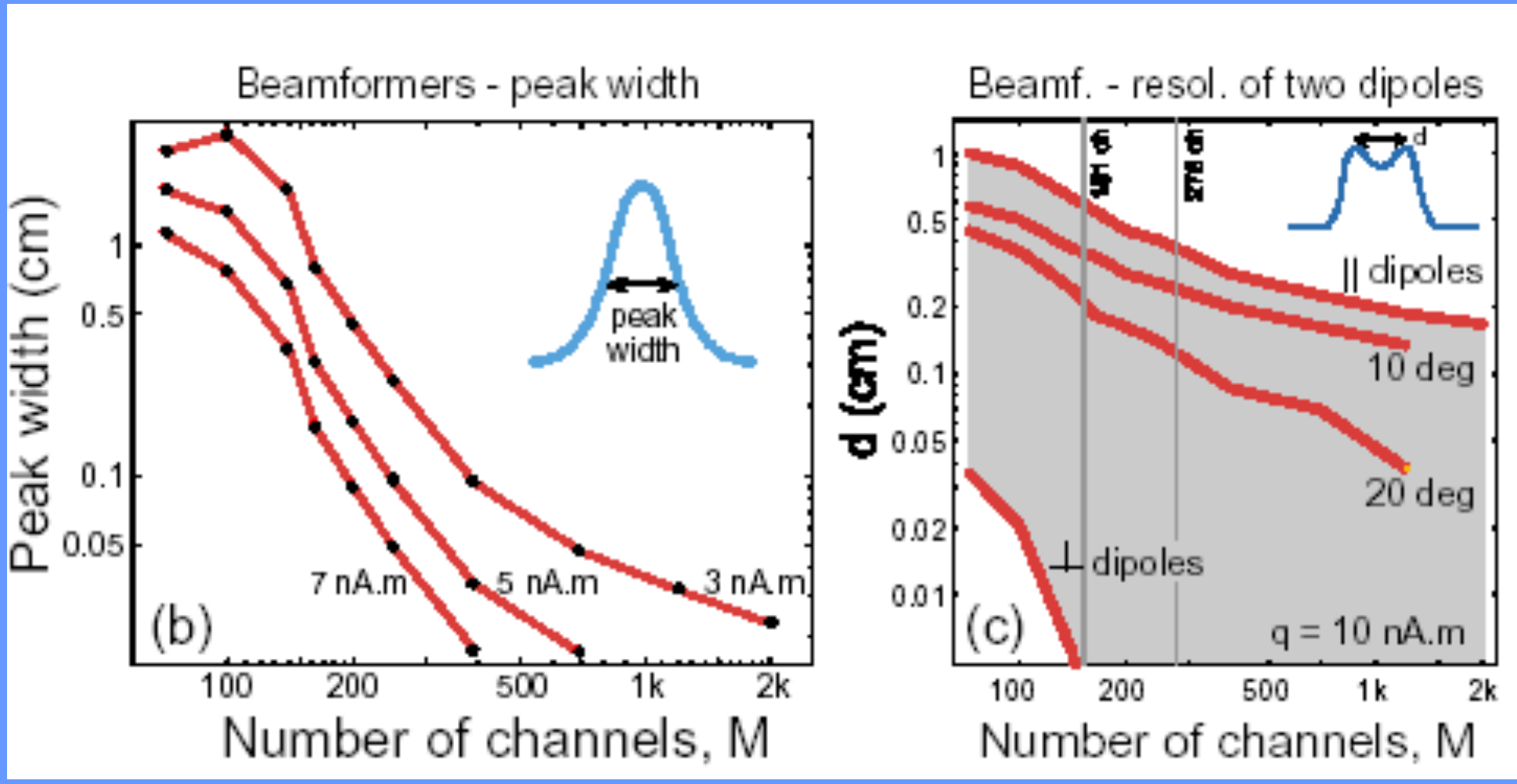
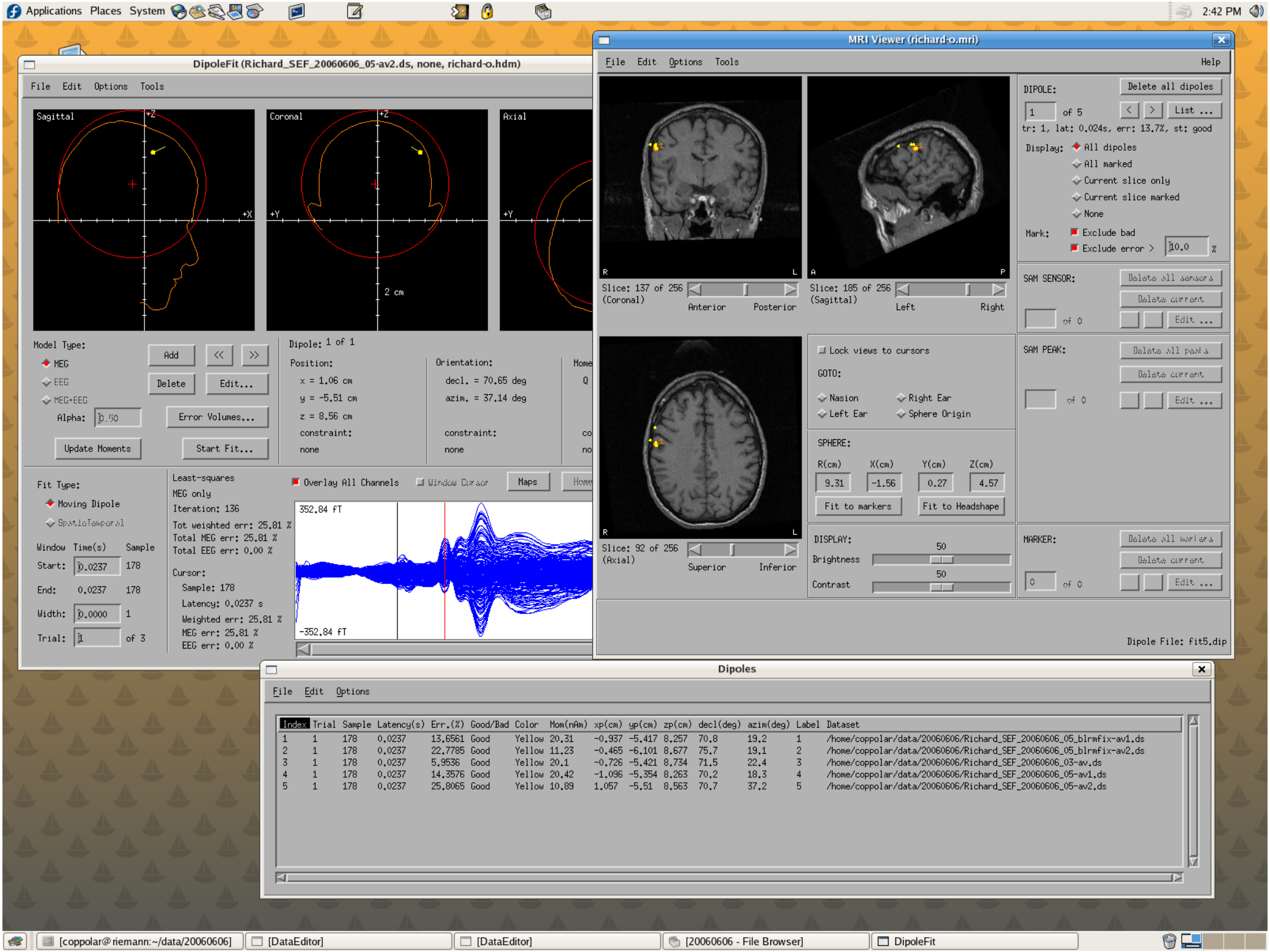


Fig.2: Benefit of increased channel number using measured brain and sensor noise in an unshielded environment with 3rd-order gradiometer noise cancellation. Dipole with 20 nA.m moment was inserted into measured brain noise, roughly 4.5 cm below the sensors. The half-amplitude 3D contours of normalized beamformer power are projected into x1-x2, x1-x3, and x2-x3 planes. White .+. indicates the exact dipole position. Red shapes . 275 channel system, volume 6.1 mm3, gray shapes . 275 channel system resampled to 138 channels, volume 37.8 mm3


Beamformers - peak width
Peak width (cm)
1
0.5
0.1
0.05
peak
width
7 nA.m
5 nA.m
3 nA.m
(b)
100
200
500
1k
2k
Number of channels, M
Beamf. - resol. of two dipoles
d (cm)
1
0.5
0.2
0.1
0.05
0.02
0.01
d
|| dipoles
10 deg
20 deg
⊥ dipoles
(c)
q = 10 nA.m
100
200
500
1k
2k
Number of channels, M


Applications Places System
2:42 PM
DipoleFit (Richard_SEF_20060606_05-av2.ds, none, richard-o.hdm)
File Edit Options Tools
Sagittal
Coronal
Axial
+Z
+X
+Y
2 cm
Model Type:
MEG
EEG
MEG+EEG
Alpha:
Add
Delete
Edit...
Error Volumes...
Update Moments
Start Fit...
Dipole: 1 of 1
Position:
x = 1.06 cm
y = -5.51 cm
z = 8.56 cm
constraint:
none
Orientation:
decl. = 70.65 deg
azim. = 37.14 deg
constraint:
none
Fit Type:
Moving Dipole
Spatio-Temporal
Window Time(s) Sample
Start: 0.0237 178
End: 0.0237 178
Width: 0.0000 1
Trial: 1 of 3
Least-squares
MEG only
Iteration: 136
Tot weighted err: 25.81 %
Total MEG err: 25.81 %
Total EEG err: 0.00 %
Cursor:
Sample: 178
Latency: 0.0237 s
Weighted err: 25.81 %
MEG err: 25.81 %
EEG err: 0.00 %
Overlay All Channels
Window Cursor
Maps
352.84 fT
-352.84 fT
MRI Viewer (richard-o.mri)
File Edit Options Tools Help
R
L
A
P
Slice: 137 of 256
(Coronal)
Anterior
Posterior
Slice: 185 of 256
(Sagittal)
Left
Right
Slice: 92 of 256
(Axial)
Superior
Inferior
DIPOLE:
Delete all dipoles
1 of 5
List ...
tr: 1, lat: 0.024s, err: 13.7%, st: good
Display:
All dipoles
All marked
Current slice only
Current slice marked
None
Mark:
Exclude bad
Exclude error >
10.0 %
SAM SENSOR:
Delete all sensors
Delete current
of 0
Edit ...
SAM PEAK:
Delete all peaks
Delete current
of 0
Edit ...
Lock views to cursors
GOTO:
Nasion
Right Ear
Left Ear
Sphere Origin
SPHERE:
R(cm) X(cm) Y(cm) Z(cm)
9.31 -1.56 0.27 4.57
Fit to markers
Fit to Headshape
DISPLAY:
Brightness 50
Contrast 50
MARKER:
Delete all markers
Delete current
0 of 0
Edit ...
Dipole File: fit5.dip
Dipoles
File Edit Options
Index Trial Sample Latency(s) Err.(%) Good/Bad Color Mom(nAm) xp(cm) yp(cm) zp(cm) decl(deg) azim(deg) Label Dataset
1 1 178 0.0237 13.6561 Good Yellow 20.31 -0.937 -5.417 8.257 70.8 19.2 1 /home/coppolar/data/20060606/Richard_SEF_20060606_05_blrmfix-av1.ds
2 1 178 0.0237 22.7785 Good Yellow 11.23 -0.465 -6.101 8.677 75.7 19.1 2 /home/coppolar/data/20060606/Richard_SEF_20060606_05_blrmfix-av2.ds
3 1 178 0.0237 5.9536 Good Yellow 20.1 -0.726 -5.421 8.734 71.5 22.4 3 /home/coppolar/data/20060606/Richard_SEF_20060606_03-av.ds
4 1 178 0.0237 14.3576 Good Yellow 20.42 -1.096 -5.354 8.263 70.2 18.3 4 /home/coppolar/data/20060606/Richard_SEF_20060606_05-av1.ds
5 1 178 0.0237 25.8065 Good Yellow 10.89 1.057 -5.51 8.563 70.7 37.2 5 /home/coppolar/data/20060606/Richard_SEF_20060606_05-av2.ds
[coppolar@riemann:~/data/20060606]
[DataEditor]
[DataEditor]
[20060606 - File Browser]
DipoleFit